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Game-Based Learning and the Coherence Principle: Their Effects on Learning Outcomes and Self-Efficacy

by

Tania Harden

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in the Department of Educational Leadership

Idaho State University

Spring 2022

Committee Approval

To the Graduate Faculty:

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

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September 15, 2021

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Sincerely,

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Human Subjects Chair

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Dedication

To all of those dealing with life’s challenges, remember: “’I did not come this far only to come this far.’ Keep going. Keep trying. Keep trusting. Keep believing. Keep growing… Heaven is cheering you on today, tomorrow, and forever.” – Jeffrey R. Holland

Acknowledgements

I would like to express my sincere thanks to everyone who has helped and encouraged me along this journey. There have been many individuals who have provided guidance, advice, and support.

To my husband, Brian, I know that you think I am crazy to WANT to do this, but you have never once doubted that I COULD do this. I love you a gazillion dollars.

To my children Brenna; Josh, his wife Haley and my grandson Liam; Jared; Jacob; and Seth, thank you for encouraging me and picking up the slack when I needed you to. I couldn't ask for more wonderful kids.

To my advisor, Dr. David Coffland, I am especially grateful for your patience, kindness, and compassion as we have worked together on this endeavor. I am also grateful for each member of my dissertation committee: Dr. Dotty Sammons-Lohse, Dr. John Curry, Dr. Patti Mortensen, and Dr. James DiSanza. Thank you for your willingness to serve and provide guidance and support that helped me improve as an instructional designer and researcher.

To my game design committee from Idaho State University Libraries: Caprice Despain Huse, Darcie Hancock, Ben Bolin, Kristin Whitman, and Laura Gleason. I am grateful for your creativity, dedication, and willingness to help. Without you, this project would not have happened. I am also grateful to Dean Sandra Shropshire and Associate University Librarian Jenny Semenza for their support and approval of this project.

To Dr. Vaia Florou and my team at the Huntsman Cancer Institute and Dr. Doug Anderson and the team at the Portneuf Cancer Center, thank you for asking how my dissertation was going every visit and for moving appointments and scheduling treatments so that I could

meet the milestones to the best of my ability. You have helped cancer not define me and for that I will be eternally grateful.

To the rest of my friends, family, ward family, and work family, thank you for the prayers, positive thoughts, good vibes, etc. on my behalf so that I could achieve this goal. I am grateful for each one of you and appreciate your efforts on my behalf. I could not have done this without you.

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Game-Based Learning and the Coherence Principle: Their Effects on Learning Outcomes and Self-Efficacy

Dissertation Abstract—Idaho State University (2022)

This purpose of this study was to examine the effects of game-based learning and the coherence principle on student outcomes and self-efficacy compared to a multimedia tutorial. The relationship between perceived self-efficacy posttreatment and student outcomes was also explored.

Participants included 99 undergraduate students in the information literacy portion of a first-year seminar course in fall 2021 at a rural, public university in the Intermountain West. Student outcomes were measured by a posttest assessment. Perceived self-efficacy was measured by the Using Information Responsibly Self-Efficacy Survey (UIRSES) scale both pre- and posttreatment. The participants were randomly assigned to one of three treatment groups. The multimedia learning (MT) group (n = 38) received instruction using multimedia tutorials. The game-based learning (G1) group (n = 36) received instruction using a virtual escape room game that contained minimal extraneous content. The game-based learning (G2) group (n = 26) received instruction using the same virtual escape room game as the G1 group, but the G2 treatment contain more extraneous content in the form of interesting topic related, but unnecessary factoids. All instruction was conducted asynchronously online.

Results indicated there were no statistically significant differences between test scores based on teaching method. This study found a statistically significant difference overall in perceived self-efficacy from pre- to posttreatment across the different teaching methods. When looked at individually, all three teaching methods resulted in gains in perceived self-efficacy, however, none of the differences between groups were statistically significant. Overall, a small, statistically significant correlation was found between posttreatment perceived self-efficacy scores and test scores. When examined individually, all three treatment groups showed a positive correlation between posttreatment perceived self-efficacy scores and test scores, but none were found to be statistically significant. Each treatment resulted in larger positive correlation between posttreatment perceived self-efficacy survey scores and test scores than between pretreatment perceived self-efficacy survey scores and test scores, indicating that all instructional treatments increased the alignment between the participant's perception of their abilities and their actual achievement.

Keywords: Cognitive Theory for Multimedia Learning, game-based learning, gamification, gaming, multimedia, multimedia learning, self-efficacy, Self-Efficacy Theory

Game-Based Learning and the Coherence Principle: Their Effects on Learning Outcomes and Self-Efficacy

CHAPTER I

Introduction

As of April 1, 2020, schools in 185 countries were closed due to the COVID-19 pandemic. These closures, which included higher education, affected more than 1.5 billion learners (Marinoni et al., 2020). In spring semester 2020, more than 1,300 colleges and universities in the United States (U. S.) cancelled face-to-face classes and moved to online only instruction (Smalley, 2020). The College Crisis Initiative (C2i) (2020), in conjunction with The Chronicle of Higher Education, tracked 2,958 U. S. colleges, universities, and community colleges in the fall of 2020. C2i found that in response to the ongoing pandemic, 301 (10%) were planning to offer fully online instruction, 1,001 (34%) were planning to offer primarily online instruction, and 622 (21%) were planning to offer hybrid instruction (C2i, 2020; Elias et al., 2020). For the spring 2021 semester, of the 1,442 institutions that reported their plans to C2i, 1,388 were planning to offer fully online instruction (C2i, 2020).

The sudden shift from face-to-face to online learning during the COVID-19 pandemic, caused a major disruption in teaching and learning (Marinoni et al., 2020). Of the higher education institutions included in the Marinoni et al. report, only 2% reported no disruption in teaching and learning, while 67% replaced classroom learning with distance learning, 24% had to suspend classes while they developed solutions to continue with teaching and learning, and 7% cancelled classes completely (2020).

While the COVID-19 pandemic forced higher education to go to online learning, the emphasis to provide online instruction as an option began almost a decade earlier when President

Barack Obama gave a joint address before Congress in 2009 and set a goal for the U. S. to have the highest percentage of college students in the world by 2020 (Bell, 2018). With that pronouncement, higher education quickly began to realize that there would be challenges to reaching that goal and most residential campuses would not have the financial resources or physical space to accommodate an influx of students. Most of the targeted population were older with work experience and would not be able to uproot their families and jobs to move close to campus for the time it would take them to obtain a degree (Bell, 2018). In 2020, the National Center for Education Statistics (NCES) reported that six-year college completion rates were only approximately 61%, meaning that many of these new students would not reach graduation. Given these issues, many educators and other invested parties felt that online education would play a major role in meeting President Obama's goal (Bell, 2018).

Allen and Seaman (2015) surveyed 4,891 U. S. public, degree-seeking institutions regarding online education. These authors found that from the 2,807 responses received, 70.8% of the institutions believed that online education was critical to their long-term strategy. College administrators also believed that 90% of their students were likely to enroll in at least one online course by 2018 (Allen & Seaman, 2015). In higher education in the U. S. in the fall of 2015, there were more than six million students taking at least one distance education course (Allen & Seaman, 2017).

Some studies have found that retention rates, learning outcomes, and satisfaction rates for students who take online courses are lower than for students enrolled in traditional courses (Alhamwi et al., 2020; Bell, 2018; McDonough & Marks, 2002). Studies in 2011 and 2013 by the Community College Research Center at Teacher's College, Columbia University, found that students who take a higher proportion of online courses have lower retention rates and lower graduation rates than students who took a lower proportion of online classes (Bell, 2018; Community College Research Center, 2013). McDonough and Marks (2002) found that participants who received instruction online had poorer learning outcomes than those who were taught face-to-face. Alhamwi et al. (2020) found significantly lower satisfaction rates from students enrolled in e-learning environments.

Bailey et al. (2018), Fidalgo et al. (2020), and Means et al. (2010) have found that statistics for online education are not all negative. These authors' studies have found higher retention and graduation rates, student attitudes and satisfaction, and student learning outcomes among students taking a combination of fully online or hybrid courses and face-to-face courses compared to students taking strictly in person classes (Bailey et al., 2018; Fidalgo et al., 2020; Means et al., 2010). The outcomes of these studies will be discussed in Chapter II, Review of the Literature.

With the increase in e-learning use, some research suggests that there is a concomitant rise in student disengagement, lack of motivation, and boredom regarding e-learning systems (Alsubhi et al., 2019; Khaleel et al., 2017; Prensky, 2005). Student engagement has been a topic of discussion for decades (Chickering & Gamson, 1987; Education Commission of the States, 2007; Finn, 1993; Fredricks et al., 2004; Hess & Takanishi, 1974; Nafukho & Chakraborty, 2014; Summerlee & Murray, 2010). The Education Commission of the States (2007) provided five areas in which schools may support students and improve student engagement: feeling successful (competency), feeling valued (belonging), feeling needed (usefulness), feeling empowered (potency), and feeling encouraged and hopeful (optimism).

Fredricks et al. (2004) divided engagement into three categories: behavioral, emotional, and cognitive. Behavioral engagement is student participation in academic, social, or extracurricular activities and is essential for positive student outcomes. These authors describe emotional engagement as creating an attachment between the student and the institution which in turn, affects the student's desire to do tasks. Emotional engagement includes both positive and negative feelings and attitudes with instructors, peers, academics, and the institution. Cognitive engagement is the amount of investment the student feels to understand complex concepts and grasp difficult skills (Fredricks et al., 2004).

To improve student engagement in online courses, researchers have examined strategies that improve engagement in face-to-face courses (Beffa-Negrini et al., 2002). Chickering and Gamson (1987) presented seven principles of good practice in face-to-face undergraduate education based on research of good teaching and learning in higher education. These authors state that the following elements are needed for improved learning: (a) faculty/student interaction; (b) student/student collaboration; (c) active learning activities; (d) prompt feedback; (e) emphasis on time on task; (f) expectations clearly communicated; and (g) respect for varied talents and ways of learning (Chickering & Gamson, 1987).

Nafukho and Chakraborty (2014) identified four types of interactions in the literature that are directed at student engagement in online courses, which include: (a) student/faculty communication; (b) student/content interactions, the students' accessibility to course information; (c) technology/student interactions, the students' ability to navigate the technology that delivers content; and (d) student/student communications. These authors proposed five student engagement strategies necessary for online learning: (a) create and maintain a positive learning environment; (b) build a learning community; (c) give timely, consistent feedback; (d) use appropriate technology for content delivery; and (e) provide a good support system. They state that a positive learning environment includes activities that promote healthy competition and critical thinking. A learning community demonstrates the following behaviors: collaboration, active participation, synchronized and asynchronized communications, and peer feedback. Consistent, timely feedback consists of providing detailed cognitive feedback within a “couple of weeks” of the assignment’s submission (p. 795). Using appropriate technology involves the selection of platforms best suited for the content as well as including easy to follow instructions. A good support system builds student confidence and would include resources that are easily accessed, including any additional resources that could be helpful for the student (Nafukho & Chakraborty, 2014).

While engagement strategies in a traditional classroom setting are similar to what research has found is needed to engage students in an online setting, most educators agree that different teaching methods are required for online/distance/e-learning (Marinoni et al., 2020; Clark & Mayer, 2016). The use of multimedia has become a popular method to transform conventional face-to-face lectures into content suitable for an online environment (Li et al., 2013). Multimedia presentations enhance problem-solving skills, motivate students to learn, improve learning outcomes, and increase student retention (Alessi & Trollip, 2001; Kiili, 2005; Li et al., 2013; Liu et al., 2009; Neo & Neo, 2010; Neo et al., 2008; Reeves, 1998). A well-designed, interactive, multimedia experience engages learners and results in higher retention and better learning outcomes (Alessi & Trollip, 2001; Kiili, 2005; Li et al., 2013; Mayer, 2021; Neo & Neo, 2010; Neo et al., 2008; Reeves, 1998). Mandernach (2009), Liu and Elms (2019), and Liu et al. (2017) found that students felt more engaged when multimedia presentations were included in class content.

Clark and Mayer (2016) considered games a unique type of multimedia where the goal of the game is to “provide learning experiences that are motivating, engaging, and effective” (p.

18). Mayer (2014a, 2021) and Clark and Mayer (2016) defined multimedia as using a combination of words (spoken or written text) and pictures (photos, videos, animations, etc.) to deliver content to learners to promote learning. Alessi and Trollip (2001) classified games as a special form of multimedia known as hypermedia which Vaughan (2014) defined as “a structure of linked elements through which users can navigate interactive media” (p. 458). Hypermedia, especially when used in a gaming environment, supports learning strategies such as metacognition, searching and navigating, learner orientation, encoding, recall, comprehension and application, cognitive mapping, coaching and cueing, collaboration, etc. as well as enhancing learner motivation (Alessi & Trollip, 2001).

It has been proposed that using game-based mechanics, aesthetics, and thinking (gamification) might be a solution to re-engaging students in e-learning (Deterding et al., 2011; Huda et al., 2018; Kapp, 2012; Prensky, 2005; Strmecki et al., 2015). The purpose of digital games/gamification in instructional content is to engage and motivate the learner and to provide effective learning experiences (Clark & Mayer, 2016; Kapp, 2012; Prensky, 2005). Prensky (2005) considers game playing as “possibly the most engaging pastime in the history of mankind” (p. 101).

Games include many of the same engagement strategies mentioned previously by Chickering and Gamson (1987), Fredricks et al. (2004), and Nafukho and Chakraborty (2014). Prensky (2005) stated that games include opportunities for learners to get practice and feedback, learn by doing, and learn from their mistakes. Prensky also stated that games provide the learner the possibility for goal-oriented learning, discovery learning and guided discovery, task-based learning, question-led learning, situated learning, role playing, constructivist learning, multisensory learning, learning objects, coaching, and intelligent tutors (2005). Gee and Hayes

(2010) stated that in games, people are no longer spectators, but actively involved, people may easily collaborate, and games include the need for complex language, thinking, and problem-solving skills. Gee (2007) said that video games encourage active, critical thinking; risk-taking in a safe environment; additional time spent on-task; the gain of tacit knowledge; learning by discovery; increased capability to transfer knowledge; and becoming part of an affinity group. Kapp et al. (2014) listed feedback, interactivity, and freedom to fail as some of the foundational elements of gamification. Kapp (2012) stated that games may involve conflict, competition, and cooperation.

Educational gaming is gaining in popularity; according to Adkins (2019) the use of educational games grew at a rate of 15.4% in higher education in 2018. In the same year, the global revenues for serious or educational games were $2.4 billion and are expected to exceed $24 billion by 2024 (Adkins, 2019; “Global $2.4 bn game-based learning market”, 2019). Even with the continued rise in use of games in education, there are still those who feel that games, in any form, have no educational value and claim there has been little empirical evidence to prove otherwise (Botturi & Loh, 2008; Gee, 2007; Mayer, 2014c).

Gee (2007) suggested that if people are playing a video game so that they are learning actively and critically, they then have the capability to see and act on the world in a new way, to associate and work with a new social group, to create new ways to learn and problem solve, and to understand how societal connections are made. Good video games may empower learners, increase problem-solving skills, and increase understanding through system thinking and experiences (Gee, 2013). McGonigal (2011) also believed that good games may have both personal and societal implications, such as improving our creativity, self-efficacy, and collaboration skills. McGonigal also states that gaming makes people more optimistic and helps them develop a growth mindset which increases perseverance when they initially fail at a task (McGonigal, 2011). Prensky (2005) stated that "computer games can provide a new way to motivate today's students to learn" (p. 97).

Kapp et al. (2014) claimed that gamification is appropriate when it is used to create interactivity, encourage engagement, allow for deep thought and reflection, positively change behavior, and provide opportunities for authentic practice. Kapp (2012) stated that games provide opportunities for distributed practice, scaffolding, failing in a safe environment, and cognitive apprenticeship.

Prensky (2005) wrote that there are five levels of learning in games that apply to all players in all age groups. In level one, players learn how to do something which may be game-specific, such as learning the moves of the game, or it may be non-game-specific skills, such as how to parallel process or multitask. Players learn in level two what to do in a game or, in other words, the rules which allow players to compare the rules of the game to real life and to discover the consequences when those rules are broken. In level three, players learn the strategy of the game or why an action is taken. Real life lessons from this level include cause and effect, long-term versus short-term gains, the benefit of persistence, etc. Players learn the context of the game in level four, meaning that they learn to understand both the game world and the real world. In both worlds, learners identify the big ideas common to each, such as right versus wrong and victory versus defeat. In the fifth and final level, players learn when and whether to make value-based or moral decisions. These levels are the how, what, why, where, and when of game learning and apply, for the most part, to all game players of any age (Prensky, 2005).

In addition to games motivating learners, engaging students, expanding cognitive capabilities, improving attitudes, and improving learning outcomes, some research indicates that games also improve self-efficacy (Clark et al., 2016; Gee, 2007, 2013; Kapp, 2012; Kapp et al., 2014; McGonigal, 2011; Ozturk & Korkmaz, 2020; Prensky, 2005). Bandura (1997) stated that self-efficacy, the "belief in one's power to produce given levels of attainment" (p. 382), plays a role in both affective and cognitive domains, regulating emotions, such as anxiety, depression, and stress. Self-efficacy also plays a role in influencing motivation, engagement, academic performance, and attitudes (Bandura, 1997; Malone, 1981; Schunk, 1989). This study will examine self-efficacy rather than self-confidence, because according to Bandura (1997) confidence is a "nondescript term that refers to strength of belief but does not specify what the certainty is about", whereas self-efficacy affirms capability in a person's "power to produce given levels of attainment" (p. 382). Games also affect the affective and cognitive domains (Bodzin et al., 2020; Budasi et al., 2020; Cagir & Oruc, 2020; Randel et al., 1992; Robinson et al., 2020; Vankus, 2021). Bodzin et al. (2020) found that virtual reality games had a positive effect on student engagement and flow, the "state where people are so involved in an activity that nothing else seems to matter" (Csikszentmihalyi, 1990, p. 4). Budasi et al. (2020) found that games had a positive effect on motivation. Cagir and Oruc (2020) and Randel et al. (1992) found that lessons including games have a positive effect on student learning outcomes in some subject areas. In their meta-analysis, Robinson et al. (2020) found that physiologically adaptive games positively affected flow, enjoyment, fun, immersion, and usability, as well as help participants reach threshold physiological responses, such as target heart rate or breathing rate. A systematic review of research by Vankus (2021) concluded that game-based learning positively affected student motivation, engagement, attitudes, enjoyment, flow, and attention. Studies have shown that games also positively impact self-efficacy (Hung et al., 2014; Say & Bag, 2015).

Statement of the Problem

Mayer (2021) addressed the question of "What elements in games promote learning?" by classifying games as multimedia. By doing so, games and gamification may be studied through the lens of the Cognitive Theory of Multimedia Learning (CTML) and its associated multimedia design principles (Clark & Mayer, 2016; Mayer, 2014a, 2021). These principles have been studied extensively in more conventional multimedia material such as slide presentations and videos; however, little evidence-based research has been done about their application in a game environment (Clark & Mayer, 2016; Mayer, 2014c).

Games, by their very nature, threaten to violate the coherence principle by adding extraneous elements, such as background music and sound effects to augment the narrative of the video game experience (Zehnder & Lipscomb, 2006). Mayer (2014c) stated that game elements, such as aesthetics, storylines, and new aspects of the game are used to make the game more interesting and inviting. Mayer (2014c) also stated that distracting game features might cause an increase in extraneous cognitive processing, thereby causing the learner to use more of their cognitive processing capacity on elements not related to the learning objectives, decreasing their ability to mentally represent the content related to the learning objectives. However, because games have been found to be engaging, using a game as part of the learning content might more fully engage the student and counteract the effects of the added extraneous cognitive load (Cai & Gu, 2019; Colliot & Jamet, 2018; Kapp et al., 2014; Prensky, 2005). Mayer (2014c) stated there is little empirical research on whether violating multimedia design principles in a game-based environment has the same effect on learning as when they are violated in a multimedia learning environment. This study will examine the coherence principle and whether the research demonstrating the negative effects of its violation also apply in game-based learning.

Purpose of the Study

The first purpose of this experimental, baseline group design quantitative study was to examine the effects of game-based learning and the coherence principle on student outcomes (module posttest scores) for students enrolled in a first-year seminar course (ROAR 1199) at Idaho State University (ISU) during the fall 2021 semester. The second purpose of this study was to measure the effects of game-based learning on perceived self-efficacy scores using the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey. The third and final purpose of this study was to determine the correlation in the sample between perceived self-efficacy posttreatment and student outcomes in the using information responsibly module of the information literacy portion of the ROAR 1199 course.

While all learning games have some form of extraneous content, this study examined violations of the coherence principle by comparing three experimental conditions. The multimedia tutorial (MT) treatment group served as the baseline group and received a multimedia tutorial presentation that has no game elements and therefore contains no game-related, extraneous material. The less extraneous game-related content (G1) treatment group was placed in a group with a virtual escape room game that included minimal game-related, extraneous material including timer background music and clickable images used as code puzzles. The more extraneous game-related content (G2) treatment group was placed in a group that included a slightly different version of the same game. This version of the game had additional game-related, extraneous material, such as seductive details that included interesting but irrelevant facts about academic integrity. In all three groups, the coherence principle of multimedia learning was violated to varying degrees.

Research Questions

This study focused on three main research questions. The research questions are listed below.

1. Does the method of instruction (MT, G1, G2) affect the learning outcomes of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the module test?
2. Does the method of instruction (MT, G1, G2) affect self-efficacy scores from pretreatment to posttreatment of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the Using Information Responsibly Self-Efficacy Scale survey?
3. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for each of the three treatments in the study?
    a. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the MT group?
    b. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G1 group?
    c. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G2 group?

Definition of Terms

- **blended learning:** Blended learning, also called hybrid learning, was defined by Zimmer (2019) as “an educational experience which is not entirely conducted through in person class meetings, nor through purely online interactions, but which uses a combination of both of these strategies” (n. p.).

- **digital game-based learning:** Prensky (2007) stated that digital game-based learning is “any learning game on a computer or online” (p. 146).
- **e-learning:** E-learning is also known as distance learning, online learning, web-based learning, virtual learning, distance education, online education, and virtual education (Power Thesaurus, n.d.). Seaman et al. (2018) declared e-learning “uses one or more technologies to deliver instruction to students who are separated from the instructor and to support regular and substantive interaction between the students and the instructor synchronously or asynchronously” (p. 5).
- **edutainment:** “In the early years of (computer) games based [*sic*] learning, games, especially computer games designed for the education sector (or at least containing educational content), were called edutainment, a merger of the words education and entertainment” (Hildmann & Hildmann, 2011, p. 132).
- **flow:** “The state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it” (Csikszentmihalyi, 1990, p. 4).
- **games:** Salen and Zimmerman (2004) and Kapp (2012) defined a game as an enterprise with established guidelines where players engage in a hypothetical conflict or challenge, that includes interactivity and feedback, may evoke an emotional reaction, and that results in a quantifiable conclusion.
- **gamification:** Kapp (2012) defined gamification as “game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems” (p. 10).

- **hypermedia:** Vaughan (2014) described hypermedia as “a structure of linked elements through which users can navigate interactive media” (p. 458).
- **interactive multimedia:** Vaughan (2014) defined interactive media as when “the end user or viewer controls what and in what sequence the elements of multimedia are delivered” (p. 459).
- **mixed reality:** Clark (2019) wrote “In a mixed reality experience, physical and digital objects coexist and interact in real time. Mixed reality is an overlay of content on the real world, and that content is anchored to or part of it” (p. 19).
- **multimedia instructional message:** Mayer (2021) defined a multimedia instructional message as “a communication using words and pictures that is intended to promote learning” (p. 67).
- **serious games:** Serious games, also called educational games, was defined by Michael and Chen (2006) as “a game in which education (in its various forms) is the primary goal, rather than entertainment” (p. 17).
- **seductive details:** Garner et al. (1989) described seductive details as “propositions presenting irrelevant details – interesting, but unimportant, information” (p. 43).
- **self-efficacy:** Bandura (1997) stated that perceived self-efficacy is the “Belief in one’s power to produce given levels of attainment” (p. 382). He contrasts confidence as a “nondescript term that refers to strength of belief but does not necessarily specify what the certainty is about” (p. 382). Self-efficacy includes both a declaration of one’s ability to perform and the strength of one’s belief in that ability, whereas confidence refers only to strength of belief (Bandura, 1997).

- **simulation:** Kapp (2012) called simulations a “self-contained immersive environment in which the learner interacts within the environment in an attempt to learn or practice skills or knowledge” (p. 283).
- **virtual reality (VR):** Virtual reality is a “computer-simulated task environment that simulates the learner’s presence in places in the real world or in places in an imaginary world” (van Merrienboer & Kester, 2014, p. 140).

Limitations

Campbell and Stanley (1963) described eight challenges to internal validity from variables that may make it difficult to reliably assess the effect of independent variables on the experiment. The eight challenges included: history, maturation, testing, instrumentation, statistical regression, differential selection, experimental mortality, and selection-maturation interaction. Cook and Campbell (1979) added an additional four challenges: experimental treatment diffusion, compensatory equalization of treatment, compensatory rivalry by the control group, and resentful demoralization of the control group. Testing, maturation, statistical regression, differential selection, experimental mortality, and selection-maturation interaction are less applicable to this study due to its design. Because there is no content pretest, testing as a threat to validity for research question 1 was minimized. The testing for research question 2 is in the form of a pre/posttreatment survey for participants’ perceptions of their own self-efficacy and ability to complete the learning objectives. The self-efficacy survey did not include any content knowledge assessment and therefore, minimized any testing threat. All participants will be first-year freshmen which mitigated the threat of maturation. The threats of statistical regression, differential selection, experimental mortality, and selection-maturation interaction were minimized due to the random assignment of subjects to the three treatment groups.

History is defined as the unexpected events that may happen during the time frame of the study (Campbell & Stanley, 1963). The study spanned seven weeks from the first administration of the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey to the treatment, second administration of the UIRSES survey, and the posttest assessment. Outside events such as tutoring, library assistance, or help from the writing center may influence a student's self-efficacy and knowledge about using information responsibly. Random assignment of the participants mitigated this possible threat to internal validity.

Instrumentation refers to the differences in results that might be attributed to a lack of reliability in instruments, raters, or observers (Campbell & Stanley, 1963). The UIRSES self-efficacy survey instrument was created by the researcher and was examined for content validity, consistency, and reliability using a panel of SMEs. The posttest assessment was also created by the researcher and vetted by SMEs.

Experimental treatment diffusion takes place when participants in the different treatment groups may communicate with each other, and information intended for one specific group may be learned by participants in the other groups (Cook & Campbell, 1979). Participants from the same section of the course were randomly assigned to the treatment groups creating the opportunity for information to be transferred between groups. The using information responsibly module of the information literacy portion of the course was asynchronous, thereby diminishing the opportunity for information to be disclosed by the instructor librarian among the students. The using information responsibly module did not include discussion groups reducing the possibility for students to disclose information to each other.

Compensatory equalization of treatment appears when an inequality exists due to the experimental group receiving treatment (Cook & Campbell, 1979). The MT group received the using information responsibly material in a multimedia tutorial format, whereas the G1 and G2 treatment groups received the same information via a game-based format. This equalized the three groups in terms of instructional content.

Compensatory rivalry by the control group develops when participants are made aware of who has been assigned to what group and the participants in the control group may feel they are at a disadvantage and work harder to minimize the difference (Cook & Campbell, 1979). Unless required, the list of participants in each group remained private and only known by the instructor, the researcher, and the instructor librarian in each course.

Resentful demoralization of the control group arises when the control group participants become resentful and demoralized because they feel that they are receiving a less desirable treatment than the other groups (Cook & Campbell, 1979). The MT group received the same using information responsibly content as the G1 and G2 treatment groups just in a different format (tutorial versus game-based). Participants were not notified of which treatment group they had been assigned to.

Delimitations

Bracht and Glass (1968) identified 12 factors that might potentially affect external validity in experiments. These 12 factors are categorized into two main groups: population (sample and target groups) and ecological (environment). The two population-based challenges include experimentally accessible population versus target population and interaction of personological variables and treatment effects. The 10 ecological-based challenges include: describing the independent variable explicitly, multiple-treatment interference, the Hawthorne Effect, novelty and disruption effects, experimenter effect, pretest sensitization, posttest sensitization, interaction of history and treatment effects, measurement of the dependent variable, and interaction of time of measurement and treatment effects (Bracht & Glass, 1968). Due to the random assignment of each participant to only one group and that no pretest was administered in this study, interaction of history and treatment effects, multiple-treatment interference and pretest sensitization were less applicable to this study.

Experimentally accessible population versus target population may occur when the results of the experiment from the group's studies are generalized to the general population (Bract & Glass, 1968). The target population for this study was university students taking an information literacy course. The accessible population were the students enrolled in the ROAR 1199 course at ISU in the fall 2021 semester. Since this is a first-year seminar course, a variety of majors might potentially participate. Generalizing this study’s findings to a broader population may not be possible due to various obstacles. The ROAR 1199 course is a first-year seminar course and only freshmen who have not taken the course before were included in the study. Other information literacy courses may not be limited to freshmen; therefore, it might not be possible to generalize the findings to the target population due to age, maturity, years attending college, and game play experience. This may make it difficult to generalize the results to students attending other institutions. This threat was reduced by randomly assigning participants into the three treatment groups to ensure as much demographic and socio-economic diversity in each group as possible. Due to the design of the study and the mitigation of this threat, results may be generalized to Idaho State University.

Interaction of personological variables and treatment effects occur when participant traits limit the generalizability of study findings to larger populations because of differences in the variables between the sample and target groups (Bracht & Glass, 1968). Because the study institution is not representative of the national norms for demographics and game playing experience, generalizing the results to broader populations may not be possible. Participants were randomly assigned, dispersing the participants traits into the three treatment groups and minimizing this threat as much as possible.

The “Describing the independent variable” threat explicitly occurs when all the details describing the experimental design of the study are not included so that the results may be replicated (Bracht & Glass, 1968). All the details of the experimental design of this study were included below in Chapter III, Methods.

The Hawthorne Effect occurs when participants’ behaviors are influenced by their perception of the treatments and cause behaviors that would not occur in a non-experimental environment (Bracht & Glass, 1968). Each participant was informed of the study before the treatment was administered which introduced the potential for their responses to be influenced by their perceptions. This threat was minimized by not disclosing the composition or aim of the study to its participants.

Novelty and disruption effects is the uniqueness or newness of the treatment influencing the findings of the experiment (Bracht & Glass, 1968). This threat was minimized by the incorporation of the treatments as regular class assignments.

Experimenter effect develops when the characteristics, behaviors, or expectations of the experimenter influences the behavior of the participants (Bracht & Glass, 1968). The using information responsibly part of the information literacy portion of the ROAR 1199 course was predominantly asynchronous and online. The Moodle learning management system served in the role as instructor and therefore limited this threat.

Posttest sensitization happens when the posttest becomes an additional learning experience and gives false positive results of the treatment (Bracht & Glass, 1968). This threat was unlikely because all participants received the same posttest regardless of the treatment.

"Measurement of the dependent variable" is the ability to generalize the results and is contingent on the dependent variables and the instruments used to measure these variables (Bracht & Glass, 1968). Student outcomes were measured by the using information responsibly posttest assessment and were tied to the subject matter addressed in the treatments. Because student outcomes were measured using a posttest only design, participants' prior knowledge of the topic was unknown. Self-efficacy was measured using the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey and was limited to the using information responsibly module of the course, therefore, limiting the generalization of the findings to the subject of using information responsibly.

Interaction of time of measurement and treatment effects occurs when the results from the measurement of the dependent variable are limited to the time of its measurement (Bracht & Glass, 1968). Administration of the treatments, the UIRSES survey (pretreatment and posttreatment), and the posttest was done asynchronously; however, access to the treatments, the posttreatment survey, and the posttest assessment was limited to a one-week window (week nine) during the semester. The access to the pretreatment UIRSES survey was limited to a four-week window (weeks five through eight) during the semester. The time of measurement of the treatment, posttreatment survey, and the posttest was controlled by the researcher, meaning that the participant was directed to the posttreatment survey after completing the treatment via the Moodle learning management system where a link to the posttreatment survey appeared after the participant completed the treatment. The participant was then directed to the posttest assessment via the Moodle learning management system where a link to the posttest assessment appeared only after the participant completed the posttreatment survey.

Significance of the Study

There have been multiple calls for additional evidence-based experimental research on multimedia learning and game-based learning (Honey & Hilton, 2011; Mayer, 2014c, 2021). Mayer (2021) stated the need for not only expanding the scope of experiments from short-term studies with immediate tests in laboratory environments to longer-term studies in authentic learning and training environments, but also the need to study the different multimedia design principles in additional types of media, such as games. Bell (2018) stated that the cases he studied lacked the longitudinal or quantitative data to declare any significance in a strictly statistical sense. This study added to the literature because it was conducted in an authentic learning environment using quantitative data and focused on studying the coherence principle in both a multimedia environment and in a game-based learning environment. The results of this study offered added evidence-based, experimental research of the effects of the method of instruction (MT, G1, G2) on student learning outcomes. Furthermore, this study offered further additional information on the effects of the method of instruction (MT, G1, G2) on self-efficacy. Lastly, this study examined the relationship between perceived self-efficacy scores posttreatment and the posttest assessment in each of the three treatment groups.

As detailed in the next chapter, previous research has not addressed whether game-based learning which includes extraneous elements, and therefore violates the coherence principle, is an effective learning environment. This study added a critical element to that literature by testing increasing extraneous loads and game elements in both multimedia and game-based environments.

CHAPTER II

Review of the Literature

This literature review begins with an overview of e-learning and its effect on motivation, engagement, learning outcomes, student attitudes and satisfaction, student retention and graduation rates, and self-efficacy. This is followed by a discussion of multimedia learning, its design principles, and their effect on essential, generative, and extraneous processing; as well as its effect on motivation, engagement, learning outcomes, student attitudes and satisfaction, student retention, and self-efficacy. After the discussion on multimedia learning, game-based learning literature is examined along with its effects on motivation, engagement, learning outcomes, student attitudes and satisfaction, student retention, and self-efficacy. Lastly, the literature on the relationship between self-efficacy and learning outcomes is reviewed.

Relevant literature was identified using the institution's article databases, including Academic Search Complete, ACM, Computer Source, Computers & Applied Sciences Complete, Education Research Complete, ERIC, Google Scholar, IEEE Xplore, JSTOR, MathSciNet, ProQuest Dissertations and Theses, Psychology and Behavioral Sciences Collection. In most cases results were limited to the previous 10 to 20 years depending on the topic, with exceptions for seminal research and notable research that was important for contextual purposes. Search terms used included combinations of the following key words: e-learning, distance learning, online learning, gamification, game-based learning, educational games, serious games, self-efficacy, learning outcomes, student retention, student attitudes, student satisfaction, graduation rates, engagement, motivation, education, multimedia learning, coherence principle, seductive details, Self-Efficacy Theory, and Cognitive Theory of Multimedia Learning (CTML). The relevant research has been primarily interpreted through the lens of the CTML and SET.

Theoretical Basis

Cognitive Theory of Multimedia Learning (CTML) and Self-Efficacy Theory (SET) are the theoretical frameworks that were used for this study. Learning outcomes were viewed through the lens of CTML, and self-efficacy was viewed through the lens of SET.

Cognitive Theory of Multimedia Learning (CTML)

The Cognitive Theory of Multimedia Learning (CTML) is built on the following criteria: theoretical plausibility, meaning it is based in current cognitive science principles regarding learning; testability, meaning its predictions may be tested scientifically; empirical plausibility, meaning it conforms with other empirical research on multimedia learning; and applicability, meaning it is important to the improvement of multimedia learning content (Mayer, 2014b). CTML is founded on three assumptions: dual channels, limited capacity, and active processes. The dual channel assumption is based on Paivio's dual coding theory (2007) and Baddeley's model of working memory (2007). It states that learners have two pathways in which they process information: a path for visual/spatial/nonverbal information and a path for auditory/verbal information (Baddeley, 2007; Mayer, 2014b; Mayer & Moreno, 2003; Paivio, 2007). CTML takes a hybrid approach and defines visual material as pictures, animations, video, on-screen text and auditory material as narration and background sounds (Mayer, 2014b). The limited-capacity assumption says that each channel may only process a finite amount of material at one time (Baddeley, 2007; Mayer, 2014b; Paas & Sweller, 2014). The average memory span may only hold five to seven chunks of material at once (Mayer, 2014b; Schnotz, 2014). The active processing assumption states that learners employ cognitive processing to incoming information to help them make sense of the information (Mayer, 2014b). To actively process the information, the learner must pay attention to relevant incoming material, organize it into a meaningful form, and integrate it with their prior knowledge (Mayer, 2014b).

There are three parts of memory where information is processed/stored: sensory memory, working memory, and long-term memory (Mayer, 2014b). Information is first received either in the visual or auditory channel by the learner in sensory memory where it is held very briefly, less than one second for visual information and less than three seconds for auditory information (Mayer, 2014b; Schnotz, 2014). As the information is brought into sensory memory, there is a change in knowledge representation from the external representation of spoken words or pictures to a sensory representation of sounds or visual images to an internal representation in working memory (Mayer, 2014b). The selection of relevant words and pictures is processed cognitively as the information passes through sensory memory into working memory. While the selected words and images are being held in working memory in their respective channels, the information is organized into a structured representation of either a verbal or pictorial model depending on the type of information. The words and images are integrated by connections formed between the verbal and pictorial models as well as relevant knowledge from long-term memory. Lastly, the information is encoded and moved from working to long-term memory (Mayer, 2014b). These processes occur multiple times through the presentation of multimedia content (Mayer, 2014b; Schnotz, 2014).

There are three types of demands placed on a learner's cognitive processing during learning: extraneous load, essential (intrinsic load), and generative (germane load) (Mayer, 2014b; Mayer & Moreno, 2003; Paas & Sweller, 2014). Extraneous processing is irrelevant to the instructional objective, essential processing is intended to mentally portray the presented information in working memory and is determined by the complexity of the information, and generative processing is meant to make sense of the presented information and is determined by the learner's motivation to learn (Mayer, 2014b).

There are multimedia principles that studies have shown help to reduce extraneous processing, manage essential processing, and promote generative processing (Clark & Mayer, 2016; Mayer, 2014b, 2021; Mayer & Moreno, 2003). The multimedia principles that reduce extraneous processing include coherence, signaling, redundancy, spatial contiguity, and temporal contiguity (Clark & Mayer, 2016; Mayer, 2021; Mayer & Fiorella, 2014; Mayer & Moreno, 2003). The coherence principle states that eliminating irrelevant material improves learning, including interesting but irrelevant or unneeded words, pictures, symbols, and music. The signaling principle states that adding cues to highlight essential material may improve learning. The redundancy principle states that adding printed text to graphics and narration does not improve learning. The spatial contiguity principle states that placing images and their corresponding text near each other on the page or screen may improve learning. The temporal contiguity principle states that presenting text and images at the same time may improve learning (Clark & Mayer, 2016; Mayer, 2021; Mayer & Fiorella, 2014; Mayer & Moreno, 2003).

The multimedia principles that manage essential processing include segmenting, pretraining, and modality (Clark & Mayer, 2016; Mayer, 2021; Mayer & Moreno, 2003; Mayer & Pilegard, 2014). The segmenting principle states that presenting content in smaller chunks is better for learning than a continuous block of content. The pretraining principle states that providing prior instruction on key parts of the material allows for deeper learning. The modality principle recommends using audio rather than on-screen text to accompany images to improve learning (Clark & Mayer, 2016; Mayer, 2021; Mayer & Moreno, 2003; Mayer & Pilegard, 2014).

The multimedia principles that promote generative processing include personalization, voice, image, embodiment, immersion, and generative activity (Clark & Mayer, 2016; Mayer, 2014e, 2021). The personalization principle suggests that using words in a conversational style rather than a formal style improves learning (Clark & Mayer, 2016; Mayer, 2014e, 2021). The voice principle suggests that learning is improved when the narration is in an appealing human voice rather than a machine generated one (Mayer, 2014e, 2021). The image principle states that adding an image of the instructor or the narrator to the screen does not improve learning (Mayer, 2014e, 2021). The embodiment principle suggests that on-screen agents should display human-like movements (Clark & Mayer, 2016; Mayer, 2014e, 2021). The immersion principle states that 3D environments do not necessarily promote learning over 2D environments (Mayer, 2021). The generative activity principle suggests that having generative learning activities, such as mapping, drawing, enacting, etc., promotes learning (Mayer, 2021).

Self-Efficacy Theory (SET)

Bandura (1994) defined perceived self-efficacy as people's beliefs about their ability to perform at levels that influence events that affect their lives. These beliefs control people's thoughts, feelings, motivations, and behaviors (Bandura, 1992, 1994, 1997). People with a strong sense of efficacy tend to look at difficult tasks as a challenge to be overcome and expect to be successful. They tend to set challenging goals and are very committed to completing them. They also tend to quickly recover from setbacks/failures and consider the reason for the setback/failure is a lack of effort or knowledge/skills. They will work to acquire the needed knowledge/skill and increase their effort on the next attempt. People who have a weak sense of efficacy tend to shy away from difficult tasks and tend to expect themselves to fail. They tend to give up quickly in difficult situations and lose faith in their ability to complete the task (Bandura, 1994, 1997).

A person's efficacy belief system may be cultivated by four main sources of influence (Bandura, 1994, 1997). The most effective way to develop a strong sense of self-efficacy is through overcoming obstacles through perseverance (Bandura, 1994). The second way to develop self-efficacy is to see people like oneself be successful in reaching a goal (modeling) (Bandura, 1994, 1997). The greater the perceived similarity to the model, the greater the potential effect of the model's successes or failures (Bandura, 1994). The third way to improve self-efficacy is through social persuasion or being told that you may succeed. This tends to lead to greater effort and helps a person work through self-doubts. The final way to increase efficacy is to reduce stress and increase positive emotional reactions. It is not the level of these reactions, but how they are perceived and interpreted that is important (Bandura, 1994).

These effects are determined by four primary processes: cognitive, motivational, affective, and selection (Bandura, 1992, 1994, 1997). Self-efficacy affects cognitive processes by influencing goal challenges people set and their commitment to achieving those goals; how they visualize completing those goals, successfully or unsuccessfully; their ability to predict events and how they control events that affect their lives; and their ability to stay on task when facing situational demands, failures, and setbacks that have serious impact on their lives (Bandura, 1992, 1994, 1997). Self-efficacy effects motivational processes by people either attributing failure to a lack of effort which may be overcome by increasing effort or a lack of ability which tends to be more difficult to overcome; by people acting on their beliefs about what they may do and their beliefs on the likely outcome; and by people seeking self-satisfaction through reaching important goals (Bandura, 1992, 1994). Self-efficacy influences motivation and goals by determining what goals people set for themselves and their level of difficulty, how much effort they put forth to achieve those goals, and how long they persist when they face challenges in achieving those goals (Bandura, 1992, 1994). Self-efficacy affects affective processes by influencing how much anxiety and depression a person feels when experiencing challenges (Bandura, 1992, 1994, 1997). The lower a person's belief in their ability to exercise control over a situation, the higher their feelings of depression and anxiety (Bandura, 1992, 1994). Self-efficacy influences selection processes by affecting the activities and environments they choose. People will avoid activities and situations they believe they are unable to handle which may influence their careers, social networks, interests, and competencies (Bandura, 1992, 1994).

E-learning

Clark and Mayer (2016) defined e-learning as "instruction delivered on a digital device that is intended to support learning" (p. 7). E-learning may be synchronous, which is instructor led; asynchronous, which is designed for the individual learner and self-paced; or hybrid, which is a combination of face-to-face and virtual learning (either asynchronous or synchronous) (Clark & Mayer, 2016; Zimmer, 2019). E-learning is also referred to as distance learning, online learning, web-based learning, virtual learning, distance education, online education, and virtual education (E-learning, n.d.).

This review of the literature found 18 studies that have found e-learning to be more effective than a traditional face-to-face learning environment (Ajayi & Ajayi, 2020; Bradley et al., 2017; Canty et al., 2019; Chen et al., 2010; Clayton et al., 2010; Dobbs et al., 2017; Fidalgo et al., 2020; Hanney & Newvine, 2006; Kurt & Yildirim, 2018; Landrum, 2020; Maki et al., 2000; Malkawi et al., 2020; Means et al., 2010; Peck et al., 2018; Rasmussen et al., 2014; Robinson & Hullinger, 2008; Tseng & Walsh, 2016). It also found four studies that have found no difference in effectiveness between e-learning and a traditional classroom (Horspool & Lange, 2012; Rasmussen et al., 2014; Sitzmann et al., 2006; Summers et al., 2005). Ten studies found that a traditional learning environment is more effective than an e-learning environment (Alhamwi et al., 2020; Carver & Kosloski, 2015; Clayton et al., 2010; Dobbs et al., 2017; Elbasuony et al., 2018; Maki et al., 2000; McDonough & Marks, 2002; Rasmussen et al., 2014; Summers et al., 2005; Watkins et al., 2019).

Growth and Longevity

In their research, Seaman et al. (2018) reported that students studying on campus has steadily declined in the United States (U. S.) since 2012. Public institutions saw a decrease of 4.5%, private non-profit institutions saw a decrease of 4.2 %, and private for-profit institutions saw a decrease of 44.1% (Seaman et al., 2018). Of the students enrolled in distance courses just under half (2,902,756) were taking distance courses exclusively (Allen & Seaman, 2017). In 2016, only 1.5% of the students enrolled in distance courses exclusively were international students (Seaman et al., 2018).

The growth and longevity of e-learning in the U. S. is not limited to a specific institution type. Allen and Seaman (2017) reported the growth of undergraduate distance students between 2012 and 2015 included an increase of 29.8% in the public four-year or above sector, 460.2% in the private two-year non-profit sector, and 41.7% in the private four-year or above non-profit sector, with all other sectors experiencing a decrease. The growth in graduate distance students during the same period was 20.4% in the public four-year or above sector and 33% in the private non-profit four-year or above sector (Allen & Seaman, 2017).

Growth in distance learning is not limited to the United States. During the period from 2013 to 2018, distance learning grew globally: Africa, 16.4%; Latin America, 9.7%; Asia, 8.9%; Eastern Europe, 8.4%; and Central Europe, 6.3% (Wotto, 2020). The current projected annual growth between 2018 and 2023 for those regions is 10.26% (Wotto, 2020). Canada saw a 10%

increase in online course registrations between 2018 and 2019 and a 71% increase was anticipated between 2019 and 2020 (Johnson et al., 2019).

The move to e-learning, especially during the COVID-19 pandemic, has necessitated a closer examination of e-learning and its effectiveness. Although our understanding of e-learning is incomplete, this mode of teaching is here to stay (Allen & Seaman, 2015, 2017; Bell, 2018; C2i, 2020; Johnson et al., 2019; Seaman et al., 2018; Wotto, 2020).

Multimedia Learning

Mayer (2021) defined multimedia learning as "the presentation of material using both words and pictures, with the intention of promoting learning" (p. 6). Words are content in verbal form (printed or spoken text) and pictures are content in pictorial form (graphics, photos, illustrations, graphs, maps, etc.) (Clark & Mayer, 2016; Mayer, 2014d, 2021).

Wankel and Blessinger (2013) stated that "In teaching and learning, they offer promising and innovative ways to create more interesting and enjoyable academic environments and offer more meaningful and authentic ways to better engage the senses of learners" (p. 3). Mayer (1997) stated that using multimedia in lessons not only benefits the students, but the educators as well by providing additional instructional options, more effective learning, and more efficient use of their time. This review of literature found 10 studies that stated including multimedia instruction in lessons enhances problem-solving skills, motivates students to learn, improves learning outcomes, increases retention, and engages learners (Alessi & Trollip, 2001; Clark & Mayer, 2016; Kiili, 2005; Li et al., 2013; Liu et al., 2009; Mayer, 2021; Neo & Neo, 2010; Neo et al., 2008; Reeves, 1998).

Multimedia Design Principles. Mayer (2021) stated that multimedia instructional design includes 13 principles used to shape the design and organization of multimedia instructional messages. The goal of these principles is to manage essential processing, foster generative processing, and reduce extraneous processing (Clark & Mayer, 2016; Mayer, 2021).

Manage Essential Processing. Mayer (2021) stated that essential processing "refers to cognitive processing aimed at mentally representing the presented material in working memory and is caused by the complexity of the material for the learner" (pp. 51-52). When the learner's cognitive capacity is mainly engaged in essential processing, good recall learning and poor transfer learning occurs (Mayer, 2021). The segmenting, pretraining, and modality principles help manage essential processing and provide learners the opportunity to learn more deeply from multimedia instructional messages (Mayer & Moreno, 2003; Mayer & Pilegard, 2014).

This review of literature found six studies that showed that managing essential processing improves student learning (Lusk et al., 2009; Mayer, Mathias, & Wetzell, 2002; Mayer, Mautone, & Prothero, 2002; Mayer et al., 2019; Moreno, 2007; Moreno & Mayer, 1999). However, it also found seven studies that failed to find improvement (Clarke et al., 2005; Crooks et al., 2012; Lee & Mayer, 2018; Mayer, Mathias, & Wetzell, 2002; Mayer, Mautone, & Prothero, 2002; Mayer et al., 2019; Moreno & Mayer, 1999).

Mayer and Pilegard (2014) defined segmenting as a multimedia message "presented in learner-paced segments rather than as a continuous unit" (p. 340). Segmenting allows the presentation of materials to be slowed down to allow the learner to properly process the information (Mayer & Pilegard, 2014).

Moreno (2007) conducted two experiments using pre-service teachers enrolled in an introductory educational psychology course at a southwestern U. S. university. The first experiment used 151 participants (111 females, 40 males). Thirty participants were randomly assigned to each of the following groups: control (C), signaling/no segmentation (SI/no-SE), and no signaling/segmentation (no-SI/SE) groups. Thirty-two participants were randomly assigned to the no signaling/no segmentation (no-SI/no-SE) group and 29 participants were randomly assigned to the signaling/segmentation (SI/SE) group. Group C scored significantly higher than the rest of the groups on the retention-theory test and significantly lower than groups SI/no-SE, no-SI/SE, and SI/SE on the transfer test. In addition, group SI/SE scored higher than group no-SI/no-SE and marginally higher than group SI/no-SE on the retention-theory test. SE groups scored significantly higher than no-SE groups on the retention-exemplar test. There were no differences between groups SI and no-SI and no significant interaction between SI and SE. Groups no-SI/SE and SI-SE gave significantly lower cognitive load ratings than group no-SI/no-SE. In the second experiment, Moreno (2007) studied 143 participants (104 female, 39 male) in the same course and same institution. There were 29 participants in groups C and no-SI/SE, 28 in group SI/no-SE, 27 in group SI/SE and 30 in group no-SI/no-SE. Group C scored significantly higher than the rest of the groups on the retention-theory test and significantly lower than groups SI/no-SE, no-SI/SE and SI/SE on the transfer test. In addition, SI/SE scored marginally higher than groups no-SI/no-SE and SI/no-SE on the retention-theory test and groups SI/SE and no-SI/SE scored significantly higher than group no-SI/no-SE on the transfer test. SE groups were able to remember significantly more relevant information from the animation than no-SE groups. There were no differences between groups SI and no-SI and no significant interaction between SI and SE. Group C gave significantly lower affective ratings than groups no-SI/no-SE and SI/no-SE and marginally lower than group SI/SE. Groups no-SI/SE and SI/SE gave significantly lower cognitive load ratings than groups no-SI/no-SE and SI/no-SE (Moreno, 2007).

Lusk et al. (2009) studied 133 undergraduate students (59 male, 74 female) who were randomly assigned into one of four Working Memory Capacity (WMC) groups: low WMC/non-segmenting instruction, low WMC/segmenting instruction, high WMC/non-segmenting instruction, and high WMC/segmenting instruction. The WMC effect was confirmed for recall as high WMC students recalled more than low WMC students resulting in a significant main effect for WMC. High WMC students generated more valid historical interpretations than low WMC students, resulting in a significant main effect for WMC. A significant main effect was found for segmentation for recall as well. The WMC and segmentation interaction reveals the proposed differential effect where the significant interaction for recall appears to be based on participants with low WMC in the non-segmented instruction group recalling less historical inquiry and Summarizing, Contextualizing, Inferring, and Monitoring (SCIM) strategy components than participants in any other condition. There was also a significant interaction for application participants with low WMC in the non-segmenting instruction group applying less historical inquiry and SCIM strategy components than participants in any other groups (Lusk et al., 2009).

In their research, Mayer et al. (2019) studied 99 college students (35 male, 64 female) at a U. S. university. Participants were randomly assigned to the following groups: large-segment/voice group (24), large-segment/text group (24), small-segment/voice group (26), and small-segment/text group (25). Results found that students in the small segment groups scored significantly higher on the transfer test than those in the large segment groups. The main effect of segmenting is not qualified by a significant interaction between segmenting and modality meaning the same pattern was found with small segmenting regardless of if its words were in text or spoken form. No statistically significant difference was found between printed or spoken text for transfer test scores. There was no significant interaction involving modality and no significant effect or interactions involving modality. A significant effect for segmenting in the small segment groups was found where the small segment groups took significantly more time with the lesson than the large segment groups. There was also a significant effect for modality where the voice groups took significantly more time with the lesson than the text groups. However, there was no significant interaction between segmenting and modality. The final finding from this study was a significant effect of segmenting where the small segment groups rated the lesson as less difficult than the large segment groups (Mayer et al., 2019).

Mayer and Pilegard (2014) defined pretraining as giving the learner the opportunity to “know the names and characteristics of the main concepts” prior to training (p. 340). Pretraining gives learners prior knowledge that may be used to process the following information using less cognitive effort (Mayer & Pilegard, 2014).

Mayer, Mathias, and Wetzell (2002) performed three experiments on pretraining using participants from the Psychology Subject Pool at the University of California, Santa Barbara. The first experiment had 67 participants randomly assigned to two groups: the pretraining group (31) and the no pretraining group (36). Independent t tests were conducted on the retention test data and the transfer test data. The pretraining group scored significantly higher than the no pretraining group on the retention test and on the transfer test. The effect sizes were 0.63 for retention and 0.91 for transfer. In the second experiment, Mayer, Mathias, and Wetzell (2002) had 33 participants (16 pretraining group, 17 no pretraining group). Independent t tests were conducted on the retention test data and the transfer test data. The pretraining group scored significantly higher than the no pretraining group on the retention test and on the transfer test. The effect sizes were 0.64 for retention and 1.54 for transfer. The third experiment included 45 participants randomly assigned to three groups: pretraining (15), no pretraining (15), and post-training (15). The groups did not differ significantly on retention test scores, indicating that the groups did not differ significantly in remembering the main ideas in the explanation. However, the groups differed significantly on transfer test scores. The pretraining group performed better than the other two groups, which did not differ significantly from each other. Thus, students in the pretraining group outperformed the other students in applying what they had learned in new situations, confirming that pretraining led to deeper understanding (Mayer, Mathias, & Wetzell, 2002).

Mayer, Mautone, and Prothero (2002) studied pretraining in three experiments using participants from the Psychology Subject Pool at the University of California, Santa Barbara. In the first experiment, 28 subjects were randomly assigned to one of two groups: the modeling group (15) and the no-modeling group (13). There was no significant difference found in correctly solved problems or time taken to solve problems between the two groups. In the second experiment, Mayer, Mautone, and Prothero (2002) compared 105 participants who were randomly assigned into four groups: both-aids (23), pictorial-scaffolding (28), strategy-modeling (29), and no-aids (25). Results found that overall, students who received pictorial scaffolding solved significantly more problems than students who did not receive pictorial scaffolding. However, no significance for problem solving was found between students who received strategic scaffolding and students who did not receive strategic scaffolding. There was no significant interaction found between pictorial scaffolding and strategic scaffolding. In relation to problem solving, the no-aids group performed significantly worse than the both-aids group. No significant difference was found for time to solve problems between the pictorial-scaffolding and no pictorial-scaffolding groups. The same was found for the strategy-modeling and no strategy-modeling groups. However, there was a significant interaction between pictorial scaffolding and strategy modeling, in which pictorial scaffolding reduced solution time when there was no strategy modeling but not when strategy modeling was provided. The no-aids group took significantly more time to solve the problems than each of the other groups. In the third experiment, Mayer, Mautone, and Prothero (2002) studied 73 participants randomly assigned to one of four groups: high-spatial/pictorial-scaffolding group (18), low-spatial/pictorial-scaffolding group (20), high-spatial/no-aid group (18) and the low-spatial/no-aids group (17). Students in the pictorial-scaffolding groups correctly solved more problems than students who did not receive pictorial scaffolding. The high-spatial groups scored significantly higher than the low-spatial groups. Spatial ability was not found to interact with the instructional group. Students in the pictorial-scaffolding groups did not differ significantly from students who did not receive pictorial scaffolding in terms of time taken to solve problems. Although high-spatial students took significantly less time to solve problems than low-spatial students, spatial ability did not interact with the instructional group. Students in the pictorial-scaffolding groups correctly solved more transfer problems than students in the no-aids groups. Although high-spatial students solved significantly more transfer problems than low-spatial students, spatial ability did not interact with the instructional group (Mayer, Mautone, & Prothero, 2002).

In their research, Clarke et al. (2005) studied 20 ninth grade high school students from an independent Australian boys' school. Students were matched in pairs on mathematical ability and randomly assigned to one of two treatment groups: the sequential group (9) or the concurrent group (11). Regarding mathematics test scores, no main effects were found for the instruction group, however, there was an interaction between instructional group and spreadsheet ability where the less experienced spreadsheet group scored higher on the math test when they received sequential instruction. There was no significant difference found with the more experienced spreadsheet group. For spreadsheet test scores, there was no main effect for instructional group or spreadsheet ability. No interaction was found between spreadsheet ability and instructional group. There was a significant interaction between instructional group and spreadsheet ability where the more experienced spreadsheet group rated significantly lower cognitive load than the concurrent group (Clarke et al., 2005).

Mayer and Pilegard (2014) defined modality as words that are “spoken rather than printed” (p. 340). Modality diminishes type two essential overload by moving the verbal processing from the visual channel to the auditory channel by using narration instead of on-screen text for displaying words (Mayer & Pilegard, 2014).

Moreno and Mayer (1999) conducted two experiments using participants from the Psychology Subject Pool at the University of California, Santa Barbara. The first experiment had 132 participants randomly assigned into the following groups: concurrent animation and narration (N) group (41), on-screen text with close animation (IT) group (41), and the on-screen text with separated animation (ST) group (40). Results found for verbal recall that the N group scored significantly higher than the IT and ST groups, with an effect size of 1.00 for narration and the IT group scored significantly higher than the ST group with an effect size of 0.47 for spatial contiguity. The results for problem-solving transfer, the N group scored significantly higher than the IT and ST groups and the IT groups scored significantly higher than the ST group with an effect size of 1.06 for modality and 0.48 for spatial contiguity. For visual-verbal matching, results showed that the N group scored significantly higher than the IT and ST groups, which did not differ significantly from each other. The effect size was 1.32 for modality and 0.17 for spatial contiguity. In the second experiment, Moreno and Mayer (1999) studied 118 students. Eighteen participants were randomly assigned into the narration following animation (AN) group and 20 participants were randomly assigned into each of the following groups: concurrent narration (NN), narration preceding animation (NA), concurrent text (TT), text preceding animation (TA), and text following animation (AT). For verbal recall, results found a modality effect (0.94) where the TT and TA groups scored significantly less than each of the three narration groups. AT also scored significantly less than NN and AN but did not differ significantly from NA. The effect size for temporal contiguity was 0.20 indicating no significant interaction between modality and temporal contiguity. For problem-solving transfer, the TT, AT, and TA groups scored significantly lower than the NN, AN, and NA groups. There was a main effect for modality, with the narration groups scoring significantly higher than the text groups. There was no main effect for temporal contiguity. No significant interaction between modality and temporal contiguity was found. For visual-verbal matching, the TT group scored significantly lower than the rest of the groups. A main effect for modality and temporal contiguity was found. The effect size for modality was 0.63 and it was 0.33 for temporal contiguity. The interaction between modality and temporal contiguity was also significant (Moreno & Mayer, 1999).

In their study, Crooks et al. (2012) looked at the data from 135 students (67 female, 68 male) from a large southwestern university. Participants were randomly assigned to one of the four experimental conditions: written text, high cueing (WTHC, 37); written text, low cueing (WTLC, 36); spoken text, high cueing (STHC, 30); and spoken text, low cueing (STLC, 32). Results showed that for learning outcomes, participants in the written text conditions statistically significantly outperformed participants in the spoken-text conditions on all dependent measures: a free recall test, a matching test, a comprehension test, and a spatial recall test. No main effects were found for cueing on any of the dependent measures. Modality interaction effect was not significant for any of the dependent measures. For mental effort, effects for modality and cueing, and the modality by cueing interaction effect were not significant (Crooks et al., 2012).

Lee and Mayer (2018) conducted an experiment on the modality and redundancy principles on Korean college students learning a second language. The 374 participants were randomly assigned into three groups: video/narration (126), video/text (138), and video/narration/text (110). Results found that for modality the video/text group performed significantly better on the comprehension test than the other groups. For cognitive load, results found that text groups reported significantly lower difficulty than the video/narration group. For redundancy, results found that the video/narration/text group scored higher on the comprehension test than did the video/narration group meaning the redundancy effect did not appear when students are learning a second language. This also held true for extraneous cognitive load where the video/narration/text group recorded significantly lower difficulty than the video/narration group (Lee & Mayer, 2018).

Although not unanimously supported by the cited studies, the consensus of the research is that managing essential processing leads to higher learning outcomes. Mayer (2021) stated that when using segmenting, pretraining, and modality (or multimedia principles in general), there are circumstances, known as boundary conditions, that when present, have shown to increase their effectiveness. These principles appear to be most effective when the material is complex and the multimedia lesson is fast paced (Mayer, 2021). Mayer and Pilegard (2014) suggested that these principles still need to be tested more in a real classroom rather than a controlled laboratory environment and on the various characteristics of the learning task. They also suggest there is a need for more testing on their effects on cognitive load (Mayer & Pilegard, 2014). For segmenting, more research needs to be done on its effectiveness in system paced lessons and the question of how long the segment chunks should be has not been determined (Clark & Mayer, 2016). For pretraining, to be most effective it is necessary for the learner to be unfamiliar with the material (Mayer & Pilegard, 2014). For modality, on-screen text increases learning outcomes for non-native language learners and people with hearing disabilities. Having on-screen text is also helpful when the material includes complex technical terms or long segments of unfamiliar text (Low & Sweller, 2014; Mayer & Pilegard, 2014).

Foster Generative Processing. Mayer (2021) stated that generative processing "refers to cognitive processing aimed at making sense of the presented material and is caused by the learner's motivation to learn" (p. 52). Engaging in appropriate generative and essential processing will allow learners to learn more deeply by promoting both good recall and good transfer learning (Mayer, 2021).

This review of literature found 11 studies which showed that fostering generative processing improves student learning (Atkinson et al., 2005; Baylor & Kim, 2009; Craig & Schroeder, 2017; Mayer, 1989; Mayer & Anderson, 1992; Mayer & DaPra, 2012; Mayer et al., 2004; Mayer & Gallini, 1990; Moreno & Mayer, 2000b; Wang et al., 2008, 2018). However, it also found 12 studies that failed to find improvement (Atkinson et al., 2005; Baylor & Kim, 2009; Craig & Schroeder, 2017; Davis et al., 2019; Mayer, 1989; Mayer & Anderson, 1992; Mayer & DaPra, 2012; Mayer et al., 2004; Mayer & Gallini, 1990; Moreno & Mayer, 2000b; Wang et al., 2008, 2018).

Mayer (2014e) described personalization as presenting multimedia material in a "conversational style rather than a formal style" (p. 365). Replicating a human's conversational style may activate a learner's social response. In human/human communication interactions, social response is the assumption that the speaker is trying to be informative, accurate, relevant, and concise. The listener in turn tries hard to understand and make sense of the information presented by the speaker, which is known as generative processing (Mayer, 2014e).

Wang et al. (2008) studied politeness in online tutors for 51 engineering graduate/undergraduate students and psychology undergraduate students from the University of Southern California (17) and the University of California, Santa Barbara (34). Students were randomly assigned to either the polite group or the direct group. Results found that the polite group scored statistically significantly better than the direct group on the test. There was no significant difference between groups on likability for the direct or polite tutor. No statistically significant difference was found in self-efficacy between the polite and the direct groups (Wang et al., 2008).

In their research, Moreno and Mayer (2000b) performed five experiments on students selected from the Psychology Subject Pool at the University of California, Santa Barbara. In the first experiment, 34 subjects were randomly assigned into two groups: personalized-speech group (17) and neutral-speech group (17). Students in the personalized-speech group generated significantly more conceptual creative solutions than students in the neutral-speech group. Students in the personalized-speech group did not perform better on the recall test than students in the neutral-speech group. In the second experiment, Moreno and Mayer (2000b) compared 44 students who were randomly assigned to either the personalized-text group (22) or the neutral-text group (22). Students in the personalized-text group generated significantly more conceptually creative solutions than students in the neutral-text group. Students in the personalized-text group did not perform better on the recall test than students in the neutral-text group. In the third experiment, Moreno and Mayer (2000b) studied 39 students who were randomly assigned to one of two groups: personalized (18) or non-personalized (21). The personalized group recalled statistically significantly more and produced significantly more correct solutions on problem solving than did the non-personalized group. There was no significant difference in lesson favorability between the two groups. In the fourth experiment, 42 students were randomly assigned to either the personalized text group (21) or the non-personalized text group (21). The personalized group recalled and produced significantly more correct solutions on problem solving than did the non-personalized group. There was no significant difference in lesson favorability between the two groups. In the final experiment, 43 students were randomly assigned into the personalized narration group (22) or the non-personalized narration group (21). The personalized group scored significantly higher on the recall test than the non-personalized group and produced significantly more correct solutions on transfer problems than the non-personalized group. There was no significant difference in lesson favorability between the two groups (Moreno & Mayer, 2000b).

Mayer et al. (2004) performed three experiments on the personalization effect using students from the Psychology Subject Pool from the University of California. Santa Barbara. In the first experiment, 62 students were randomly assigned to either the personalized (29) or non-personalized (33) groups. No statistically significant difference was found in retention scores between the two groups; however, the personalized group did score statistically significantly higher on the transfer test than the non-personalized group. In the second experiment, 27 students were randomly assigned into the personalized (14) or non-personalized (13) group. Results were the same as in the first experiment, no statistically significant difference was found in retention scores between the two groups, however, the personalized group did score statistically significantly higher on the transfer test than the non-personalized group (Mayer et al., 2004). In the third experiment, 32 students were randomly assigned into either the personalized (17) or non-personalized (15) group. The same results were found as in the first and second experiments, no statistically significant difference was found in retention scores between the two groups, however, the personalized group did score statistically significantly higher on the transfer test than the non-personalized group (Mayer et al., 2004).

Mayer (2014e) suggested that using a “human voice with a standard accent rather than a machine voice or a foreign-accented human voice” enhances learning (voice principle) (p. 365). Voice cues also activate a learner’s social response. Research suggests that a standard accent conveys the best opportunity to invoke a social response in the learner resulting in increased generative processing (Mayer, 2014e).

In their research, Atkinson et al. (2005) performed two experiments on the voice principle using a human voice and a computer-generated voice. The first experiment included 50 undergraduate college students recruited from educational psychology courses at Mississippi State University. They were randomly assigned into two equal groups: human voice and machine voice. Results found that there was no significant difference in perceived example understanding or perceived example difficulty between the two groups. It was found that the human voice group performed statistically significantly higher on the practice problems, the near transfer questions, and the far transfer questions than the machine voice group. Participants in the human group also rated the human voice speaker significantly more favorably than the machine voice group. In the second experiment, Atkinson et al. (2005) studied 40 high school students recruited from several mathematics courses taught by the same instructor at Starkville High School in Starkville, Mississippi. Students were randomly assigned equally into either the human voice or machine groups. Results found no significant difference between the groups in perceived example understanding or perceived example difficulty. It was found that the human voice group performed statistically significantly higher on the practice problems, the near transfer questions, and the far transfer questions than the machine voice group. Participants in the human group also rated the human voice speaker significantly more favorably than the machine voice group (Atkinson et al., 2005).

Craig and Schroeder (2017) studied the 140 participants that were randomly assigned to a human pedagogical agent that had a classic voice engine (50), a modern voice engine (50), or a human voice recording (40). For learning measures, no significant difference was found between groups for the pretest, the multiple-choice questions, or the retention test. For the transfer test, a statistically significant difference was found where the modern voice engine group scored higher than the classic voice engine or human voice recording groups. For cognitive load, no significant differences were found between groups. For perceptions, a statistically significant difference was found where the classic voice condition scored lower than the other groups. There were no significant differences found between the modern speech engine and the human voice groups (Craig & Schroeder, 2017).

The voice principle in non-native language speakers was studied by Davis et al. (2019) using 172 undergraduates (87 male, 85 female) studying a foreign language (English) in Seoul, South Korea. Two American male professional voice actors were used for the human voices. Participants were randomly assigned to either the human strong-prosodic voice condition, the human weak-prosodic voice condition, or the modern computer synthesized voice condition. Results for cognitive load found no significance between intrinsic cognitive load and extrinsic cognitive load. Germane cognitive load was found to be significant between the weak-prosodic voice condition and the modern computerized synthesized voice condition. No other significant differences were found. For the Korean agent persona, there was a statistically significant difference between the voice conditions. There was a significant difference between the weak-prosodic voice condition and the modern computer synthesized voice condition. No other significant differences were found (Davis et al., 2019).

Mayer (2014e) stated that on-screen agents should "display humanlike gesturing, movement, eye contact, and facial expressions" (image principle) (p. 365). An on-screen agent that exhibits human-like characteristics will also activate a social response in the learner and will, therefore, increase generative processing (Mayer, 2014e).

In their research, Wang et al. (2018) studied pedagogical agents and learning outcomes in three experiments using Chinese university students. In the first experiment, there were 51 undergraduates (39 female, 12 male) from a central China university. Participants were randomly assigned into either the PA (personal agent) group or no PA group. Results found that the PA group scored statistically significantly higher on the retention test and the transfer test than the no PA group. There was no statistically significant difference found on the matching test. This experiment also found that the PA group differed significantly from the no PA group on each of the five eye-tracking measures, indicating that PA group had more fixation time on the target material, more fixations on the target material, longer fixation duration, longer first fixation, and more glances. Results also showed that learners in the PA group did not continuously look at the onscreen agent during the entire lesson but spent very little time looking at the on-screen agent, and only mainly at the beginning of the lesson. In the second experiment, participants included 109 undergraduates (96 women, 13 men) randomly assigned into four groups: PA-gesture (27), PA-no gesture (27), no PA-gesture (26), and no PA-no gesture (29). For learning performance, the retention test results showed the main effect for image was significant, where the PA groups scored higher than the no PA groups. The main effect for gesture was also significant, with the gesture groups scoring higher than the no gesture groups. There was a significant interaction found between image and gesture where the PA group significantly outscored the no PA group when there included gestures and the gesture group significantly outperformed the no gesture group when there was an agent on screen. The transfer test also showed a significant effect for images where the PA groups performed better than the no PA groups and a significant effect for gestures where the gesture groups performed better than the no gesture groups. The interaction between image and gesture was not significant. The PA group significantly outperformed the no PA group when there were gestures, and the gesture group outperformed the no gesture group when there was an agent on the screen. For the matching test, the main effect for image and for gesture were not significant. The interaction between image and gesture was significant, indicating that the PA group significantly outscored the no PA group when there included gestures and the gesture group outperformed no gesture group when there was an agent on the screen (Wang et al., 2018). In the third experiment, there were 96 participants (84 women, 12 men) randomly assigned to four groups: gesturing/signaling (25), gesturing/no-signaling (20), no-gesturing/signaling (26), and no-gesturing/no-signaling (25). For learning outcomes, the study found that the main effect for gesturing was significant in the retention test where the gesturing groups outperformed those in the no-gesturing groups. The main effect of signaling was not significant. The interaction between gesturing and signaling was significant, where the gesturing group significantly outperformed the no-gesturing group when there was no signaling. Signaling did not significantly improve learning whether there was gesturing or not. For the transfer test, the main effect of gesturing was significant where the gesturing groups outperformed those in the no-gesturing groups. The main effect of signaling was not significant. The interaction between two factors was significant where the gesturing group significantly outperformed the no-gesturing group when there was no signaling. Signaling significantly improved learning when there was no gesturing. For the matching test, the main effect of gesturing was significant with the gesturing groups outperforming the no-gesturing groups. The main effect of signaling was not significant. The interaction between the two factors was significant with the gesturing group significantly outperforming the no-gesture group when there was no signaling. Signaling did not significantly improve learning when there was gesturing (Wang et al., 2018).

Mayer and DaPra (2012) conducted three experiments using participants from the Psychology Subject Pool at the University of California, Santa Barbara. In the first experiment, there were 88 subjects (66 female, 22 male) randomly assigned into three groups: high embodiment/human voice (HE-HV, 30), low embodiment/human voice (LE-HV, 29), and no onscreen agent/human voice (NA-HV, 29). For transfer scores, results found that the HE-HV group scored significantly higher than the other groups. For retention scores, there was no significant difference between groups. For social ratings, the groups differed significantly on three of the four dimensions: agent facilitated learning, agent was credible, and agent was engaging. In each case, the HE-HV group significantly outperformed the LE-HV group, in favor of the high embodiment group over the low embodiment group. In the second experiment, 106 participants (80 female, 26 male) who were randomly assigned into four groups: high embodiment/human voice (HE-HV, 26), low embodiment/human voice (LE-HV, 27), high embodiment/machine voice (HE-MV, 26), and low embodiment/machine voice (LE-MV, 27). For transfer scores and embodiment, the HE groups outperformed the LE groups. There was also a significant embodiment/voice interaction for transfer where the HE groups significantly outscored the LE groups when the agent had a human voice. For transfer scores and voice, the HV groups performed better than the MV groups, but the results were not significant. There was a nonsignificant trend in the direction of the HV group outscoring the MV group when the onscreen agent was rendered with high embodiment. There were no significant main effects or an interaction involving retention test score, indicating that all groups learned the basic material to equal levels (Mayer & DaPra, 2012). In the final experiment, 115 participants (97 women, 18 men) were randomly assigned into one of four groups: high embodiment/choice (HE-C, 29), high embodiment/no choice (HE-NC, 29), low embodiment/choice (LE-C, 29), low embodiment/no choice (LE-NC, 28). For embodiment and transfer, the HE groups outperformed the LE groups, however there were no significant embodiment/choice interactions. For choice and transfer, there was a nonsignificant trend in which the mean transfer score for the choice groups was in the predicted direction over the mean transfer score for the no-choice groups. There were no significant main effects for embodiment or choice and retention scores. For social ratings, students who viewed highly embodied agents gave significantly higher social ratings than students who viewed less embodied agents on three of the four areas: agent facilitated learning, agent was human-like, and agent was engaging. Students who were given a choice concerning their agent gave significantly higher social ratings than students who did not have a choice on three of the four dimensions: agent facilitated learning, agent was human-like, and agent was engaging. There were no significant interactions between embodiment and choice (Mayer & DaPra, 2012).

In their study, Baylor and Kim (2009) compared 236 undergraduate students (32% male, 68% female) enrolled in a computer literacy course in a public southeastern university who were randomly assigned to one of eight conditions. Results found the main effects of facial expression and deictic gesture (pointing with arms and hands) were each significant, whereas the type of instruction did not have a significant effect on the dependent variables. The interactions between the type of instruction and gesture conditions, between the type of instruction and facial expression conditions, and between facial expression conditions and gesture conditions were all statistically significant. The interaction effect between the type of instruction and facial expression significantly influenced participants' attitude toward the content. In the AIM (attitudinal instructional module), participants reported a significantly more positive attitude toward the instruction when agent facial expressions were present. In contrast, with the PIM (procedural instructional module) participants reported a significantly more positive attitude toward the instruction when agent facial expressions were absent. Participants who interacted with agents that had facial expressions rated the agents' overall persona significantly higher than participants who had an agent with no facial expression. The interaction effect between facial expression and deictic gesture was significant where participants that had an agent with facial expression but without gestures reported the greatest sense of agent persona and participants who had an agent without facial expression but with gestures reported greater agent persona than those who had an agent without gestures. For learning, the PIM participants learned more when agent facial expressions were present. With AIM, the presence of facial expressions facilitated learning more than no facial expressions. Procedural learning was significantly enhanced when agent gesture was present, whereas attitudinal learning was facilitated when agent gesture was absent. When facial expression was absent, the presence of agent gesture enhanced learning, where in contrast, when facial expression was present, the absence of agent gesture enhanced learning (Baylor & Kim, 2009).

Mayer (2021) stated that the multimedia principle "demonstrates that student learning may be enhanced when pictures are added to words; that is, when material is presented in two forms rather than one" (p. 135). Using both narrated text and pictures allows the learner to construct verbal and visual mental models and to build a connection between the two (Mayer, 2021).

Mayer (1989) performed two experiments on college students. The first experiment included 34 females randomly assigned into either the illustrations group or the no illustrations group. Results found that the illustrations group recalled almost twice as much explanative information relative to non-explanative information, however, the results did not reach significance. For transfer, the illustrations group generated significantly more creative answers than the no illustrations group. The second experiment included 44 females randomly assigned into one of three groups: illustrations (15), illustrations without labels (15), and labels without illustrations (14). For recall, a significant interaction between treatment group and type of recall was found. The illustrations group recalled more explanative information than either of the other groups and the labels without illustrations group recalled more explanative information than the illustrations without labels group. For transfer, the illustrations group performed better than the other groups on creative problem solving but not on verbatim recognition. The illustrations group performed significantly better than the other groups for problem solving. No significant difference was found for verbatim retention (Mayer, 1989).

Mayer and Anderson (1992) performed two experiments using college students from the University of California, Santa Barbara. In the first experiment, 136 students were randomly assigned equally ($n = 17$) to one of eight groups. For retention, results found that the control group (no instruction) scored significantly lower than each of the other groups and the remaining seven groups did not differ from each other, except the ANANAN group (three successive cycles of animation followed by narration) scored higher than the AAA group (animation presented three times). For problem solving, the concurrent group (animation and narration at the same time) performed significantly better than the other groups who did not differ significantly from one another. In the second experiment, Mayer and Anderson (1992) compared 144 students who were randomly assigned to one of eight groups. For retention, results found that each of the treatment groups except for the AAA group scored significantly higher than the control group and none of the groups differed significantly from each other. For problem solving, the concurrent group scored significantly higher than the other groups, who did not differ significantly from each other (Mayer & Anderson, 1992).

In their study, Mayer and Gallini (1990) performed three experiments on college students from the Psychology Subject Pool at the University of California, Santa Barbara. In the first experiment, 96 students were randomly assigned to four groups (n = 24): no illustrations, parts illustrations, steps illustrations, and parts-steps illustrations. For recall and explanative illustrations, the parts-steps illustrations group outperformed the control group for recall of explanative information but not on recall of non-explanative information. For creative problem solving and explanative illustrations, the parts-steps group outperformed the control group for problem solving, but not for verbatim retention. For conceptual recall and explanative illustrations, the parts-steps group outperformed the steps, parts, and control groups on recall of explanative information. For problem solving and explanative illustrations, the parts-steps group outperformed the steps, parts, and control groups on problem-solving. For recall, explanative illustrations, and low/high prior knowledge students, the parts-steps, steps, parts, and control groups do not seem to differ in explanative recall for high prior knowledge students. For explanative illustration, creative problem solving, and low/high prior knowledge students, the parts-steps, steps, parts, and control groups do not seem to differ in problem solving for high prior knowledge students. For the second experiment, 96 students were randomly assigned into the same groups as in the first experiment. For explanative illustrations and recall, the parts-and-steps group outperformed the control group on recall of explanative information but not on recall of non-explanative information. The parts-steps group outperformed the control group in recall of explanative information, however, the parts-steps group not only failed to outperform the control group on recall of non-explanative information, but the control group recalled significantly more non-explanative information than the control group. For explanative illustrations and creative problem solving, the parts-steps group outperformed the control group on problem solving but not on verbatim retention. For explanative illustration and conceptual recall, the parts-steps group outperformed the control group, but the other illustration groups did not outperform the control group. For explanative illustrations and problem solving, the parts-steps group outperformed the control group, but the other illustration groups did not outperform the control group. For explanative illustrations, recall, and low/high prior knowledge, results showed mildly significant differences among the groups for high prior knowledge students. For explanative illustrations, creative problem solving, and low/high prior knowledge, the parts-steps, steps, parts, and control groups do not seem to differ in problem solving for high prior knowledge students (Mayer & Gallini, 1990). In the third experiment, 108 students were randomly assigned into the following groups: the no-illustrations group (17 low prior knowledge and 18 high prior knowledge students), the parts group (15 low prior knowledge and 21 high-prior knowledge students), and the parts-steps group (12 low-prior knowledge and 25 high prior knowledge students). For explanative illustrations and recall, the parts-steps group outperformed the control group on recall of explanative information but not on recall of non-explanative information. For explanative illustration and creative problem solving, the parts-steps group outperformed the control group on problem solving but not on verbatim retention. For explanative illustrations and conceptual recall, the parts-steps group outperformed the control group, but the parts groups did not outperform the control group. For explanative illustrations and problem solving, the parts-steps group outperformed the control group, but the parts group did not outperform the control group. For explanative illustrations, recall, and low/high prior knowledge, the differences among the parts-steps, parts, and control groups in explanative recall (26%, 16%, and 11%, respectively) were relatively large for high prior knowledge students. Inconsistent with the prior two experiments, data for high prior knowledge students showed significant differences among the groups and is like the pattern for low prior knowledge students where explanative illustrations were effective in improving explanative recall. For explanative illustrations, creative problem solving and low/high prior knowledge, the parts-steps, parts, and control groups do not seem to differ in problem solving for high prior knowledge students (Mayer & Gallini, 1990).

Although not unanimously supported by the cited studies, the consensus of the research is that by using the personalization, voice, embodiment, multimedia, and image principles, it fosters generative processing and leads to higher learning outcomes. Mayer (2014e) has suggested that all these principles need further research on their effect on cognitive load, as well as their effect when in a real classroom setting, and their effect on learners with different knowledge levels. For personalization, the level or amount of personalization should be studied to see if there is a point when it becomes distracting to the learner (Clark & Mayer, 2016, Mayer, 2014e). For voice, research on learner preference for and effectiveness of certain accents (the same as the learner, specific foreign accents, etc.) (Mayer, 2014e). Mayer (2021) suggested that the voice principle may be most effective when there are no negative social cues present, such as the image of a low-embodied agent on-screen. Clark and Mayer (2016) suggested additional study is needed on whether there is a point when embodiment becomes a distraction and if gender or gesturing, eye fixations, and locomotion influences its effectiveness. Mayer (2021) stated that having a highly embodied agent on the screen is most effective when there are no negative social cues, such as a machine voice, and that how much of the agent's body is showing might influence its effectiveness, such as when the agent's hand is showing while drawing. The multimedia principle should be studied more in the context of a self-directed learning environment and with new technologies, such as in a virtual environment (Butcher, 2014). Mayer (2014e) suggested that the image principle should be studied more in combination with gesturing, including comparing the use of other on-screen agents that do not resemble the instructor.

Reducing Extraneous Processing. Mayer (2021) stated that extraneous processing "refers to cognitive processing that does not support the instructional goal and is caused by poor instructional design" (p. 51). When too much of the learner's cognitive capacity is used for extraneous processing, learning cannot occur (Mayer, 2021).

This review of the literature has found 31 studies that have shown that reducing extraneous processing improves student learning (Bartsch & Cobern, 2003; Bauhoff et al., 2012; Craig et al., 2015; Fenesi et al., 2014, 2016; Garner et al., 1989, 1991; Gemino et al., 2005; Harp & Mayer, 1997, 1998; Johnson & Mayer, 2012; Lehman et al., 2007; Lehman & Seufert, 2017; Li et al., 2019; Mayer & Anderson, 1991; Mayer & Jackson, 2005; Mayer & Johnson, 2008; Mayer & Sims, 1994; Mayer et al., 1999, 2001, 2007, 2008; Moreno & Mayer, 2000a; Muller et al, 2008; Richter et al., 2018; Rop et al., 2018; Sanchez & Wiley, 2006; Sung & Mayer, 2012; Thompson et al., 2012; Wade et al., 1993; Xie et al., 2019). However, it found 20 studies that failed to find improvement (Bauhoff et al., 2012; Craig et al., 2015; Doolittle & Altstaedter, 2009; Fenesi et al., 2014, 2016; Garner et al., 1989; Gunnell, 2017; Johnson & Mayer, 2012; Lehman & Seufert, 2017; Mayer & Anderson, 1991; Mayer et al., 2008; Mayer & Johnson, 2008; Mayer & Sims, 1994; Moreno & Mayer, 2000a; Muller et al, 2008; Richter et al., 2018; Rop et al., 2018; Sanchez & Wiley, 2006; Wiggins, 2013; Xie et al., 2019).

Mayer and Fiorella (2014) described signaling as cues that are "added that highlight the organization of the essential material" in a multimedia instructional message (p. 309). Signaling directs attention to the essential content in the multimedia message and away from the extraneous content (Mayer & Fiorella, 2014).

Richter et al. (2018) studied signaling using 127 students (47 female, 80 male) in seven classes of three schools in southern Germany who were randomly assigned to one of two conditions: basic signaling (62) or extended signaling (65). For comprehension performance, the results of recoding dummy variables regarding the reference group showed that all classes from schools A and B performed better than did three of the overall four classes from school C. The focal contrast explained a significant amount of variance in the model. For the residual contrasts, the explained variance was not significant. The results for comprehension performance, which again show a fully reversed signaling effect for high prior knowledge (HPK) learners. For recall performance, the predictor variables domain-specific interest and class were not significant. The focal contrast explained a significant amount, whereas the residual contrasts did not. The data indicate a fully reversed signaling effect for HPK learners. For cognitive load, extraneous cognitive load (ECL) was not significant. The predictor variables domain-specific interest and class were not significant and focal contrast was not significant. Despite the overall nonsignificant model, the subset of residual contrasts explained a significant amount of variance. Low prior knowledge (LPK) learners experienced an overall higher ECL than did medium prior knowledge (MPK) and HPK learners. A reverse pattern to what had been expected for LPK learners was present in the data, suggesting that LPK learners in the extended signaling condition perceived more ECL than in the basic signaling condition even though they performed better in the extended signaling condition. There was a negative correlation between ECL and learning outcomes for recall and comprehension. The regression model for germane cognitive load (GCL) was not significant. GCL was higher in the extended signaling condition compared with the basic signaling condition for HPK learners. Bivariate correlations between GCL and learning outcomes yielded no significant relations for the measure of misconceptions, recall performance, or comprehension performance. For time-on-task, there were no main effects for either signaling, or prior knowledge, but there was a significant signaling/prior knowledge interaction only for HPK students. The time-on-task was not significantly correlated with learning outcomes, measure of misconceptions, recall performance, and comprehension performance (Richter et al., 2018).

In their research, Xie et al. (2019) performed three experiments on Chinese college students. In the first experiment, 123 students were randomly assigned into four groups: coordinated dual cues (29), visual-only cues (32), auditory-only cues (32), and no cues (30). For learning outcomes, learners in the coordinated dual cues group had significantly better retention performance than learners in the visual-only cues group and the no cues group. Learners in the auditory-only cues group also performed significantly better than those in the no cues group. No significant differences were found between the coordinated dual cues and auditory-only cues groups, the visual-only cues and auditory-only cues groups, or the visual-only cues and no cues groups. Coordinated dual cueing and auditory-only cueing were effective in improving retention test performance, but visual-only cueing was not. Learners in the coordinated dual cues group performed significantly better for transfer than each of the other groups (coordinated dual cues vs. visual-only, coordinated dual cues vs. auditory-only cues, coordinated dual cues vs. no cues) while no significant differences were observed among visual-only cues, auditory-only cues, and no cues groups. Coordinated dual cueing was effective in improving transfer test performance but auditory-only and visual-only cueing were not. For time-locked eye tracking, concerning time to first fixation, learners in the coordinated dual cues group attended more quickly to the elements mentioned in the narration than learners in the auditory-only, cues group, and no cues group. Learners in the visual-only cues group also attended more quickly to the elements mentioned in the narration than those in the auditory-only cues group, and no cues group. No significant differences were found between coordinated dual cues and visual-only cues groups, and between the auditory-only cues and no cues groups. Concerning fixation duration, learners in the coordinated dual cues and visual-only cues groups fixating longer at the elements currently mentioned in the text than learners in the auditory-only cues and no cues groups (coordinated dual cues vs. auditory-only cues, coordinated dual cues vs. no cues, visual-only cues vs. auditory-only cues. visual-only cues vs. no cues). No significant difference was found between the coordinated dual cues and visual-only cues groups, or between the auditory-only cues and no cues groups. Concerning fixation count, learners in the coordinated dual cues and visual-only cues groups fixating more frequently at the elements being mentioned in the narration than learners in the auditory-only cues and no cues groups (coordinated dual cues vs. auditory-only cues, coordinated dual cues vs. no cues, visual-only cues vs. auditory-only cues, visual-only cues vs. no cues). No significant difference was found between the coordinated dual cues and visual-only cues groups or between the auditory-only cues and no cues groups. Regarding the relationship between eye tracking and learning outcomes, results showed that time to first fixation on the relevant messages was negatively related to retention scores with a moderate effect size as well as to transfer scores with a small effect size, indicating that faster visual search time was associated with better learning outcomes of retention and transfer. Xie et al. (2019) conducted a second experiment, using 97 students (80 female, 17 male) were randomly assigned into three groups: coordinated dual cues (33), mismatched dual cues (32), and no cues (32). For learning outcomes, learners in the coordinated dual cues group had better retention scores than learners in the mismatched dual cues group and no cues group. No differences were found between the mismatched dual cues and no cues groups. Overall, coordinated dual cueing was effective in improving retention test performance but mismatched dual cueing was not. Learners in the coordinated dual cues group had a better transfer score than learners in the mismatched dual cues group and no cues group. No differences were found between the mismatched dual cues and no cues groups. Overall, coordinated dual cueing was effective in improving transfer test performance but mismatched dual cueing was not. For time-locked eye tracking, concerning the time to first fixation, learners in the coordinated dual cues group attended more quickly to the text-relevant elements than learners in the mismatched dual cues group and no cues group. Learners in the mismatched dual cues group attended more slowly to text-relevant elements than learners in the no cues group. Learners in the mismatched dual cues group attended more quickly to the text-irrelevant elements than learners in the coordinated dual cues group and no cues group. There was no significant difference between coordinated dual cues and no cues groups for the time elapsing until the first fixation on the text- irrelevant elements. Learners in both coordinated dual cues and no cues groups attended more quickly to the text-relevant elements than the text-irrelevant elements (coordinated dual cues, no cues). Learners in the mismatched dual cues group attended more quickly to the text-irrelevant elements than the text-relevant elements (mismatched dual cues). Concerning fixation duration, learners in the coordinated dual cues group attended longer to the text-relevant elements than learners in the mismatched dual cues group and no cues group. Learners in the mismatched dual cues group spent less time on the text-relevant elements than learners in the no cues group. Learners in the mismatched dual cues group paid more time looking at the text-irrelevant elements than learners in the coordinated dual cues group and no cues group. There was no significant difference between coordinated dual cues and no cues groups for the total time spent on the text-irrelevant elements. Learners in both coordinated dual cues and no cues groups attended longer to the text-relevant elements than the text-irrelevant elements (coordinated dual cues, no cues). However, learners in the mismatched dual cues group spent more time on the text-irrelevant elements than the text-relevant elements (mismatched dual cues). Concerning fixation count, learners in the coordinated dual cues group attended more frequently to the text-relevant elements than learners in the mismatched dual cues group and no cues group. Learners in the mismatched dual cues group attended less frequently to the text-relevant elements than learners in the no cues group. Learners in the mismatched dual cues group attended more frequently to the text-irrelevant elements than learners in the coordinated dual cues group and no cues group. There was no significant difference between coordinated dual cues and no cues groups for the number of eye fixations on the text-irrelevant elements. Learners in both coordinated dual cues and no cues groups attended more frequently to the text-relevant elements than the text-irrelevant elements (coordinated dual cues, no cues). Learners in the mismatched dual cues group attended more frequently to the text-irrelevant elements than the text-relevant elements (mismatched dual cues). Results showed that time to first fixation on the text-relevant messages was negatively related to retention scores with a large effect size, as well as to transfer scores, indicating that faster visual search time for the text-relevant elements were associated with better learning outcomes of retention and transfer. Both fixation duration and fixation count on the text-relevant messages were positively associated with retention scores with large effect sizes, as well as with transfer scores suggesting that fixating longer and more frequently on the text-relevant objects was related to better retention and transfer of what had been learned (2019). In the third experiment, 123 students (103 women, 20 men) were randomly assigned to the following groups: coordinated dual cues (30), visual-before-auditory (32), visual-after-auditory (33), and no cues (28). For learning outcomes, learners in the coordinated dual cues group had a better retention score than learners in the visual-before-auditory cues group, visual-after-auditory cues group and no cues group. No differences were found among visual-before-auditory cues, visual-after-auditory cues, and no cues groups. Overall, coordinated dual cueing was effective in improving retention test performance but visual-before-auditory cueing and visual-after-auditory cueing were not. Learners in the coordinated dual cues group had a better transfer score than learners in the visual-before-auditory cues group, visual-after-auditory cues group, and no cues group. No differences were found among visual-before-auditory cues, visual-after-auditory cues, and no cues groups. Overall, coordinated dual cueing was effective in improving transfer test performance but visual-before-auditory cueing and visual-after-auditory cueing were not. For time-locked eye tracking, concerning the time to first fixation, learners in both coordinated dual cues and visual-before-auditory cues groups attended more quickly to the elements mentioned in the narration than learners in the visual-after-auditory cues group (coordinated dual cues vs. visual-after-auditory cues, visual-before-auditory cues vs. visual-after-auditory cues) and no cues group (coordinated dual cues vs. no cues, visual-before-auditory cues vs. no cues). Learners in the visual-after-auditory cues group also attended more quickly to the elements mentioned in the narration than those in the no cues group. No significant difference was found between coordinated dual cues and visual-before-auditory cues groups. Concerning fixation duration, learners in both coordinated dual cues and visual-before-auditory cues groups attended longer to the elements currently mentioned in the text than learners in the visual-after auditory cues group (coordinated dual cues vs. visual-after-auditory cues, visual-before-auditory cues vs. visual-after-auditory cues) and no cues group (coordinated dual cues vs. no cues, visual-before-auditory cues vs. no cues). Learners in the visual-after-auditory cues group also fixated longer at the elements currently mentioned in the text than those in the no cues group. No significant difference was found between coordinated dual cues and visual-before-auditory cues groups. Concerning fixation count, learners in the coordinated dual cues group attended more frequently to the elements being mentioned in the narration than learners in the visual-before-auditory cues group, visual-after-auditory cues, and no cues group. Learners in the visual-before-auditory cues group also fixated more frequently at the elements being mentioned in the narration than those in the visual-after-auditory cues group and no cues group. No difference was found between visual-after-auditory cues and no cues groups. Results showed that time to first fixation on the relevant messages was negatively related to retention scores with a moderate effect size, as well as to transfer scores with a small effect size indicating that faster visual search time was associated with better learning outcomes of retention and transfer. Positive correlations emerged respectively between fixation duration and retention performance with a moderate effect size, as well as between fixation duration and transfer performance with a small effect size. Positive correlations with moderate effect sizes were found between fixation count and retention test and between fixation count and transfer test (Xie et al., 2019).

Li et al. (2019) studied 123 undergraduate students (105 female, 18 male) from a university in central China who were randomly assigned into four groups: specific point gesture (SPG, 32), general pointing gesture (GPG, 30), non-pointing gesture (NPG, 31), and no gesture (NG, 30). For learning outcomes, for the immediate retention test, the SPG group significantly outperformed the GPG group, NPG group, and NG group, which did not differ significantly from each other. For the immediate transfer test, the SPG group significantly outperformed the GPG group, NPG group, and NG group, which did not differ significantly from each other. The results on the immediate tests show that students learn best with an agent who exhibits specific gestures during instruction. For the delayed retention test, the SPG group significantly outperformed the GPG group and NG group, which did not differ significantly from each other. For the delayed transfer test, the SPG group significantly outperformed the GPG group, NPG group, and NG group, which did not differ significantly from each other. Delayed learning outcomes show the same pattern of results as the immediate learning outcomes, with the best learning outcome for the group that received a pedagogical agent who displayed specific pointing gestures. For eye movements during learning, concerning fixation time, the groups differed significantly and showed the SPG group had significantly longer fixation time on the relevant part of the illustration than the GPG, NPG, and NG groups, which did not differ significantly from each other. For fixation count, the SPG group had a significantly higher fixation count than the GPG, NPG, and NG groups, which did not differ significantly from each other. For average fixation, the SPG group had a significantly longer average fixation on the relevant part of the illustration than the GPG, NPG, and NG groups, which did not differ significantly from each other. For first fixation time, the SPG group had a significantly longer first fixation duration on the relevant part of the illustration than the GPG and NG groups, which did not differ significantly from each other. For revisits, the SPG group had significantly more revisits to relevant areas than the GPG and NPG groups, which did not differ significantly from each other (Li et al., 2019).

Mayer and Fiorella (2014) stated that "people learn more deeply from graphics and narration than from graphics, narration, and on-screen text" (p. 309). Redundancy eliminates the need to process both graphics and text in the visual-pictorial channel, and the need to integrate auditory and text in the auditory-verbal channel (Mayer & Fiorella, 2014).

Fenesi et al. (2014) compared 99 undergraduate students from McMaster University enrolled in an introductory psychology course. Thirty-three participants (46% men, 54% women) were randomly assigned to each of the three conditions: complementary, redundant, and audio. Participants in the complementary condition performed significantly better on the multiple-choice questions than those in the redundant and audio. Independent samples t tests contrasting mean performance for the complementary condition versus the redundant condition and the complementary condition versus the audio condition were statistically significant with medium-to-large effect sizes (0.61 and 0.81 respectively); however, the contrast between the redundant condition versus the audio condition was not significant. Participants rated their understanding as greater for complementary and redundant conditions compared with audio, but there was no difference between complementary and redundant conditions. A statistically significant difference with medium to large magnitude-of-effects was found for perceived understanding between audio and redundant ($d = 0.77$) and between complementary and audio, ($d = 1.14$). No significant difference was found for redundant versus complementary. Lecture engagement was rated differently across multimedia presentations and found to be significant, where the complementary condition perceived as most engaging, followed by the redundant condition, and then the audio condition. These results were supported by statistically significant differences with medium-to-large effect sizes for audio only versus redundant (d = 0.67), redundant versus complementary (d = 1.45), and complementary versus audio only (d = 1.77) (Fenesi et al., 2014).

In their study, Rop et al. (2018) performed two experiments on redundant text. The first experiment included 225 participants (108 female, 117 male) who were randomly assigned to one of eight conditions: system-paced diagram only (35), system-paced separated (21), system-paced integrated (28), system-paced integration-instruction condition (26), and self-paced diagram only (34), self-paced separated (37), self-paced integrated (24), and self-paced integration instruction (30). The average time on task was found to be higher in the self-paced rather than the system-paced conditions except for the separated condition. For the components test, no significant difference was found between the self-paced and the system-paced conditions for learning performance. No significant differences were found between layout conditions when the presentation was either self-paced or system paced. On the blood chains test, no significant difference was found for learning outcomes between the two layout conditions or between the self-paced or system-paced conditions. On the blood flow test, a marginally significant advantage for the self-paced conditions compared with the system-paced conditions was found; however, no performance differences between layout conditions were indicated when the presentation was either self-paced or system-paced. Results also showed that participants in the system-paced conditions invested more mental effort during learning than participants in the self-paced conditions. In the second experiment, Rop et al. (2018) studied 122 German university students randomly assigned to one of four conditions: diagram only (29), separated (33), integrated (32), and integration-instruction (28). On the blood chains test, a significant difference was found between conditions. Participants in the integrated condition had a statistically significantly lower performance than participants in the separated condition and participants in the integration-instruction condition. No other comparisons were significant. On the blood flow test, a significant difference between the conditions were found. Participants in the integrated condition had statistically significant lower performance than participants in the separated condition. None of the other comparisons yielded significant results. There were no significant differences found in self-reported mental effort invested during learning between the conditions. For fixation duration on the unnecessary text in the separated, integrated, and integration-instruction conditions, results showed no significant differences among conditions. A significant main effect of layout was found where participants in the diagram-only condition spent more time looking at the relevant information than participants in the separated condition ($d = 1.91$); integrated condition ($d = 1.72$), and integration-instruction condition ($d = 2.35$). All other comparisons were not significant. For unnecessary–relevant and relevant–relevant transitions, results showed a significant main effect of layout where participants in the integrated condition made more transitions between the unnecessary text and the relevant parts of the diagram than participants in the separated condition ($d = 1.89$) and the integration-instruction conditions ($d = 1.77$). The analysis revealed no differences between the separated and integration-instruction conditions. Analysis of the relevant–relevant transitions also revealed a significant main effect of layout where participants in the diagram-only condition made more relevant–relevant transitions than participants in the integrated ($d = 0.94$), separated ($d = 1.21$), and integration-instruction conditions ($d = 1.39$). All other comparisons were not significant (Rop et al., 2018).

Mayer and Johnson (2008) conducted two experiments using undergraduate students from the Psychology Subject Pool from the University of California, Santa Barbara. In the first experiment, 90 students (58 women, 32 men) were randomly assigned to two groups: nonredundant (45) and redundant (45). Results revealed that the redundant group scored significantly better than the nonredundant group on the retention test, whereas the redundant group and the nonredundant group did not differ significantly on the transfer test. In the second experiment, 62 students (27 women, 35 men) were randomly assigned to two groups: nonredundant (31) and redundant (31). The redundant group scored significantly better than the nonredundant group on the retention test, whereas the redundant group and the nonredundant group did not differ significantly on the transfer test (Mayer & Johnson, 2008).

Mayer and Fiorella (2014) describe spatial contiguity as when "corresponding words and pictures are presented near rather than far from each other on the page or screen" (p. 309). Spatial contiguity reduces the need for the learner to switch back and forth between the text and the graphic (Mayer & Fiorella, 2014).

Craig et al. (2015) compared 77 U. S. participants randomly assigned to one of the following conditions: general gesture, specific gesture, and no gesture. Retention was found to be significantly different where specific and general gesture conditions had higher performance scores on the essay than the no gesture conditions. There was no difference in performance between the specific and general gesture conditions. Results found no difference among conditions on the transfer test or on the retention multiple choice assessment (Craig et al., 2015).

In their research, Johnson and Mayer (2012) performed three experiments using students from the Psychology Subject Pool at University of California, Santa Barbara. In the first experiment, 48 students were randomly assigned into two groups: separated (23) and integrated (25). For learning outcomes, results showed the integrated group had significantly higher scores on the transfer test than the separated group, meaning that deeper processing of the material occurred when the lesson was presented in an integrated format rather than a separated format. The integrated group had higher scores on the retention test than the separated group but the difference in performance was not statistically significant. For eye movement analysis, the integrated group made more transitions between the text and diagram areas of interest (AOIs) than did the separated group. This provides evidence that the integrated presentation format encourages learners to attempt to engage in appropriate cognitive processing during learning. The integrated group made more text-to diagram transitions than those in the separated group. Learners in the integrated condition made more corresponding transitions from the text to the corresponding part of the diagram than those in the separated condition. The integrated presentation format led learners to make more corresponding transitions between the text and relevant areas of the diagram. The integrated condition tended to make a higher proportion of corresponding fixations than the separated group, but this difference was not statistically significant. The integrated group and separated group did not differ on the proportion of fixations on the diagram, the proportion of fixations on the text, the total fixation time on the diagram, and the total fixation time on the text. There is no evidence that the integrated presentation format affected the cognitive process of selecting during learning. However, learners in both groups had a higher proportion of fixations on the text than on the diagram. In the second experiment, Johnson and Mayer (2012) compared 58 students who were randomly assigned to two groups: separated (29) and integrated with labels (29). For learning outcomes, the integrated group had significantly higher scores on the transfer test than the separated group. The integrated group had higher scores on the retention test than the separated group, but the difference in performance was not significant. For eye movement analysis, the integrated with labels group did make significantly more integrative transitions than the separated group. The integrated-with-labels group and the separated group did not differ significantly on proportion of fixations on the diagram and total fixation time on the diagram, however, the groups did differ on the proportion of fixations on the text, with the integrated with labels group making fewer fixations on the text than the separated group. The integrated with labels group also spent less time fixating on the text than the separated group. Learners in both groups had a higher proportion of fixations on the text than on the diagram. In the third experiment, 50 participants were randomly assigned to the legend (25) or integrated (25) groups. For learning outcomes, the integrated group did not have significantly higher scores on the transfer test than the legend group. On the retention test, the integrated group did not have significantly higher scores than the legend group. For eye movement analysis, concerning attempts at integrating, the integrated group made significantly more integrative transitions between the text and diagram than the legend group. The integrated group made significantly more text-to-diagram transitions than the legend group. The integrated format encouraged learners to attempt to engage in the cognitive process of integrating more than did the separated format. There was a marginal difference between the number of transitions between the text/numbers and diagram and vice versa in the legend group and integrated group. The integrated group made significantly more corresponding transitions than the legend group. The proportion of corresponding text-to-diagram transitions between the groups favored the integrated group over the legend group. Learners in the integrated group were more successful than learners in the legend group in making correspondences between the text they were reading and the corresponding part of the diagram concerning the cognitive process of selecting. The two groups did not differ significantly in the proportion of fixations on the diagram, the proportion of fixations on the text, the total fixation time on the diagram, and total fixation time on the text. There was no evidence that the integrated presentation shifted the learners' attention toward the diagrams. Across both conditions there were significantly more fixations on the text than on the diagram (Johnson & Mayer, 2012).

Bauhoff et al. (2012) studied 44 college students (22 women, 22 men) from the University of Tubingen, Germany. Subjects were randomly assigned into two groups: stimulus related information or stimulus unrelated information. Results showed that for the failure detection task concerning the number of inter-hemifield gaze shifts, there were fewer gaze shifts with increasing distances between the pictures. There was a significant main effect for the factor distance, but there was no main effect found for domain knowledge nor was there an interaction found for domain knowledge with distance. For processing intervals between hemifield gaze shifts, a significant main effect was found for factor distance with increasing length of processing intervals for increasing distances. There were no other main effects or interactions. For response time, there was a significant main effect for the factor distance, with longer response times for larger distances between the pictures. The main effects for domain knowledge, block, and the interaction of domain knowledge and distance, block and distance, and all remaining main effects and interactions were not significant. For proportion correct, significant main effect was found for block, indicating higher performance in the second block. There were no other significant main effects or interactions. For visual memory span, concerning inter-hemifield gaze shifts, the regression model was significant. Results showed a main effect on visual memory span. A significant interaction was found for domain knowledge and visual memory span. In contrast to the control condition, the domain knowledge condition showed a positive effect for visual memory span. For the domain knowledge condition, results showed that participants with a low visual memory span significantly decreased their number of inter-hemifield gaze shifts. For the processing interval, the regression model for differences in length of processing intervals between the two blocks was not significant. There were no significant main effects or interactions. For response time, the regression model was significant, with a significant main effect for visual memory span and a significant interaction effect for domain knowledge and visual memory span. The simple slope of the domain knowledge condition showed a positive effect for visual memory span (Bauhoff et al., 2012).

Mayer and Fiorella (2014) describe temporal contiguity as when "corresponding animation and narration are presented simultaneously rather than successively" (p. 309). Temporal contiguity keeps corresponding words and pictures in the working memory at the same time, removing the learner's need to hold the representation in working memory for a longer period (Mayer & Fiorella, 2014).

Mayer and Anderson (1991) conducted three experiments using college students from the Psychology Subject Pool at the University of California, Santa Barbara. In the first experiment, 30 students were randomly assigned evenly into two groups: words-with-pictures and words-before-pictures. For problem-solving performance, the words-with-pictures group generated approximately 50% more solutions to the test problems than did subjects in the words-before-pictures group. In the second experiment, 24 students were randomly assigned evenly into the same two groups. Results found that for problem-solving, the words-with-pictures group generated about 50% more creative solutions to problems than did subjects in the words-before-pictures group. The proportion of creative solutions for subjects in the words-with-pictures group was greater than the proportion in the words-before-pictures group. For recall of verbal information, the mean proportions of verbal statements produced on the recall test by the words-with-pictures group and by the words-before-pictures group did not differ significantly (Mayer & Anderson, 1991). The third experiment consisted of 48 students randomly assigned evenly into four groups: words-with-pictures, words only, pictures only, and control. For problem-solving performance, the words-with-pictures group generated substantially more creative solutions on the problem-solving test than did the other groups. The mean problem-solving scores of the groups differed significantly from one another. The words-with-pictures group outperformed the other three groups, which did not differ significantly from one another. For recall of verbal information, the means for the words-with-pictures, words-only, pictures-only, and control groups were .67, .64, .45, and .30, respectively, and the corresponding standard deviations were .22, .24, .24, and .20, respectively. The words-with-pictures and words-only groups did not differ from each other in that both performed better than did the control group, whereas the pictures-only group did not differ from any of the other groups (Mayer & Anderson, 1991).

In their study, Mayer and Sims (1994) conducted two experiments using college students. In the first experiment, 86 subjects were randomly assigned into one of three groups: concurrent (10 high spatial ability, 12 low spatial ability), successive (21 high spatial ability, 22 low spatial ability), and control (seven high spatial ability, 14 low spatial ability). For the contiguity effect, results found a main effect for the treatment group. The concurrent group scored significantly higher than did the successive and control groups, which did not differ significantly from one another. The lack of difference between the successive and control groups indicates that the separated visual and verbal instruction provided to successive students was not effective. For contiguity effect for low versus high spatial ability, there were significant differences between groups where the concurrent group scored higher than did the other two groups and that the other two groups did not differ from one another. Low-spatial ability students who received concurrent presentations of animation and narration did not generate significantly more creative solutions on transfer problems than did students who received successive presentations or no presentation (Mayer & Sims, 1994). The second experiment consisted of 97 subjects randomly assigned to one of three groups: concurrent (17 high spatial ability, 15 low spatial ability), successive (15 high spatial ability, 18 low spatial ability), and control (17 high spatial ability, 15 low spatial ability). For the contiguity effect, a main effect for the treatment group was found. The concurrent group scored significantly higher than did the successive group, which scored significantly higher than the control group. For the contiguity effect for low versus high spatial ability, significant differences between groups were found. The concurrent group scored higher than did both the successive group and the control group, which did not differ from one another. The low-spatial ability students who received concurrent presentations of animation and narration generated approximately the same number of creative solutions on transfer problems as did students who received successive presentations. There were significant differences among the groups that included low spatial ability students. The two treatment groups each performed significantly better than did the control group, but they did not differ from one another (Mayer & Sims, 1994).

Two experiments were conducted by Mayer et al. (1999) using college students from the Psychology Subject Pool at the University of California, Santa Barbara. The first experiment included 60 undergraduate students that were randomly assigned evenly to five groups: concurrent (concurrent animation and narration), AN (successive large bites of animation followed by narration), NA (successive large bites of narration followed by animation), ANAN (successive small bites of animation followed by narration), and NANA (successive small bites of narration followed by animation). For retention, there was a statistically significant main effect for the group, in which the successive large bites group scored significantly lower than the other two groups, which did not differ significantly from each other. For transfer, there was a significant main effect for the group, in which the large bites group scored significantly lower than the other two groups, which did not differ significantly from each other. For the matching test, there was a significant main effect for the group, in which the successive large bites group scored significantly lower than the other two groups, which did not differ significantly from each other (Mayer et al., 1999). The second experiment consisted of 60 undergraduate students randomly assigned evenly to the same five groups as in the first experiment. For retention, there was a statistically significant main effect for the group, in which the successive large bites group scored significantly lower than the other two groups, which did not differ significantly from each other. For transfer, there was a significant main effect for the group, in which the successive large bites group scored significantly lower than the other two groups, which did not differ significantly from each other. For the matching test, there was a significant main effect for the group, in which the concurrent group scored significantly higher than the other two groups, which did not differ significantly from each other (Mayer et al., 1999).

This study focuses on the coherence principle. The coherence principle is a multimedia design principle that claims learning is improved when extraneous material, including unneeded pictures, words, symbols, and music, is excluded from a multimedia presentation (Clark & Mayer, 2016; Mayer, 2014d, 2021). Additionally, extraneous material may include engaging storylines that are not necessary elements to the learning objectives, background music and/or environmental sounds added for esthetics and motivation, and/or images or text that is interesting and related but irrelevant to the main ideas of the content (Wiggins, 2013). These details usually include information that is memorable because it deals with subjects that are controversial or perhaps shocking such as sex, scandal, love affairs, or death (Lehman et al., 2007). Garner (1992) defined the seductive detail effect in textbooks as “novel, active, concrete, and personally involving” details added to enhance the interest of the text (p. 54). These vivid details would often be recalled by students in assessments while the important pieces of the content would not (Garner, 1992).

Garner et al. (1989) originally presented the term “seductive details" which they defined as “propositions presenting irrelevant details – interesting, but unimportant, information” (p. 43). Results found that when both adult learners and children had content that included seductive details, they performed worse at macroprocessing tasks, such as recalling the important, main ideas from the text. The study also found that in microprocessing tasks, such as matching pictures of animals to information based on the text, there was no statistically significant difference found in adults who received the embellished text and those who did not. The same was not found to be true for children; however, results also found that children receiving seductive details performed worse than children who did not receive the embellished text (Garner et al., 1989).

Harp and Mayer (1998) presented three ways that seductive details interfere with learning: distraction, disruption, and diversion. Seductive details distract the learner when irrelevant information turns a learner’s attention away from relevant information. The learner is disrupted when the insertion of seductive details interrupts the linking of information between events in the learner’s working memory, therefore, not allowing them to organize important ideas and form a coherent mental representation. The learner is diverted when the learner forms a coherent mental representation, but it is formed based on the information around the irrelevant details and not on the important ideas. Study results found that learners recall significantly fewer important ideas and performed worse on transfer tests when irrelevant text and/or images are present (Harp & Mayer, 1998).

Lehman et al. (2007) developed three modified hypotheses based on Harp and Mayer's (1998) disruption, distraction, and diversion hypotheses discussed previously. Reduced attention hypothesis (distraction hypothesis) is when the learner uses their attentional resources to process the irrelevant information instead of using those resources to process the important ideas. The coherence break hypothesis (disruption hypothesis) states that the irrelevant information reduces text coherence and forces the learner to spend more time trying to create links between cause-and-effect events reducing their understanding of the main ideas. The inappropriate schema hypothesis (diversion hypothesis) is when the mental representation of the information is formed around the irrelevant information rather than the main ideas (Lehman et al., 2007).

This review of the literature found 18 studies that have shown that reducing extraneous processing by adhering to the coherence principle improves learning outcomes (Bartsch & Cobern, 2003; Fenesi et al., 2016; Garner et al., 1989, 1991; Gemino et al., 2005; Harp & Mayer, 1997, 1998; Lehman et al., 2007; Lehman & Seufert, 2017; Mayer & Jackson, 2005; Mayer et al., 2001, 2007, 2008; Moreno & Mayer, 2000a; Sanchez & Wiley, 2006; Sung & Mayer, 2012; Thompson et al., 2012; Wade et al., 1993). However, it also found nine studies that have failed to find improvement (Doolittle & Altstaedter, 2009; Fenesi et al., 2016; Garner et al., 1989; Gunnell, 2017; Lehman & Seufert, 2017; Mayer et al., 2008; Moreno & Mayer, 2000a; Sanchez & Wiley, 2006; Wiggins, 2013).

Mayer et al. (2001) performed a study on the effect of irrelevant details in the form of added video clips and their effect on recall and transfer. The study included 38 college students from the University of California, Santa Barbara, who were randomly assigned into two groups: the video group and the no-video group. Results showed a statistically significant difference for recall and transfer solutions where the no-video clip group recalled more main ideas and produced more solutions than the video clip group (Mayer et al., 2001).

Researchers Harp and Mayer (1998) studied the recall and problem-solving performance of 81 undergraduates at the University of California, Santa Barbara. Participants were randomly assigned to four treatment groups: the base-passage group, the base-passage-plus-highlighting group, the base-passage-plus-seductive-details group, and the base-passage-plus-seductive-details-plus-highlighting group. The study found a statistically significant difference for recall and problem-solving solutions where the treatment groups that included seductive details scored lower than the groups that did not. Results found no interaction between seductive details and highlighting for the recall of important content or for problem-solving solutions. However, no statistically significant difference was found in the groups that included the highlighting (Harp & Mayer, 1998).

Mayer and Jackson (2005) compared 43 first-year college students at the University of California, Santa Barbara, who were randomly assigned into two groups: the concise group and the expanded group whose content included extra text and illustrations. A statistically significant difference was found in mean test scores for the concise group where that group scored higher than the expanded group (effect size 0.94). A second experiment added a time on task requirement to the conditions and included 27 first-year college students from the same institution randomly assigned to the same two groups. A statistically significant difference was found between the groups where the concise group had a higher mean test score than the expanded group (effect size 0.97). In a third experiment, 40 first-year college students were randomly assigned to the concise and expanded groups. This experiment also found a statistically significant difference where the concise group had a higher mean test score than the expanded group (effect size 0.69) (Mayer & Jackson, 2005).

Mayer et al. (2007) studied the effect of additional information on retention and transfer. The study consisted of 90 college students (53 women, 37 men) from the University of California, Santa Barbara, who were randomly assigned to the concise computer group, the concise paper group, the expanded computer group, or the expanded paper group where the expanded groups included additional explanations on related subjects. Results found a statistically significant difference between the groups where the concise groups performed better on retention and transfer tests than the expanded groups (Mayer et al., 2007).

In their research, Wade et al. (1993) studied 43 college students in an introductory education course at a large public university. Results found a statistically significant main effect for importance where participants recalled more unimportant material than important material. There was also a statistically significant main effect for interest, where participants recalled more interesting material than uninteresting material. The study also found a statistically significant two-way interaction between importance and interest where the highest level of recall was high interest/low importance, the second highest level was high interest/high importance, third was low interest/low importance, and last was low interest/high importance (Wade et al., 1993).

Garner et al. (1991) performed two experiments on undergraduate students. In the first experiment, 48 participants were randomly assigned to four treatment groups (12 in each group) where interesting information was placed in four different locations in four passages: Hawking's Grand Unification Theory, the role of black holes in the origins of the universe. a wager Hawking made with Kip Thorne about black holes, and Hawking's 1974 paper on Grand Unification presented at Oxford. The study found that the interesting, but irrelevant information was remembered more frequently in recall tests than the important information. The second experiment included 228 undergraduate students and replicated the methodology of the first experiment, but participants were tested on physics concepts. The results of this study also found that the irrelevant information was recalled more frequently than the important details; however, if the participant had a high domain knowledge, they were more likely to recall the important details (Garner et al., 1991).

Gemino et al. (2005) studied 72 undergraduate students (45% male, 55% female) that were divided into three groups: the control group, which had content with no graphics; treatment group one, which had content that included irrelevant graphics; and treatment group two, which had content that included relevant graphics. The study found a statistically significant difference in transfer across the treatment groups where group three, the relevant graphic group, scored higher than the other two groups (Gemino et al., 2005).

Researchers Sung and Mayer (2012) studied the effect of additional graphics on learning in 200 South Korean undergraduate students (120 women, 80 men). Participants were randomly assigned to four treatment groups: the instructive graphics group, the decorative graphics group, the seductive group, and the no graphics group. Results found a statistically significant difference for recall where the instructive graphics group (effect size 0.79) scored higher than the other three groups (Sung & Mayer, 2012).

Harp and Mayer (1997) studied irrelevant text and illustrations and their effect on recall and transfer. The study included 74 college students from the University of California, Santa Barbara, who were randomly assigned into four groups: the base group, the base-plus-seductive-text group, the base-plus-seductive-illustrations group, and the base-plus-seductive-text-plus-seductive-illustrations group. Results found a statistically significant difference where the base group recalled more relevant ideas and generated more creative transfer solutions than the other three groups (Harp & Mayer, 1997).

In their study, Lehman et al. (2007) compared 53 undergraduate students in an introductory psychology course at a large western university. Participants were randomly assigned to either the control group, which received the base text and the seductive details group, which included the base text plus the seductive details text. Results found that the seductive details group spent less time on task reading the base text, had lower performance on a recall test, and had lower performance on the deeper processing of the text (Lehman et al., 2007).

Sanchez and Wiley (2006) studied 36 undergraduate students with high working memory capacity and 36 undergraduate students with low working memory capacity from the University of Illinois, Chicago. Results from essay responses found that the students with low working memory performed statistically significantly lower on both recall and inference verification tasks when seductive images were present. The high working memory students performed better on both recall and inference verification tasks when seductive images were included. In a second experiment at the same institution, Sanchez and Wiley (2006) studied five low working memory capacity individuals and five high working memory individuals. Results from this study found that participants with low working memory performed significantly worse on the essay responses but found no statistically significant difference on the inference verification tasks. When tracking eye movements, the high working memory group spent statistically significantly less time looking at the seductive images than did the low working memory group (Sanchez & Wiley, 2006).

Moreno and Mayer (2000a) studied the effect of irrelevant sounds and background music and their effects on retention and transfer. The first experiment included 75 undergraduate students from the University of California, Santa Barbara, who were randomly assigned to four treatment groups: the narration group, the narration plus environmental sounds group, the narration plus music group, and the narration plus environmental sounds plus music group. In this experiment, a statistically significant difference was found for verbal recall and problem-solving transfer in the groups that included music, where the music groups remembered less verbal material, however, there was no statistically significant difference for recall or transfer in the groups that included environmental sounds. The second experiment included 75 undergraduate students from the same institution who were randomly into four treatment groups: the narration group, the narration plus mechanical sounds group, the narration plus music group, and the narration plus mechanical sounds plus music group. This experiment found a statistically significant difference between the groups that included music and the groups that included mechanical sounds, where less recall and problem-solving transfer occurred in the groups that included music and/or mechanical sounds (Moreno & Mayer, 2000a).

In their research, Thompson et al. (2012) studied the effect of background music and reading comprehension in 25 undergraduate students (16 female, 9 male) ranging in age from 17 to 26 years. Results found that when background music was played fast and loud, reading comprehension was lower (Thompson et al., 2012).

Lehman and Seufert (2017) studied the interaction of background music and working memory capacity on learning using 86 university students (71 female, 15 male) between 16 and 50 years of age. The study found a statistically significant difference for participants in the group with no background music where they had higher comprehension outcomes than the group that included background music, however, they found no statistically significant difference for the two groups for recall (Lehman & Seufert, 2017).

In their research, Bartsch and Cobern (2003) found in their first study of 39 undergraduate students in a Social Psychology class from the University of Texas of the Permian Basin, there was a statistically significant difference between the PowerPoint presentation that had added irrelevant sound effects and the presentation that did not, where the students who received the content with added sound effects scored lower on the quiz. In their second study, Bartsch and Cobern (2003) compared 27 undergraduate students from the same institution, a statistically significant difference was found in recall and recognition between the group that had PowerPoint slides that included unrelated graphics and the groups that had slides with text only or had slides that included only relevant graphics, where the latter two groups had better recall and recognition than the group that had content with irrelevant graphics (Bartsch & Cobern, 2003).

In contrast, Muller et al. (2008) studied 104 Australian high school and first-year university astronomy students in an authentic online learning environment. Results found no statistically significant difference in learning performance between the group receiving the concise content and the group receiving the extended content that included seductive details (Muller et al, 2008).

Wiggins (2013) randomly assigned 67 undergraduate and graduate college students (31 native English speakers, 36 non-native English speakers) into three groups: a group with only essential content, a group with non-essential background music, or a group with non-essential background images. The study found no statistically significant difference in test scores between the control group (essential information only) and the experimental groups (non-essential background music and images) (Wiggins, 2013).

Gunnell (2017) randomly assigned 87 university media production course students to one of three treatment groups: narration only, narration with non-designed music which contained music that had no relationship to the content, and narration with designed music which was composed with regards to the speed and narration of the content. No statistically significant difference was found in retention scores, cued-retention scores, or transfer scores between the three groups (Gunnell, 2017).

Fenesi et al. (2016) in a study of 71 first-year McMaster University undergraduate students (26 male, 45 female), randomly assigned participants into either a group that included images congruent with the narration or a group that included images incongruent with the narration. The results found no statistically significant difference in comprehension between the two groups. However, the study did find that participants with lower working memory capacity in the incongruent group performed significantly lower on recognition and applied questions (Fenesi et al., 2016).

In their study, Doolittle and Altstaedter (2009) randomly assigned 106 undergraduate students (74 men, 32 women) into two groups: the animation and narration group or the animation, narration, and seductive details group which included background sounds and additional graphics. Results found no statistically significant main effect for recall or transfer tests between the group that had only narrated animation and the group that had narrated animation with seductive details (Doolittle & Altstaedter, 2009).

Mayer et al. (2008) studied the effects of adding high interest details on transfer and retention. The first experiment included 89 college students (30 men, 59 women) from the University of California, Santa Barbara, who were randomly assigned to one of six groups: the low booklet group, the high booklet group, the low PowerPoint group, the high PowerPoint group, the low narrated animation group, and the high narrated animation group. Results found a statistically significant difference between the groups that had low interest details added and the groups that had high interest details added regardless of presentation format, where the low interest groups had higher transfer scores (effect size 0.80). However, there was no statistically significant difference found in retention scores between the groups. In the second experiment, 53 college students from the same institution were randomly assigned to the low interest detail group or the high interest detail group, the study found that the low interest group performed statistically significantly better on transfer tests than the high interest group (effect size 0.86). As in the first experiment there was no statistically significant difference in retention scores between the two groups (Mayer et al., 2008).

The research cited above shows that the consensus is that the signaling, redundancy, spatial contiguity, temporal contiguity, and coherence principles help reduce extraneous processing which leads to higher learning outcomes. Mayer and Fiorella (2014) suggested that these principles need more testing in a real classroom environment rather than in a laboratory environment. The type of cue used, as well as the use of a dynamic or static cue requires more research (Mayer & Fiorella, 2014; van Gog, 2014). Mayer (2021) stated that studies have shown that the type of signaling (verbal, visual, auditory) is only effective in certain circumstances. Mayer also suggested that signaling may be particularly useful when used sparingly, when the learner has less knowledge, and when the multimedia lesson is disorganized or contains a significant amount of extraneous material (2021). Redundant on-screen text might be beneficial to non-native speakers, learners with hearing disabilities, learners with low prior knowledge, learners who have received pretraining on key concepts, or when presentation pace is slow or is learner-controlled (Clark & Mayer, 2016; Mayer & Fiorella, 2014). Mayer (2021) and Mayer and

Fiorella (2014) also stated that redundant text may be beneficial when no graphics are included, when the captions are shortened to a few words placed directly next to the graphic they describe, or when words are unfamiliar or in a second language. Spatial contiguity is most beneficial when the material is complex, the diagram needs words to be understandable, and the learner has low prior knowledge (Mayer, 2021). Temporal contiguity needs to be tested for time limits, meaning is it effective when the timing is simultaneous or is it still effective if there are a few seconds difference (Mayer & Fiorella, 2014). Mayer (2021) stated that this principle may be less effective when the lesson contains short segments or when the lesson is under learner control. Ayres and Sweller (2014) and Kalyuga et al. (2000) stated that contiguity tends to effect low knowledge learners more, and in high knowledge learners it may create an expertise reversal effect, meaning that the spatial and temporal contiguity principles may have a positive effect on low knowledge learners, but a negative effect on high knowledge learners. The coherence principle, which is the focus of this study, may be particularly harmful to low knowledge learners or those with low working memory capacity, and when the extraneous material is particularly interesting (Clark & Mayer, 2016; Mayer, 2021). It may also produce an expertise reversal effect in high knowledge learners (Mayer & Fiorella, 2014). Additional research needs to be done on the coherence principle to understand if students may learn to ignore the irrelevant material or whether signaling the relevant material negates its effect (Clark & Mayer, 2016). The coherence principle's effects on games and simulations, such as the use of music and sound effects, is also a topic in need of additional study (Mayer, 2014c).

Game-Based Learning. Using games as a teaching tool is not a new concept (Botturi & Loh, 2008; Kapp, 2012). Botturi and Loh (2008) have dated the mention of playing and games as far back as to the times of the Greek philosopher Heraclitus. Kapp (2012) stated that there is a belief among many historians that the seventh century game Chaturanga might have been used as a war game simulation to train military personnel. Studies have shown that game-based learning positively affects student motivation, engagement, attitudes, enjoyment, flow, and attention (Vankus, 2021).

There is a gap in the literature regarding game-based learning violating the coherence principle, but still increasing learning. Suggesting that there is another factor that has a stronger influence over learning. The next section will examine possible affective domain reasons for this.

Motivation

Mayer (2011) defines motivation to learn, also called academic motivation, as a learner's "internal state that initiates and maintains goal-directed behavior" (p. 39). This makes academic motivation personal, as it occurs within the learner; activating, as it triggers the act of learning; energizing, as it promotes perseverance and excitement during learning; and directed as it puts focus on achieving a learning goal (Mayer, 2011, 2014b). Mayer (2011) also stated that academic motivation correlates with the amount of effort the learner exerts to make sense of the material presented. Meaningful learning occurs when the learner exerts enough effort to cognitively process the learning materials appropriately.

Tseng and Walsh (2016) suggested that "learners in the 21st century desire the opportunity to learn using a digitally rich curriculum and to interact using web-communication and Web 2.0 technologies" (p. 50). Phipps and Merisotis (1999) stated that regarding student learning and satisfaction in online learning "technology is not nearly as important as other factors, such as learning tasks, learner characteristics, student motivation, and the instructor" (p. 8). These researchers also suggested that the most successful learners in an online environment tend to already be motivated, independent, and organized (Phipps & Merisotis, 1999). Peck et al.

(2018) stated that motivation and self-regulation issues may be “significant factors in academic success when students are separated from each other and from the instructors” (p. 2).

This review of literature found three studies which showed that e-learning motivates learners and improves learning outcomes (Ajayi & Ajayi, 2020; Canty et al., 2019; Tseng & Walsh, 2016). However, it also found four studies that failed to show that e-learning is motivating or that it improves learning outcomes (Horspool & Lange, 2012; Means et al., 2010; Rasmussen et al., 2014; Watkins et al., 2019). Extrinsic motivators have also been shown to have a strong influence on a student’s decision to enroll in online courses (Clayton et al., 2010; Peck et al., 2018).

Tseng and Walsh (2016) studied 26 students (13 male, 13 female) from two blended format courses and 26 students (18 male, 8 female) from two traditional format courses. Results found that participants in the blended courses reported statistically significantly higher overall learning motivation than participants in the traditional courses. Results also found that participants in the blended courses scored statistically significantly higher on their final grades than participants in the traditional courses (Tseng & Walsh, 2016).

Canty et al. (2019) studied 145 participants in a cardiac ultrasound course who were divided into two groups: human model (traditional) group and self-directed simulator group. Study results found that the self-directed simulator group had superior image acquisition skills than the human model group (Canty et al., 2019).

Ajayi and Ajayi (2020) performed a quasi-experimental study on 38 post-graduate students in Science Education from two universities in Nigeria. Results found a statistically significant difference in the posttest mean scores of the experimental (online collaboration component) and control groups (no online component) where the experimental group performed better than the control group. Study results also found that the experimental group was statistically significantly better at retention ability (Ajayi & Ajayi, 2020).

In contrast, Watkins et al. (2019) studied 98 students (29 online, 69 flipped classroom) in a 200 level Family Diversity undergraduate course in the spring 2014, summer 2014, fall 2014, and spring 2015 semesters using a mixed methods design. Results found no statistically significant difference for motivation between the flipped classroom and the online course. Results also found a statistically significant difference where the students in the online course performed worse than those in the flipped classroom on hot topic presentations (Watkins et al., 2019).

Rasmussen et al. (2014) found more mixed results when they performed a meta-analysis that included 4,955 students in 49 studies. Eleven studies found higher learning outcomes in e-learning groups compared to traditional learning groups. Twenty-one studies found no statistically significant differences or found mixed results between e-learning and traditional groups (Rasmussen et al., 2014).

In a meta-analysis of 50 experimental or quasi-experimental design studies that included effect size, Means et al. (2010) found that classes that were fully online or blended produced stronger learning outcomes on average than face-to-face classes (overall effect size $d = 0.20$). While the effect size for K-12 learners was not found to be statistically significant, the effect size was statistically significant for undergraduate students (0.30) and graduate students and professionals ($d = 0.10$). A larger effect size was found for those studies comparing hybrid learning to face-to-face instruction ($d = 0.35$) than for studies comparing strictly online to face-to-face instruction ($d = 0.05$) (Means et al., 2010).

Horspool and Lange (2012) studied 88 students taking an online course and 64 students taking a face-to-face course in the Principles of Microeconomics. Their results found no statistically significant difference in overall course grades between the online and face-to-face groups (Horspool & Lange, 2012).

Other studies have shown that there are extrinsic motivators that influence a student's decision to take online classes (Clayton et al, 2010; Peck et al., 2018). Clayton et al. (2010) surveyed 132 students (20 male, 112 female) from two New York City urban public colleges. Their research showed that students' motivations for taking online courses were motivated by family/personal schedules, jobs, and personal control (Clayton et al., 2010). Peck et al. (2018) found that 67% of their study participants claimed that it was extrinsic motivators that prevented them from dropping out of the distance education program.

The research cited above shows that there have been mixed results on how e-learning affects learner motivation and/or learning outcomes. While some studies show that e-learning has a positive effect, others have shown that it has no effect on student motivation or achievement. Regardless of the type of learning environment, Mayer (2011) stated that for meaningful learning to take place, the learner must be motivated to actively engage in the appropriate cognitive processes (selecting, organizing, and integrating) to properly make sense of the learning content.

One of the most meaningful ways to foster learning in computer-based multimedia learning environments is to increase the learner's interest which enhances their engagement in cognitive processing (Mayer, 2021; Mayer et al., 2004). Mayer (2011) defined motivation as "an internal state that initiates and maintains goal-directed behavior" (p. 131). Academic motivation or the motivation to learn is dependent upon the amount of effort exhibited by the learner to make sense of the material (Mayer, 2011). Generative processing is directly affected by the learner's motivation to learn (Mayer, 2014b). Mayer (2021) and Huang & Mayer (2016, 2019) suggested that there are design principles for multimedia learning that might increase students' motivation.

This review of literature found three studies which showed that multimedia motivates learners and improves learning outcomes (Ajayi & Ajayi, 2020; Canty et al., 2019; Tseng & Walsh, 2016). However, it also found four studies that have shown no difference or that including multimedia has a negative effect on student motivation and/or student achievement (Huang & Mayer, 2016; Sung & Mayer, 2013).

Liu et al. (2017) studied 45 (19 male, 26 female) 9 to 10-year-old Taiwanese elementary students from an urban public elementary school program for English as Foreign Language learners. The experimental group used the re-mix approach to creatively generate online artifacts to form new stories from the model stories. The control group retold the model stories. The results found that students in the experimental group were statistically significantly more intrinsically motivated than students in the control group (Liu et al., 2017).

Junaidu (2008) studied 700 computer science and computer engineering undergraduate students enrolled in an online Data Structures course over a five-year period. Results found that students performed better when the algorithm educational materials included animations (Junaidu, 2008).

Huang and Mayer (2019) studied 142 students (73 lab participants, 69 online participants) recruited from a mid-western U. S. university. The goal of the study was to increase motivation by increasing self-efficacy and reducing anxiety using four specific motivation design features: modeling examples, imagination or mental practice, attributional feedback, and math anxiety coping strategy. The participants were assigned to four groups: lab treatment group (35), lab control group (38), online treatment group (36), and online control group (33). Results found that the anxiety reducing design features did statistically significantly reduce anxiety. Results also found that the treatment group reported statistically significantly higher post self-efficacy than the control group. Negative correlations were found between self-efficacy and anxiety, and anxiety with posttest performance. There was a positive correlation between self-efficacy and posttest performance (Huang & Mayer, 2019).

Ellis (2004) studied an animated multimedia presentation and its effect on learning. Participants included 38 men and women ranging in age from 25 to 50 at a private, two-year college randomly assigned to the control group (classroom presentation) and the experimental group (animated multimedia presentation). Results found that there was a statistically significant difference between the control and experimental groups where the experimental group scored higher on a posttest for the ability to apply new information to solve a problem (Ellis, 2004).

By contrast, Huang and Mayer (2016) studied 54 undergraduates at a Midwest U. S. university. Participants were randomly assigned to two groups: control group (28) and treatment group (26). Two anxiety coping strategies were added to a statistical multimedia lesson for the treatment group. The anxiety coping methods included an anxiety coping message delivered by a pedagogical agent to the students before they started the treatment and an expressive writing activity students completed after the treatment but prior to the posttest. Results found no statistically significant difference in anxiety levels between the groups. The treatment group did perform statistically significantly better on the retention test, but there was no statistically significant difference in performance on the transfer test. Lastly, results found no statistically significant difference in self-efficacy or cognitive load between groups (Huang & Mayer, 2016).

Sung and Mayer (2013) studied 89 college students (34 male, 55 female) from the Psychology department at the University of California, Santa Barbara. Participants were divided into four groups: desktop-standard (24), desktop-enhanced (24), mobile-standard (20), and mobile-enhanced (21). Results found no statistically significant difference between groups for method regarding motivation (Sung & Mayer, 2013).

The studies mentioned above demonstrate that multimedia learning may increase student motivation and learning outcomes. Other research has shown that multimedia has either no effect or a negative impact on motivation and learning outcomes. Mayer (2011, 2021) stated that well designed multimedia presentations increase academic motivation and promote active cognitive processing resulting in meaningful learning.

Kapp (2012) stated that games are well known for their ability to motivate their players. Mayer (2014c) stated that the "challenge of effective game design is to use game features that promote motivation to learn, but do not disrupt the appropriate cognitive processing during learning; and use instructional features that prime appropriate cognitive processes during learning, but do not shut down the player's motivation to learn" (p. 79).

Bell (2018) stated that there are elements inherent to games that may be designed into the development of learning materials that will improve student motivation and learning outcomes. Pawar et al. (2019) stated that the "most important function of game mechanics in educational games is to facilitate learning. Meaningful learning activities are introduced to learners when appropriate game mechanics are implemented based on learning mechanics" (p. 356).

This review of literature found 12 studies which showed that game-based learning may be motivating to learners and improve learning outcomes (Beylefeld & Struwig, 2007; Blakely et al., 2009; Brady & Devitt, 2016; Budasi et al., 2020; Clark et al., 2016; Eltahir et al., 2021; Hung et al., 2014; Ozturk & Korkmaz, 2020; Randel et al., 1992; Rondon et al., 2013; Sabirli & Coklar, 2020; Su & Cheng, 2013). In contrast, it also found five studies stating that game-based learning has no effect or even an adverse effect on motivation and learning outcomes (Blakely et al., 2009; Randel et al., 1992; Rondon et al., 2013; Souza et al., 2020; Tham & Tham, 2014).

Sabirli and Coklar (2020) studied 90 Saricam public primary school students in the 2017-2018 school years using a pretest/posttest control group quasi-experimental research design. The control group (24 male, 21 female) used no English educational games and the experimental group (26 male, 19 female) used English educational games. A statistically significant difference was found in motivation scores between the control group and the experimental group. While both groups saw a statistically significant increase in motivation after the treatment, the experimental group saw a higher increase in motivation scores than the control group. The study also found a statistically significant difference between the control group and the experimental group where the experimental group had a higher level of academic success (Sabirli & Coklar, 2020).

Brady and Devitt (2016) studied 34 postgraduate students in a business master's program using a qualitative design. Findings from the data strongly suggest that the business simulation game promoted higher order cognitive skills (Brady & Devitt, 2016).

Eltahir et al. (2021) studied game-based learning using Kahoot! and its effects on motivation to learn Arabic language grammar. Participants included 107 (54 game-based learning group, 53 control group) College of Humanities and Sciences students at Ajman University. Results found that participants in the game-based learning group were highly motivated (M = 4.16). The study also found a statistically significant difference between student achievements where participants in the game-based learning group scored higher on the posttest (Eltahir et al., 2021).

Hung et al. (2014) conducted a quasi-experimental study of 68 fifth grade elementary math students who were assigned to three groups: experimental group A (11 male, 12 female), experimental group B (12 male, 11 female), and the control group (13 male, 10 female). Group A received the digital game-based learning approach, group B received the technology-enhanced learning approach, and the control group received the traditional instruction approach. The study found that there was a statistically significant difference in motivation between group A and the other two groups, where group A had higher learning motivation (Hung et al., 2014).

Budasi et al. (2020) studied motivation in learning English using 84 fourth grade elementary students in Denpasar using a posttest only, control group, quasi-experimental design. Results found a statistically significant difference between the experimental group (40, PowerPoint game) and the control group (44, no game) where the students in the experimental group were more motivated than those in the control group (Budasi et al., 2020).

Ozturk and Korkmaz (2020) studied 60 fifth grade students and their achievement scores in social studies in a game-based learning environment. A quasi-experimental design with pretest/posttest and a control group was used. The control group (14 female, 15 male) had traditional course content and the experimental group (13 female, 18 male) used traditional content with the addition of a game. Results found a statistically significant difference in achievement scores in favor of the experimental group (Ozturk & Korkmaz, 2020).

Clark et al. (2016) looked at 69 empirical studies dating from January 2000 to September 2012 that included students in K-16 with ages ranging from six to 25 and totaled 6,868 participants. It was found that in 57 of those studies there were statistically significant differences indicating that students learning with digital games or augmented reality games had better learning outcomes than those in non-game-learning environments. Overall learning outcomes had an effect size of 0.33, while both cognitive and intrapersonal competencies had a mean effect size of 0.35 (Clark et al., 2016).

Beylefeld and Struwig (2007) studied 100 third-year students who had completed a module on infectious diseases in November 2002. Results found that after playing the Med Micro Fun with Facts game, students showed increased motivation by doing additional work, such as additional reading and participating more in discussions (Beylefeld & Struwig, 2007).

Su and Cheng (2013) studied 63 (47 male, 16 female, average age 20-21) software engineering college students randomly assigned into a game-based learning group and a traditional face-to-face group. Results found that the game-based learning group showed a statistically significant difference between their pretest and posttest scores. The traditional group showed no statistically significant difference between their pretest and posttest scores (Su & Cheng, 2013).

Randel et al. (1992) found in their meta-analysis that out of 68 empirical studies performed between 1963 and 1991, 38 (56%) found no difference between games and traditional instruction and 22 (32%) found that games did have a positive effect on student performance. Math, language arts, and some of the hard sciences reported a statistically significant difference in learning outcomes favoring games. While games teaching the social sciences showed no statistically significant difference in learning outcomes over traditional instruction (Randel et al., 1992).

Blakely et al. (2009) reviewed 15 studies on game-based learning in the health sciences. Overall, the studies reported that participants in the game-based groups had higher levels of motivation than those in the control groups. In contrast, in seven of the studies where long-term retention was studied, four studies found a statistically significant difference where game-based learning had a positive effect on outcomes. Three studies found no statistically significant difference between the game-based and control groups (Blakely et al., 2009).

Souza et al. (2020) studied 23 students in a neuroanatomy course randomly assigned into seven teams of three and one team of two. Results found no statistically significant difference between the virtual reality groups and the synthetic (viewed on a projector) groups for learning and knowledge retention (Souza et al., 2020).

Tham and Tham (2014) used a qualitative design to study 36 year three, full-time students (25 male, 11 female) in a Contemporary Issues in IT course from an institute of higher learning in Singapore. Results found that 22 participants found the game to be motivating. Nine participants were motivated by the rewards given for playing the game, not the game itself. The remaining five participants were motivated by achieving good grades in the course and were not interested in playing the game (Tham & Tham, 2014).

Rondon et al. (2013) studied 29 Speech-Language and Hearing Science undergraduate students at the School of Medicine of Sao Paulo. Participants were randomly assigned to either the game-based learning group (15) or the traditional learning method group (14). Results found that the game-based learning group performed statistically significantly better in the posttest assessment anatomy questions. The traditional group performed statistically significantly better on posttest and long-term posttest assessments when considering both the anatomy and physiology questions (Rondon et al., 2013).

The research presented above exhibits that game-based learning may be motivating to learners and improve learning outcomes. However, studies have also shown that game-based learning has no effect/negative effect on motivation and learning outcomes. Mayer (2014c) stated that games academically motivate learners by stimulating the most productive parts of a player's interests, beliefs, goals, and needs. Effective game design will use game features that stimulate the motivation to learn and activate the appropriate cognitive processes during learning (Mayer, 2014c).

Engagement

Student disengagement in e-learning courses is a serious concern (Alsubhi et al., 2019; Khaleel et al., 2017). Prensky (2005) suggested that today's learners are fundamentally different due to the "arrival and rapid dissemination of digital technology in the last decades of the twentieth century" (p. 98). These learners have grown up surrounded by this technology and they "think and process information in fundamentally different ways" than previous generations (Prensky, 2006, p. 28). Quinn (2005) declared that students want to be engaged where they are "cognitively and affectively connected to the learning experience" (p. 12). Prensky (2007) stated that while distance learning is a major part of a training and education experience, the blending of fun and engagement with serious learning is the most important way to actively involve the learner in the learning process.

Clark and Mayer (2016) defined two types of engagement: behavioral and psychological. Behavioral engagement is action taken by the learner during an instruction session. Psychological engagement is the cognitive processing of learning material that leads to the achievement of the learning objective by the learner. Psychological engagement is necessary for learning to occur, whereas behavioral engagement is not needed (Clark & Mayer, 2016). Bell (2018) stated that engagement has "long been identified as an essential precursor of student success in face-to-face and online classes" (p. 28).

Chen et al. (2008) stated that engagement is associated with several positive results, including better learning outcomes, higher student satisfaction, and persistence. Greeno et al. (1996) suggested that when students become active participants in the learning process, it promotes engagement. Csikszentmihalyi (1990) described a person who is fully mentally involved and continually engaged in an activity, such as when playing a game, as in a state of flow.

This review of literature found four studies which showed that e-learning engages learners (Chen et al., 2010; Marcus et al., 2021; Pellas & Kazanidis, 2015; Robinson & Hullinger, 2008). However, one other study failed to show that e-learning is engaging (Stewart & Lowenthal, 2021).

Chen et al. (2010) studied 17,819 students (6,122 male, 11,649 female) from 45 U. S. baccalaureate degree-granting institutions. Their results found a positive correlation between student engagement and course-related technology in on-line and hybrid courses (Chen et al., 2010).

Pellas and Kazanidis (2015) compared 125 trainees (40 female, 85 male) with 70 enrolled in the blended instruction and 55 in the online instruction. The study results have shown that graduate students of online instruction had significant positive results online method, rather than those who participated with the blended method. The study results also revealed that the overall engagement level of the graduate students in the online instruction had significantly higher levels of engagement in various learning tasks than the undergraduates who enrolled in the blended instruction (Pellas & Kazanidis, 2015).

Robinson and Hullinger (2008) studied 86 men and 115 women undergraduates enrolled in at least one online class at Oklahoma State University, Capella University, and Northeastern

State University. The study found that online students reported higher levels of engagement than freshmen and seniors who attended face-to-face courses (Robinson & Hullinger, 2008).

Marcus et al. (2021) compared 22 Malaysian undergraduate students who participated in one of the e-service learning courses. Results found that students felt more engaged and more motivated when using the online platform ClassDojo (Marcus et al., 2021).

In contrast, Stewart and Lowenthal (2021) in their qualitative study interviewed 14 undergraduate and one graduate exchange students in the Republic of Korea during the COVID-19 pandemic. Results found that in most of the e-learning courses, engagement was lacking (Stewart & Lowenthal, 2021).

The research cited above shows that e-learning may help to engage learners. This review of literature also found two studies which showed that e-learning may have the opposite effect on learners and cause a disconnect between the student and their interest in the content being taught (Alsubhi et al., 2019; Nortvig et al., 2018).

Wankel and Blessinger (2013) stated that increased motivation and academic success should be the goal when using multimedia technologies. These tools should enhance the learning experience by “allowing students to engage in such ways that is more interesting and meaningful and authentic to them” (Wankel & Blessinger, 2013, p. 4).

This review of literature found six studies that have shown that including multimedia in instruction is engaging to students (Chipangura & Aldridge, 2017; Liu & Elms, 2019; Liu et al., 2017; Mandernach, 2009; Moen, 2021; Sadik, 2008). It also found two other studies that have shown no difference or that including multimedia has a negative effect on student engagement (Li, 2019; Moen, 2021).

Chipangura and Aldridge (2017) studied 365 students and the effect of multimedia material on student engagement in science and mathematics courses. Students were assigned to either the frequently exposed to multimedia group (197 participants) or the infrequently exposed to multimedia group (168 participants). Results found that students in the frequently exposed group were more engaged than students in the infrequently exposed group (Chipangura & Aldridge, 2017).

Sadik (2008) studied students from two private Basic Education schools in Qena. Results found that student motivation and engagement in story development increased using a multimedia tool for storytelling (Sadik, 2008).

Mandernach (2009) performed a quasi-experimental study on four sections of an introductory general psychology course. Participants were divided into four groups: control (14), video (6), audio PowerPoint (13), and video PowerPoint (18). Qualitative results found that students felt more engaged when instructor generated multimedia presentations were included (Mandernach, 2009).

Liu and Elms (2019) studied the impact of cartoon instructional videos on student engagement. These researchers surveyed 254 undergraduate students in a final year accounting course at an Australian university over two semesters and found that 72% of the participants strongly agreed that the animated videos stimulated their interest in the educational content (Liu & Elms, 2019).

Liu et al. (2017) studied 45 (19 male, 26 female) 9 to 10-year-old Taiwanese elementary students from an urban public elementary school program for English as Foreign Language learners. The experimental group used the re-mix approach to creatively generate online artifacts to form new stories from the model stories. The control group retold the model stories. The results found that students in the experimental group which contained interactive multimedia content were statistically significantly more engaged than students in the control group (Liu et al., 2017).

In contrast, Li (2019) studied 59 third-year computer science undergraduate students enrolled in a Mobile Phone Programming to Learn Windows Phone programming course. Results found no statistically significant difference for engagement level between low knowledge and high knowledge students learning from video lectures (Li, 2019).

Moen (2021) studied 58 participants (33 female, 23 male, two non-binary) enrolled in a general psychology course. Results found no differences between the picture-only and the text plus picture presentations for how engaging or interesting the presentation was. However, participants did rate the text plus picture presentation more engaging, but they rated the picture only presentation more interesting (Moen, 2021).

The studies mentioned above demonstrate that including multimedia in instruction may increase student’s feelings of engagement. This review of the literature found one other study that found no difference in feelings of engagement between students who had multimedia included in their instruction and those who did not. Including multimedia technologies will not ensure increased student engagement and retention (Wankel & Blessinger, 2013). However, if they are used in a purposeful manner, include clearly defined learning objectives, and are used in a way that is meaningful to the students, they are likely to generate more effective learning through increased engagement (Sadik, 2008; Wankel & Blessinger, 2013).

As stated previously by Mayer (2011) meaningful learning occurs when the learner exerts enough effort to cognitively process the learning materials appropriately. Game-based learning may increase four types of cognitions learners bring to a learning experience: interests, beliefs, goals, and needs (Mayer, 2014c).

Csikszentmihalyi (1990) describes eight components that help people obtain a flow state: achievable task, concentration, clear goals, feedback, effortless involvement, control over actions, concern for self disappears, and loss of sense of time. Kapp (2012) stated that the “ideal goal of game designers is to shape the instructional games they develop so it is possible for players to enter into a state of flow” (p. 73).

This review of literature found 10 studies which showed that game-based learning may be engaging to learners and improve learning outcomes (Beylefeld & Struwig, 2007; Bodnar et al., 2016; Bodzin, 2020; Eltahir et al., 2021; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Tham & Tham, 2014; Wronowski et al., 2020). On the other hand, it also found six studies which showed that game-based learning has no effect or even an adverse effect on engagement or learning outcomes (Bodnar et al., 2016; Isiaq & Jamil, 2018; Khan et al., 2017; Kim & Chang, 2010; Wronowski et al., 2020; Zhang et al., 2021).

Bodzin et al. (2020) studied 54 students ages 16 to 18 in an Eastern United States urban school environmental science class. The study found adolescent learners demonstrated a high level of engagement and flow when using the watershed immersive virtual reality game (Bodzin, 2020).

Eltahir et al. (2021) studied game-based learning using Kahoot! and its effects on engagement in learning Arabic language grammar. Participants included 107 (54 game-based learning group, 53 control group) College of Humanities and Sciences students at Ajman University. Results found that participants in the game-based learning group were highly engaged ($M = 3.57$) (Eltahir et al., 2021).

Wronowski et al. (2020) studied 218 undergraduate students from a four-year research-intensive institution enrolled in an entry level statistics course. Results found a statistically significant difference in engagement between the intervention (game) group and the control (no game) group, where the intervention group reported higher engagement, absorption, and interest in statistics. However, results found no statistically significant difference in overall statistics knowledge between the intervention group and the control group (Wronowski et al., 2020).

Beylefeld and Struwig (2007) studied 100 third-year students who had completed a module on infectious diseases in November 2002. Results found that after playing the Med Micro Fun with Facts game, students reported feeling more engaged. Seventy-five percent of participants reported they were pleasantly preoccupied while playing the game (Beylefeld & Struwig, 2007).

Nadolny and Halabi (2016) studied 71 undergraduate students (43 female, 28 male) in a game-based learning structured course in fall 2013. Results found that the course maintained a high level of participation and persistence with an average lab attendance of 91% and an average lecture attendance of 92% compared to a previous non-game-based learning version of the course where attendance averaged between 65-70% (Nadolny & Halabi, 2016).

Hays (2005) looked at 48 empirical studies performed between 1973 and 2005 and found that research has shown that games may improve learning in relation to certain subjects, such as math, sociology, physics, and nutrition facts. However, Hays found that most of these studies had methodological flaws that made it difficult to draw valid conclusions about the effectiveness of using games (2005).

Khan et al. (2017) compared 72 eighth grade participants from a low-cost private school in suburban Islamabad Capital Territory, Pakistan. Results found a statistically significant difference between the control and treatment (game-based learning) groups where the treatment groups had more fun and were more excited while playing the game application than the control groups. The study did not find a statistically significant difference in posttest scores between groups (Khan et al., 2017).

In contrast, Tham and Tham (2014) used a qualitative design to study 36, year 3, full-time students (25 male, 11 female) in a Contemporary Issues in IT course from an institute of higher learning in Singapore. Results found that 22 participants found the game to be fun and engaging and preferred playing the game over having a lecture. Nine participants found the game enjoyable but were more interested in the rewards earned by playing the game. The remaining five participants were uninterested in playing the game (Tham & Tham, 2014).

Kim and Chang (2010) used the National Assessment of Educational Progress (NAEP) 2005 U. S. dataset to study the effect of math computer games on math learning outcomes. The total number of students used for the analysis was 3,732,411. Students who reported they played math games sometimes showed high math scores ($r = 0.031$, $p < .01$) while students who played math games every day showed low math scores ($r = 0.028$, $p < .01$) (Kim & Chang, 2010).

Zhang et al. (2021) studied 53 participants (18 females, 35 males) and their engagement over a five-month period using a gamified app. The study found that use of the app decreased over time from 37 data entries per participant initially to approximately five data entries per person after the initial five weeks. Indicating that students were less engaged over time (Zhang et al., 2021).

Bodnar et al. (2016) performed a systematic review of the literature on game-based learning used in undergraduate engineering courses. Results found that 54 of the 62 studies (87%) reported some degree of improvement of learning outcomes when game-based learning was used. The remaining eight studies (13%) found no statistically significant difference in learning outcomes between game-based learning and other instruction methods (Bodnar et al., 2016).

Isiaq and Jamil (2018) studied 53 students (32 simulator group, 21 traditional group) in a university in the United Kingdom. Results of the mixed methods study found that the simulator group had higher behavioral and emotional engagement scores than did the traditional group. However, cognitive engagement scores were lower in the simulator group than in the traditional group (Isiaq & Jamil, 2018).

The research presented above exhibits that game-based learning may be engaging to learners. Additional studies found that students were either not interested in playing games or interest was lost over time. Ryan and Rigby (2019) stated that the goal of game-based learning is to “foster the kind of engagement that involves active and motivated assimilation and greater integration of knowledge” (p 156).

Attitudes

Student emotions, attitudes, and beliefs may influence student success (Rosenberg et al., 2005). Bandura (1986) suggested that it is not attitude that influences behavior, but “experiences accompanying changes in behavior that alters attitudes” (p. 160). Attitudinal and behavioral changes are more likely to occur when conditions are created that promote the desired behavior (Bandura, 1986).

This review of literature found 10 studies that have shown that e-learning improves learner attitudes, retention, and learning outcomes (Bailey et al., 2018; Dobbs et al., 2017; Fidalgo et al., 2020; Hanney & Newvine, 2006; Kurt & Yildirim, 2018; Levy, 2007; Malkawi et al., 2020; McDonough & Marks, 2002; Nelson, 1999; Tseng & Walsh, 2016). However, it found

13 other studies that failed to show that e-learning positively affects student attitudes, retention, or learning outcomes (Alhamwi et al., 2020; Bains et al., 2011; Carver & Kosloski, 2015; Clayton et al., 2010; Community College Research Center, 2013; Dobbs et al., 2017; Elbasuony et al., 2018; Maki et al., 2000; McDonough & Marks, 2002; Rasmussen et al., 2014; Sitzmann et al., 2006; Sorenson & Donovan, 2017; Summers et al., 2005).

Levy (2007) studied 133 students registered in 18 e-learning courses. Of the 133 participants, 25 dropped out of their courses and 108 completed their courses. Results of the study found that student satisfaction was a statistically significant factor in students' decisions to complete or drop an e-learning course (Levy, 2007).

Kurt and Yildirim (2018) surveyed 31 students attending the third- and fourth-year classes of Elementary Mathematics Teaching in a southeastern Turkey state university during the 2016-2017 academic year. The results of the mixed methods design study found that 97% of the participants were satisfied with the blended learning process (Kurt & Yildirim, 2018).

Tseng and Walsh (2016) studied 26 students (13 male, 13 female) from two blended format courses and 26 students (18 male, 8 female) from two traditional format courses. Results found that participants in the blended courses reported high satisfaction regarding their blended format experience and stated that they would like to take more courses in the blended format (Tseng & Walsh, 2016).

Hanney and Newvine (2006) surveyed 217 students from August 2004 to August 2005 comparing their perceptions of online versus traditional learning. A statistically significant difference was found between student perceptions of course quality in traditional versus online courses, where students perceived online courses were higher quality. Seventy percent reported they preferred taking courses in an online format. Fifty-nine percent of the participants reported their grades were higher in the online format than in the traditional format and 57% reported they felt like they learned more in an online format (Hanney & Newvine, 2006).

Malkawi et al. (2020) studied 532 United Arab Emirates University students (435 female, 97 male) during the 2019/2020 academic year. Results found that the satisfaction level for using e-learning and virtual classes was strong with an overall mean of 5.01 (Malkawi et al., 2020).

Fidalgo et al. (2020) surveyed 55 Portuguese (9% male, 91% female), 98 United Arab Emirates (UAE) (7% male, 93% female), and 70 Ukrainian (43% male, 57% female) undergraduate students between the ages of 17 and 50. The results found that many of the students in the study had a favorable and very favorable (UAE 36.84%, Portugal 58.18%, Ukraine 68.57 %) attitude towards distance education courses. The study also found that 27.27% of the Portuguese, 43.15% of the UAE, and 67.15% of the Ukrainian participants were somewhat interested or extremely interested in enrolling in a distance learning course (Fidalgo et al., 2020).

Dobbs et al. (2017) surveyed 180 students enrolled in upper division criminology and criminal justice courses. Participants who had taken online courses reported that those courses were of good quality (31.3%) or very good quality (39.4%). Approximately half (50.3%) of participants reported that they preferred online courses. A majority (81.8%) said that they would take more online courses in the future. However, although participants had a good attitude about online courses, many participants who had taken online courses reported that they learned only about the same (44.0%) or less (26.4%) in online courses (Dobbs et al., 2017).

Bailey et al. (2018) found that at Houston Community College (HCC), which includes 56,000 community college students, first time freshmen taking at least one fully online course had retention rates that were nine to ten percent higher than students taking only face-to-face courses. HCC also saw up to a 17% higher graduation rate among students who took at least one distance or hybrid course over those students who enrolled only in face-to-face courses. Students in the Kentucky Community and Technical College System, which includes over 100,000 students, were 18% more likely to be retained if they took a mixture of face-to-face and online courses. The students in online courses also saw graduation rates that were 21% better than those students taking strictly face-to-face courses (Bailey et al., 2018).

Nelson (1999) studied distance students enrolled in a telecourse over several semesters. Results found that in the fall 1997 semester, 24 out of 70 (34%) completed the course. In the spring 1998 semester, 27 out of 73 students (36%) completed the course. In the fall 1998 semester 21 of 72 (29%) completed the course. In the spring 1999 semester, 23 of 64 students (36%) completed the course. Retention began to show an increase in fall semester 1998 when an integrated software product was introduced for course support. That semester, seven of the 18 students (39%) completed the course. Finally, spring semester 1999, 10 of the 13 students (77%) completed the course (Nelson, 1999).

McDonough and Marks (2002) studied 37 third-year medical students from King's College Hospital medical school. The students in the study rated computer teaching on average as "fairly educational" and pleasurable; however, participants rated face-to-face teaching statistically significantly more educational and enjoyable than computer teaching. The study also showed that participants who received instruction via a computer performed statistically significantly lower on a posttest than those who were taught face-to-face (McDonough & Marks, 2002).

Some studies found no difference in student attitudes, preference, or satisfaction between online and traditionally formatted courses. Rasmussen et al. (2014) performed a meta-analysis that included 4,955 students in 49 studies. None of the studies found statistically significant differences in attitudes or preferences for e-learning over traditional learning (Rasmussen et al., 2014).

In their meta-analysis, Sitzmann et al. (2006) found that students were equally satisfied with web-based instruction as with classroom instruction. They also found that students who took courses with a blended learning approach reacted six percent less favorably than students who took face-to-face courses (Sitzmann et al., 2006).

In their research, Alhamwi et al. (2020) studied 496 undergraduate dental students (62% male, 38% female) from various Riyadh, Saudi Arabia, universities. Study results found that more than half of the first (91%), second (62%), third (59%) and fourth year (55%) dental students were unsatisfied or highly unsatisfied with their e-learning experience (Alhamwi et al., 2020).

Carver and Kosloski (2015) surveyed 584 high school students (543 face-to-face students, 41 online students) in Washington state. Results showed that there was a statistically significant difference in enjoyment between students taking online courses and students taking face-to-face courses where the students found the face-to-face courses to be more enjoyable (Carver & Kosloski, 2015).

Maki et al. (2000) studied 435 students enrolled in four online and two lecture sections of a general psychology course at Texas Tech University during fall 1998 and spring 1999 semesters. Results found that students in the lecture course found psychology more interesting and expressed greater overall satisfaction than those in the online course. It was also found that students in the online sections were able to answer more questions correctly by the end of the course (Maki et al., 2000).

Elbasuony et al. (2018) studied 80 nursing students at King Khalid University, Saudi Arabia, during the second semester of the 2016/2017 academic year. Results found that 75% were unsatisfied and 25% were satisfied with e-learning and the Blackboard learning management system. Study results also found that 22% had a negative attitude, 44% had a neutral attitude, and 34% had a positive attitude toward e-learning and Blackboard. (Elbasuony et al., 2018).

Summers et al. (2005) studied 38 undergraduate nursing students (17 online, 21 face-to-face) enrolled in a statistics course at a large midwestern university. Results found that the students enrolled in the online course were less satisfied than those enrolled in the traditional course. Results also found no statistically significant difference in learning outcomes between students enrolled in the online course and those enrolled in the traditional course (Summers et al., 2005).

Clayton et al. (2010) surveyed 132 students (20 male, 112 female) from two New York City urban public colleges. The survey found that 73% of participants preferred face-to-face courses, 25% preferred a hybrid format, and 2% preferred an online format (Clayton et al., 2010).

Bains et al. (2011) studied e-learning, face-to-face learning, and blended learning in 90 fourth-year undergraduate dental students. Results found that the was no significant difference in attitude toward blended and face-to-face learning, but e-learning was found to be less preferable than the other two methods (Bains et al., 2011).

A 2011 study by the Community College Research Center at Teacher’s College, Columbia University found that online courses have an eight percent lower retention rate than traditional face-to-face courses (Bell, 2018). The Community College Research Center at

Teacher's College (2013) found that four to five percent of students in the western and southern state systems who took one or more online courses in their first semester were less likely to return the following semester. This study also found that learners who took a higher proportion of online classes were six percent less likely to graduate with an associate degree and four percent less likely to transfer to a four-year institution than students who took a lower proportion of online courses (Community College Research Center, 2013).

Sorenson and Donovan (2017) performed a non-experimental mixed-methods study of 396 former College of Education online undergraduate students from Ashford University who dropped out during the 2013-2014 academic year. There were 18 participants (72% female, 17% male, two did not indicate gender) ranging in age from 25 to 50 interviewed for the study. Their reasons for dropping out included too busy with work and/or family (39%), not receiving necessary support from faculty and advisors (38%), the course material was too difficult (28%), not receiving a quality education (22%), and other (need a break, technology issues, disability worsened, misled/misplaced in program) (22%) (Sorenson & Donovan, 2017).

The research cited above showed mixed results for e-learning improving learner attitudes, retention, and learning outcomes. Some studies showed that students enrolled in online courses were satisfied with the format and interested in taking more online courses, others were highly dissatisfied with e-learning and would prefer a face-to-face course format.

Sammons (1995) reported that using multimedia presentations made classes more interesting, exciting, and fun. Smeltzer and Vance (1989) stated using graphics increased interest, perceived comprehension and retention, and information clarity.

This review of literature found eight studies that have shown that including multimedia in instruction improves student attitudes, retention, and learning outcomes (Chipangura & Aldridge, 2017; Draus, 2020; Li, 2019; Karapetian, 2020; Mansouri et al., 2020; Miner & Stefaniak, 2018; Sankey et al., 2011; Sung & Mayer, 2012). It found two other studies which showed no difference or that including multimedia has a negative effect on student attitudes, retention, and learning outcomes (Khan, 1997; Sankey et al., 2011).

Chipangura and Aldridge (2017) studied 365 students and the effect of multimedia material on student perceptions in science and mathematics courses. Students were assigned to either the frequently exposed to multimedia group (197) or the infrequently exposed to multimedia group (168). Results found that students in the frequently exposed group held more positive perceptions of the multimedia learning environment than students in the infrequently exposed group (Chipangura & Aldridge, 2017).

Karapetian (2020) studied the effect on student perceptions of using a multimedia textbook in an English for Specific Purposes (ESP) course. Eighty-seven participants were included in the study (44 in the experimental group, 43 in the control group). The experimental group felt positive about the flipped classroom environment and the use of the multimedia textbook. The experimental group also showed a greater increase in academic performance than the control group (Karapetian, 2020).

Sankey et al. (2011) studied 60 students (68.4% female, 31.6% male) at The University of Southern Queensland. The qualitative results of this study found that students perceive educational material that includes multimedia content, specifically text with narration and/or interactive diagrams, increased their comprehension, understanding, and retention. They also found that type of multimedia content was more interesting and enjoyable to use. However, the quantitative results of this study found no statistically significant difference in learning outcomes between the groups that had learning content that included text, narration, and/or interactive diagrams and those that had text only (Sankey et al., 2011).

Sung and Mayer (2012) studied the effect of additional graphics on learning in 200 South Korean undergraduate students (120 women, 80 men). Participants were randomly assigned to four treatment groups: the instructive graphics group, the decorative graphics group, the seductive group, and the no graphics group. Results found a statistically significantly higher satisfaction rating with any group that included a graphic, regardless of its relevance to the learning material (Sung & Mayer, 2012).

Draus (2020) studied 30 undergraduate and graduate students in an introductory and an advanced Python programming course. Overall, the participants had a positive attitude about the instructional videos being helpful to their learning (mean score 4.5 out of 5) (Draus, 2020).

Li (2019) studied 59 third-year computer science undergraduate students enrolled in a Mobile Phone Programming to Learn Windows Phone programming course. Results found a statistically significant difference for attitudes toward video viewing between low knowledge and high knowledge students learning from video lectures where high knowledge students had a more positive attitude toward video lectures. Results also found a statistically significant difference for learning performance between low knowledge and high knowledge students learning from video lectures where high knowledge students answered more questions correctly on a midterm exam (Li, 2019).

Miner and Stefaniak (2018) surveyed 35 students (24 female, 11 male) at a mid-Atlantic university in the United States. Results showed that students' felt that multimedia video presentations may increase their learning, especially when used as an enhancement to lectures (Miner & Stefaniak, 2018).

Mansouri et al. (2020) studied 80 kidney transplant patients. Their study found that the group that received the multimedia educational materials showed statistically significantly improved quality of life for emotional, fatigue, and uncertainty/fear related factors. No statistically significant improvement was shown for physical symptoms or appearance domains (Mansouri et al., 2020).

Khan (1997) studied students enrolled in a freshman level (group A) and junior level (group B) course at the University of Texas, Brownsville. The multimedia based Interactive Computing Concepts computer assisted learning (CAL) software was implemented to study if it would affect retention rates for a predominately disadvantaged Hispanic student population. Both groups had a corresponding control group that received traditional lecture instruction. The study found that retention rates in group A and its control group remained relatively the same. However, group B showed higher retention rates than its control group (Khan, 1997).

While many of the studies mentioned above demonstrate that including multimedia in instruction improves student attitudes, retention, and learning outcomes. Other research found no difference in student attitudes, retention, and learning outcomes when multimedia was included.

Davis et al. (1992) defined enjoyment as the extent to which an activity is perceived as entertaining and fun without respect to anticipated performance results. Wilson et al. (2017) stated that “games should be fun to play and engaging otherwise players will quickly lose interest and stop playing them” (p. 528). According to Giannakos (2013), player enjoyment is gaming’s most important goal especially in educational games, where “enjoyment measures how the game helps achieve the task-related objectives” (p. 431).

This review of literature found 23 studies that have shown that game-based learning positively effects student attitudes, retention, and learning outcomes (Beylefeld & Struwig, 2007;

Bodzin et al., 2020; Boeker et al., 2013; Budasi et al., 2020; Cagir & Oruc, 2020; Camilleri & Camilleri, 2017; Chiang, 2020; Contreras-Espinosa & Gomez, 2020; Giannakos, 2013; Iten & Petko, 2016; Kanthan & Senger, 2011; Kaplan et al., 2021; Kiron et al., 2020; Krause et al., 2015; Neves da Nova Fernandes et al., 2019; Ozturk & Korkmaz, 2020; Pechenkina et al., 2017; Putra et al., 2021; Reed & Miller, 2020; Tham & Tham, 2014; Vaibhav & Gupta, 2014; Yesilbag et al., 2020; Zhonggen, 2019). On the other hand, it also found seven studies that stated game-based learning has no effect or even an adverse effect on attitudes, retention, and learning outcomes (Castelijn, 2017; Chiang, 2020; Kumar & Lightner, 2007; Luch, 2018; Sabirli & Coklar, 2020; Yesilbag et al., 2020; Zhonggen, 2019).

Cagir and Oruc (2020) studied 30 students in sixth grade in Istanbul in the second term of the 2018-2019 school year. Results found a statistically significant difference in post-application means between the experimental group (lesson with games) and the control group (traditional lesson) where the experimental group method was effective in positively increasing student attitudes about social studies. The study also found a statistically significant difference between the experimental group and the control group where the method applied in the experimental group increases student learning outcomes more than the method applied in the control group (Cagir & Oruc, 2020).

Neves da Nova Fernandes et al. (2019) studied 45 second-year undergraduate nursing students. Results found a positive change in attitude about the elderly after the nurses played the “Aging Nursing Game” as measured by the Kaop scale (Neves da Nova Fernandes et al., 2019).

Putra et al. (2021) studied 73 first-year students (20 male, 53 female) in the Geography Education study program at the State University of Malang. The experimental group (36) received educational content using a mobile augmented reality platform and the control group

(37) received the content using an audio-visual platform. Results found that the mobile augmented reality experience had a positive effect on student attitudes about responsible decision making. Results also found that the experimental group had statistically significantly higher posttest scores than the control group (Putra et al., 2021).

Kanthan and Senger (2011) studied 114 first-year medical students enrolled in Med 102 during 2007-2009 and 77 second-year medical students enrolled in Med 202 during 2008-2009 at the University of Saskatchewan College of Medicine. Two digital games were used in the study: Path to Success and The Path is Right. Satisfaction survey results showed positive feedback for both digital games for both the first- and second-year groups. Results found that game-based learning enhanced overall academic performance as measured by examination test scores for both groups (Kanthan & Senger, 2011).

Camilleri and Camilleri (2017), using a qualitative design, interviewed 41 students at St. Clare’s College, Malta. Interview sessions suggested that students perceived that using the simulation game enhanced their digital skills and competences, as well as their problem-solving, critical thinking, interpersonal, and social skills (Camilleri & Camilleri, 2017).

Bodzin et al. (2020) studied 54 students ages 16-18 in an Eastern United States urban school environmental science class. The study found that 98.1% had positive attitudes toward using the watershed immersive virtual reality game (Bodzin et al., 2020).

Beylefeld and Struwig (2007) studied 100 third-year students who had completed a module on infectious diseases in November 2002. Results found that after playing the Med Micro Fun with Facts game, students reported being more enthusiastic and having a more positive attitude toward microbiology (Beylefeld & Struwig, 2007).

Iten and Petko (2016) studied 74 children (age range 10 to 13 years) from five primary school classes in central Switzerland. Results found that students had a generally positive attitude towards games for learning. Results also found that the greater the enjoyment experienced, the greater the engagement and motivation to learn; however, enjoyment did not influence cognitive learning gains (Iten & Petko, 2016).

Boeker et al. (2013) studied the student attitudes toward game-based learning compared to conventional instruction using 145 third-year medical students training in the Department of Urology at the University Medical Center Freiburg, Germany. Eighty-two participants were trained using an educational adventure game and 69 had conventional training. Results found a statistically significant difference for student attitudes where the game-based learning group had a more positive attitude about the learning material than the conventional group and where the game-based learning group had higher scores than the conventional group (Boeker et al., 2013).

Tham and Tham (2014) used a qualitative design to study 36, year 3, full-time students (25 male, 11 female) in a Contemporary Issues in IT course from an institute of higher learning in Singapore. Results found that 31 participants found the game to be fun and enjoyable. In general, students felt that game-based learning improved their interest and was an enjoyable experience (Tham & Tham, 2014).

Kiron et al. (2020) examined 49 (27 males, 21 females, one other) first-year undergraduate students in an introductory computer science course in the fall of 2019. The study found that students generally enjoyed learning course materials in a game-based learning environment and felt the quiz game was useful as a learning tool (Kiron et al., 2020).

Contreras-Espinosa and Gomez (2020) studied 15 fifth graders and 15 sixth graders randomly selected from the Barcelona metropolitan area using a qualitative methods design.

Most of the participants responded affirmatively when asked "Would you like to learn more about mathematics (or history) in a game like this?" (Contreras-Espinosa & Gomez, 2020).

Budasi et al. (2020) studied student perceptions in learning English using 84 fourth grade elementary students in Denpasar using a posttest only, control group, quasi-experimental design. Results found that students in the experimental group (40, PowerPoint game) had a high perception of the effectiveness of the PowerPoint game when used in the classroom for learning English. Results also found a statistically significant difference between the experimental group and the control group (44, no game) where the students in the experimental group had higher achievement scores than those in the control group (Budasi et al., 2020).

Ozturk and Korkmaz (2020) studied 60 fifth grade students and their attitude toward social studies in a game-based learning environment. A quasi-experimental design with pretest/posttest and a control group was used. The control group (14 female, 15 male) had traditional course content and the experimental group (13 female, 18 male) used traditional content with the addition of a game. Results found a statistically significant difference in attitude toward social studies in favor of the experimental group (Ozturk & Korkmaz, 2020).

Giannakos (2013) studied 46 Greek middle school students (29 male, 17 female). Researcher observations noted that the students were enthusiastic when playing the game. Teachers observed a higher level of engagement from students who typically did not pay attention in class (Giannakos, 2013).

Reed and Miller (2020) surveyed 167 participants using a mixed method design approach. Results found a small effect size (.03) for perceived usefulness of the gamified library orientation for undergraduates. The study also found a small effect size (.04) for preference of the gamified library orientation over other orientation options among undergraduates (Reed & Miller, 2020).

Pechenkina et al. (2017) studied 265 first-year accounting students and 129 first-year science cohort students during three semesters who used a gamified quiz on a mobile app. Results showed that the mobile app improved student retention rates in all three semesters: 2013, 5.37%; 2014, 9.22%; 2015, 12.23%. Those who used the app also had 7.03% higher average grades than students who did not use the app (Pechenkina et al., 2017).

Krause et al. (2015) collected data from 206 students enrolled in a MOOC. Students were divided into three groups: plain (no game elements), game (gamification elements with no social elements), and social game (gamification elements with social elements). Their study found that the game group had a statistically significantly higher average retention period than the plain group. The social game group had a statistically significantly higher average retention period than the game group and the plain group. In addition, their study found that the game group and the social game group had statistically significantly higher final test scores than the plain group (Krause et al., 2015).

Kaplan et al. (2021) surveyed 30 third and fourth grade students (16 female, 14 male, ages ranging from 8-10 years old) and 19 parents in the 2018-2019 academic year at a village school in Mardin Province, Turkey. Results found no statistically significant difference in student attitudes toward English when using ClassDojo, a gamified application used by teachers to help improve targeted student behaviors. Overall, students’ and parents’ opinions of ClassDojo were positive and they felt that using the application had a positive effect on targeted behaviors (Kaplan et al., 2021).

Zhonggen's (2019) meta-analysis analyzed 76 articles published between 2009 and 2018 and found that serious game-based learning was significantly more effective than non-game-based learning in understanding scientific concepts, increasing cognitive abilities, improving learner satisfaction, and improving learning outcomes. Negative effects were found in terms of cognitive load and learning, where some serious games produced a heavier mental workload which negatively influenced the learning effect and no statistically significant difference was found in in-depth learning (Zhonggen, 2019).

Vaibhav and Gupta (2014) studied 100 students enrolled in a MOOC. Their study found that the participants in the game group (84%) had higher attendance for the final exam than those in the non-game group (70%). Of the 42 participants in the gamified environment, 36 passed the course (Vaibhav & Gupta, 2014).

Kumar and Lightner (2007) studied 68 students from a two-year regional campus of a state college/university using a mixed methods design. Students rated the game on a Likert scale from 1 (low rating) to 5 (high rating). While the quantitative data showed students felt the experience was generally positive and enjoyable ($M = 3.956$, $SD = .76$), the qualitative data showed more mixed results (Kumar & Lightner, 2007).

In contrast, Castelijn (2017) studied 52 students enrolled in a massive open online course (MOOC). The results found no statistically significant difference between the control group (no game) and the experimental group (game) in relation to retention in the course (Castelijn, 2017).

Sabirli and Coklar (2020) studied 90 Saricam public primary school students in the 2017-2018 school years using a pretest/posttest, control group, quasi-experimental research design. The control groups (24 male, 21 female) used no English educational games and the experimental groups (26 male, 19 female) used English educational games. No statistically significant difference was found in student attitude between the two groups after the educational process (Sabirli & Coklar, 2020).

Yesilbag et al. (2020) researched 60 (27 males, 33 females) tenth-grade Anatolian high school students during the 2019-2020 school year using a quasi-experimental pre- and posttest design with a control group. The control group (30) were taught using traditional English education program activities while the experimental group (30) used educational computer games. Results found no statistically significant difference in attitude scores toward English between the two groups. Results found a statistically significant difference between the mean scores of the groups in favor of the experimental group (Yesilbag et al., 2020).

Luch (2018) studied 28 undergraduates from a college in the United States. Participants included both full-time and part-time students. The quantitative study found no correlation between gamification and student retention (Luch, 2018).

Chiang (2020) compared 60 English as a Foreign Language sophomores (14 male, 46 female) from the department of Applied Foreign Languages in a private college. Results found that although students had a positive view of Kahoot! and its ability to improve the effectiveness of the course, promote learning persistence in classroom activities, motivate cooperate learning, achieve active learning, and increase successful learning. However, students felt that using Kahoot! as a testing tool was too complicated (Chiang, 2020).

Most of the research presented above exhibits that that game-based learning positively affects student attitudes, retention, and learning outcomes. However, there is also research that has found that game-based learning has no effect or even an adverse effect on attitudes, retention, and learning outcomes. Although students may have an improved attitude toward learning when games are included, that does not always equate to added learning gains or overall satisfaction (Chiang, 2020; Iten & Petko, 2016; Kumar & Lightner, 2007; Zhonggen, 2019).

Self-Efficacy

This review of literature found two studies that indicated that student self-efficacy regarding online courses has an influence on student retention and learning outcomes (Bradley et al., 2017; Peck et al., 2018). Students who exhibit higher self-efficacy in online classes tend to be more successful and are more likely to stay in school than students who had not taken any online classes (Bradley et al., 2017; Peck et al., 2018).

This review of literature also found four studies that have shown that e-learning improves perceived self-efficacy (Bradley et al., 2017; Clayton et al., 2010; Landrum, 2020; Peck et al., 2018). However, it also found one other study that failed to show that e-learning affects self-efficacy (Torun, 2020).

Bradley et al. (2017) studied 266 undergraduate students aged 18 to 43 years (213 female, 52 male, one undeclared) at a small university in Georgia. Results found a statistically significant difference for self-efficacy where participants who had taken at least two online courses had higher self-efficacy beliefs that they would be successful in an online course than those who had taken zero or one online course (Bradley et al., 2017).

Peck et al. (2018) surveyed 113 undergraduate and graduate distance education students at two U. S. universities. Study results found a correlation between self-efficacy and student retention meaning the higher a student’s self-efficacy in online courses, the more likely they will remain in school (Peck et al., 2018).

Clayton et al. (2010) surveyed 132 (20 male, 112 female) from two New York City urban public colleges. The survey found a statistically significant difference for self-efficacy for students in online classes versus traditional classes, where those in online classes showed greater self-efficacy (Clayton et al., 2010).

Landrum (2020) surveyed 88 undergraduate and graduate students (72 female, 16 male) enrolled in an online psychology class in two universities in Texas. Results found a correlation between the participants’ satisfaction with online learning and self-efficacy to learn online. The more confident the participant was in their ability to learn online, the higher their satisfaction with online learning (Landrum, 2020).

Torun (2020) studied 153 freshmen students from a public university. Results found that the correlations between online, Internet, and computer self-efficacy and self-directed learning were small. The correlation for computer self-efficacy and e-learning readiness was not statistically significant. These results imply that learners who may make appropriate arrangements of their own learning and choose learning materials and activities they like on online training courses, may generate better learning outcomes. Computer self-efficacy, Internet self-efficacy, online self-efficacy and learner control were not the significant predictors of e-learning readiness (Torun, 2020).

Much of the research cited above shows that e-learning improves perceived self-efficacy. There are also studies that show there is no correlation between e-learning and self-efficacy.

Mayer (2021) stated that the “learner’s motivation to exert effort on a multimedia lesson can be shaped by the learner’s affect, beliefs, interest, and feelings of social connection” (p. 58). Affect is the student’s emotional state during learning. Beliefs are the student’s thoughts about themselves as learners (self-efficacy). Interest is the student’s reaction to learning material that invokes engagement with that material. Social processes are the student’s feeling of social connection with the instructor (Mayer, 2021).

This review of literature found three studies that have shown that including multimedia in instruction improves student self-efficacy and achievement (Huang & Mayer, 2019; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009). It found two other studies which showed the use of multimedia has no effect/negative effect on perceived self-efficacy and achievement (Huang & Mayer, 2016; Liu et al., 2017).

Huang and Mayer (2019) studied 142 students (73 lab, 69 online) recruited from a mid-western U. S. university. The goal of the study to increase self-efficacy and reduce anxiety using four specific motivation design features: modeling examples, imagination or mental practice, attributional feedback, and math anxiety coping strategy. The participants were assigned to four groups: lab treatment group (35), lab control group (38), online treatment group (36), and online control group (33). Results found that the anxiety reducing design features did statistically significantly reduce anxiety. Results also found that the treatment group reported statistically significantly higher post self-efficacy than the control group. Negative correlations were found between self-efficacy and anxiety, and anxiety and posttest performance. There was a positive correlation between self-efficacy and posttest performance (Huang & Mayer, 2019).

Zheng, McAlack, Wilmes, Kohler-Evans, and Williamson (2009) studied 222 students (72 male, 150 female) from three universities in the United States. Results from the one-way ANOVA found a statistically significant difference between the interactive multimedia and non-interactive multimedia groups and self-efficacy. Results from the repeated measures ANOVA found a statistically significant difference between subjects. There was a statistically significant interaction between self-efficacy and multimedia. Results from the correlation analysis found that multimedia was statistically significantly correlated to both self-efficacy and achievement.

Multimedia was also a significant predictor of self-efficacy and achievement (Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009).

Van der Meij et al. (2018) studied 65 fifth and sixth grade students (32 male, 33 female) from a Netherlands elementary school. Results found that using the video tutorials as part of the learning content statistically significantly enhanced self-efficacy (van der Meij et al., 2018).

Conversely, Huang and Mayer (2016) studied 54 undergraduates at a Midwest U. S. university. Participants were randomly assigned to two groups: control group (28) and treatment group (26). Two anxiety coping strategies were added to a statistical multimedia lesson for the treatment group with the intention of improving self-efficacy. The anxiety coping methods included an anxiety coping message delivered by a pedagogical agent to the students before they started the treatment and an expressive writing activity students completed after the treatment but prior to the posttest. Results found no statistically significant difference in self-efficacy between groups (Huang & Mayer, 2016).

Liu et al. (2017) studied 45 (19 male, 26 female) 9 to 10-year-old Taiwanese elementary students from an urban public elementary school program for English as Foreign Language learners. The experimental group used the re-mix approach to creatively generate online artifacts to form new stories from the model stories. The control group retold the model stories. The results found that overall, students in the experimental group reported more creative self-efficacy than students in the control group, however, the results were not statistically significant (Liu et al., 2017).

The studies mentioned above demonstrate that including multimedia as a part of an instruction session may increase self-efficacy and improve student achievement. More research is needed in relation to improving self-efficacy by using the motivational design principles mentioned by Mayer (2021) in such a way that students improve their feelings of competence through learning using multimedia presentations.

Mayer (2014c) stated that self-efficacy is “relevant to games for learning when students who might otherwise have low self-efficacy for school-based learning tasks have high self-efficacy for certain kinds of game-based learning tasks” (p. 73). If games include the desired learning objectives, students may persist in their attempts at learning via the games when they would not do so in other types of learning environments (Mayer, 2014c).

Besides being more persistent, students will also expend more effort during learning if they believe that their successes and failures are due to effort rather than ability (Bandura 1994, 1997). As students play games and see improvement in their game play, this reinforces their belief that their improvement is due to their efforts which in turn, improves their learning performance (Mayer, 2014c).

This review of literature found three studies that have shown that game-based learning improves learner self-efficacy and learning outcomes (Hung et al., 2014; Say & Bag, 2015; Zheng, Young, Brewer, & Wagner, 2009). On the other hand, it also found one study that stated game-based learning has no effect or even an adverse effect on perceived self-efficacy and learning outcomes (Rachels & Rockinson-Szapkiw, 2018).

Say and Bag (2015) studied 444 seventh grade science students attending seven different schools in seven different regions of Turkey. The quasi-experimental designed study found that there was a statistically significant difference between the experimental group that played the science computer game and the control group, where the experimental group reported higher self-efficacy levels (Say & Bag, 2015).

Hung et al. (2014) conducted a quasi-experimental study of 68 fifth grade elementary math students who were assigned to three groups: experimental group A (11 male, 12 female), experimental group B (12 male, 11 female), and the control group (13 male, 10 female). Group A received the digital game-based learning approach, group B received the technology-enhanced learning approach, and the control group received the traditional instruction approach. The results found that there was a statistically significant difference in self-efficacy between both group A, group B, and the control group where groups A and B reported higher self-efficacy. Results also found that group A outperformed both groups B and the control group in the posttest (Hung et al., 2014).

Zheng, Young, Brewer, and Wagner (2009) studied 61 Chinese public middle school students who were randomly assigned to either the QA (Quest Analysis) (31) or non-QA (30) group. Results found a significant difference in relation to self-efficacy and participation in QA where the QA group had improved self-efficacy (Zheng, Young, Brewer, & Wagner, 2009).

However, Rachels and Rockinson-Szapkiw (2018) conducted a quasi-experimental design study with 164 third and fourth grade students from a South Florida private school. The study found no statistically significant difference in self-efficacy between the control group (traditional face-to-face classroom instruction) and the treatment group (Spanish learning content taught using the Duolingo app). The results also found no statistically significant difference in Spanish language achievement results between the control group and the treatment group (Rachels & Rockinson-Szapkiw, 2018).

The research presented above exhibits that the consensus is that game-based learning improves learner self-efficacy and learning outcomes. Mayer (2014c) stated that self-efficacy is important to game-based learning when students who typically have low self-efficacy for certain non-game related learning tasks have high self-efficacy for certain game-based learning tasks. If the high self-efficacy game-based tasks are used to teach academic content, those learners might exert more effort to learn and increase their potential for academic success (Mayer, 2014c).

Self-efficacy and Learning Outcomes.

Bandura (1997) stated that "efficacy beliefs affect thought patterns that may enhance or undermine performance" (p. 116). Bandura (1986) also stated that because a person's thoughts mediate the relationship between knowledge and action, people often do not perform to the best of their ability even though they are aware of what they need to do. Efficacy involves more than just knowing what to do. It involves a generative ability where cognitive, social, and behavioral skills are organized into actions and where proficiency requires both skills and self-efficacy (Bandura, 1986).

Perceived self-efficacy encourages engagement, promotes competency development, and affects achievement levels and motivation (Schunk, 1989; Zimmerman, 1995). There has been significant research done on self-efficacy and its effects on student achievement (Pajeres, 1996).

This review of literature found five studies where self-efficacy had a positive correlation with student achievement (Austin et al., 2018; Chemers et al., 2001; Huang & Mayer, 2019; Travis et al., 2020; Wasylkiw et al., 2020). When students feel capable in their ability to learn something from class, they are more satisfied in their learning experience and have lower risk of dropping out and have evidence that they have what it takes to succeed (Bradley et al., 2017; Levy, 2007).

Wasylkiw et al. (2020) studied 214 undergraduate students and self-esteem, self-compassion, self-efficacy, and mindsets as potential predictors of grades. Of these predictors, self-efficacy was the only variable that was an indicator of student grades (Wasylkiw et al., 2020).

Austin et al. (2018) studied 2,648 organic chemistry students in two U. S. institutions over five semesters. Results found that self-efficacy had a strong correlation with course performance, with large effect sizes in each semester for the southwestern U. S. institution (0.54, 1.08, 0.79, 0.75, 0.72 respectively) and the northeastern U. S. institution (0.69, 0.75, 0.37, 0.69 respectively) (Austin et al., 2018).

Travis et al. (2020) studied 853 (62% female, 38% male) undergraduate students enrolled in a private college and public university in the southeast. The study found a statistically significant difference between academic self-efficacy and GPA where self-efficacy was positively associated with GPA (Travis et al., 2020).

Chemers et al. (2001) surveyed 373 first-year college students. The results found statistically significant differences where participants with higher self-efficacy had greater academic expectations, better academic performance, less stress, fewer health problems, and better adjustment (Chemers et al., 2001).

In contrast, Torun (2020) studied 153 freshmen students from a public university. Results found that self-efficacy, as a sub-dimension of e-learning readiness, was not a predictor of academic achievement in terms of Internet, computer, and online self-efficacy (Torun, 2020).

The consensus from the above cited research has shown that self-efficacy has a positive correlation with student self-efficacy. Pintrich and De Groot (1990) explained this relationship by concluding that self-efficacy facilitated cognitive engagement which might lead to increased use of cognitive strategies and increased academic performance.

Summary

Mayer (2014c, 2021), Clark and Mayer (2016), Bell (2018), and Mayer and Fiorella (2014) have repeatedly called for the need for additional research on the coherence principle in a classroom setting. The results of this study will add to the existing literature by providing an example of the effects of multimedia learning and more particularly game-based learning, and its degree of adherence to the coherence principle, on learning outcomes in an authentic learning environment.

There has been minimal research on game-based learning and multimedia learning and their relationship to self-efficacy. The results of this study will add to the limited existing research by providing additional data on multimedia learning, specifically video tutorials, and game-based learning and their effects on self-efficacy.

While there has been significant research done on self-efficacy and its effects on student achievement (Pajeres, 1996). Little research has been done specifically on multimedia learning and game-based learning as teaching methods and their influence on the relationship between self-efficacy and learning outcomes. The results of this study will add to the existing literature in the game-based and multimedia learning contexts, as well as in the discipline of information literacy.

CHAPTER III

Methods

The first purpose of this quantitative study was to examine the effects of game-based learning, both minimally extraneous and more extraneous versions, on student learning outcomes compared to a multimedia tutorial presentation as measured by posttest grades for students in the information literacy portion of a first-year seminar course (ROAR 1199) at Idaho State University (ISU) during the fall 2021 semester. Secondly, this study measured the effects of game-based learning, both minimally extraneous and more extraneous versions, on perceived self-efficacy scores pre- to posttreatment compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course as measured by the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey. The third and final purpose of this study was to determine the relationship between perceived self-efficacy posttreatment and student outcomes in a game-based learning environment, both minimally extraneous and more extraneous versions, compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course.

Mayer (2014c) stated that there is a lack of evidence-based, experimental research on computer games for learning. The results of this study offered added evidence-based, experimental research of the effects of game-based learning, in both minimally extraneous and more extraneous versions, on student outcomes compared to a multimedia tutorial presentation. Furthermore, this study offered further information on the effects of game-based learning, both minimally extraneous and more extraneous versions, on perceived self-efficacy pre- to posttreatment compared to a multimedia tutorial presentation. Lastly, this study examined the relationship between perceived self-efficacy posttreatment and learning outcomes in a game-based learning environment, both minimally extraneous and more extraneous versions, compared to a multimedia tutorial presentation.

Research Questions

This study focused on three main research questions. The research questions are listed below.

1. Does the method of instruction (MT, G1, G2) affect the learning outcomes of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the module test?
2. Does the method of instruction (MT, G1, G2) affect self-efficacy scores from pretreatment to posttreatment of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the Using Information Responsibly Self-Efficacy Scale survey?
3. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for each of the three treatments in the study?
    a. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the MT group?
    b. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G1 group?
    c. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G2 group?

Research Design

As illustrated in Table 1 below, this study used an experimental, baseline group design. It will include one independent variable: teaching method that includes multimedia learning and game-based learning (includes minimally extraneous content and more extraneous content), and two dependent variables: student learning outcomes and self-efficacy.

Table 1

Research Design for the Study

MT Group					
Multimedia tutorial instruction	R	S_1	X_0	S_2	O_1
G1 Group					
Minimally extraneous game content	R	S_1	X_1	S_2	O_1
G2 group					
More extraneous game content	R	S_1	X_2	S_2	O_1

Note. R indicates random assignment to groups. S_1 represents the pretreatment self-efficacy survey. Xi for each group represents the presence of game-based learning. S_2 represents the posttreatment self-efficacy survey. O_1 represents the content area posttest.

Participants were randomly assigned (R) into three groups: the multimedia tutorial group (MT), the minimally extraneous group (G1), and the more extraneous group (G2). After random assignment into the treatment groups, the participants were given the same pretreatment UIRSES survey (S_1) in weeks five through eight of the course. Following the pretreatment UIRSES survey (S_1), the three treatments were applied during week nine of the course. The treatments included a multimedia instruction tutorial (X_0); a single-player, virtual escape room game with minimally extraneous content (X_1); and a single-player, virtual escape room game with more extraneous content (X_2). In week nine, participants were given a posttreatment UIRSES survey (S_2) after the treatments. Following the posttreatment UIRSES survey (S_2), all three groups were given the same content area posttest (O_1).

Participants and Sampling

The population of this study was drawn from students enrolled in the ROAR 1199 first-year seminar course at a medium-sized institution in the Intermountain West during the fall 2021 semester. The desired, minimum number of participants for this study was 90 students (N = 30 for each treatment group). Based on fall 2020 enrollment data, there was expected to be approximately 180 potential participants. As of August 22, 2021, there were 321 students enrolled in 17 sections of the course. All students enrolled in the ROAR 1199 course were allowed to choose to participate in the study. Consent was collected prior to conducting the study. Participants enrolled in the ROAR 1199 were typically first-year freshmen and considered novice learners of the using information responsibly topic.

There are two groups of students who are potential subjects that were not included in this study. Any students repeating the course were excluded from this study because they might have retained prior knowledge on the module topic. Additionally, due to time constraints and the unavailability of outside resources, the current iterations of the game are not 504 compliant. Visually impaired students were not included in this study since it was necessary to place them in the MT group whose treatment is 504 compliant. Placing visually impaired students in the MT group and including them in the study would have negated random assignment.

Participants were randomly assigned to one of three groups: the MT group, the G1 group, and the G2 group. Random assignment to the three groups was done using the RAND () function in Microsoft Excel. After participants were randomly assigned to a group in Excel, they were input into the appropriate group in the Moodle learning management system. In Moodle, the three groups were created using the groups setting.

Treatment Development

There were three treatments used for this study: the multimedia tutorial instruction, the virtual escape room game G1 version, and the virtual escape room game G2 version. The multimedia tutorial instruction was originally created by the instruction department at Idaho State University Libraries (University Libraries) and named Academic Integrity tutorials. They were used in the ROAR 1199 course in fall 2020 and spring 2021 semesters. These tutorials were updated during the spring 2021 semester and renamed Using Information Responsibly during the summer 2021 in preparation for their use beginning in the fall 2021 semester.

The Deadline: The Professor vs. Plagiarism virtual escape room game G1 version was created during the spring 2021 semester by the researcher and a group of five faculty and staff from University Libraries including two staff members with expertise in creating escape room games. These same two staff members vetted both versions of the game. The G2 version of the game was created during summer 2021 by the same group from University Libraries. Details of the G1 and G2 version of the game are included in the Game subsection below.

The instructional objectives of the game mirrored the instructional objectives in the Using Information Responsibly tutorials as provided to the researcher by the head of instruction at the University Libraries. The multimedia instruction tutorial, the G1 version of the game, and the G2 version of the game share the following learning objectives:

1. Define plagiarism, paraphrasing, and citation.
2. Explain academic integrity and academic dishonesty.
3. Discuss copyright, fair use, public domain, and creative commons.
4. Select correct paraphrasing and quotations.
5. Identify where to go for writing and research help.

6. Demonstrate the ability to correctly cite a source both in-text and in a reference list.
7. Analyze examples of plagiarism.
8. Create an academic paragraph with proper paraphrasing, quotation use, and citations.

The MT group watched a series of four multimedia video tutorials covering the subject of using information responsibly. The tutorials did not include any game-like elements. The four tutorials include approximately 40 minutes of instructional content and cover the following topics:

- Video one – Academic Integrity
- Video two – Plagiarism
- Video three – Citations
- Video four – Copyright

The tutorials were part of the ROAR 1199 curriculum when the course first began in fall 2020. The videos were refreshed with updated information and the title was changed from Academic Integrity to Using Information Responsibly in the spring and summer of 2021, however, the learning objectives and core content remained the same. The Using Information Responsibly tutorials consist of four parts: Academic Integrity, Plagiarism, Citations, and Copyright. Video one, Academic Integrity, is approximately 10 minutes in length and covers the topics of academic integrity and academic dishonesty. Video two, Plagiarism, is approximately eight minutes in length and covers the topics of plagiarism, paraphrasing, quotations, and citations. Video three, Citations, is approximately 16 minutes long and consists of the topics of citations, both in-text and reference list, paraphrasing, common knowledge, and identifying where to go for research and writing help. Video four, Copyright, is approximately seven minutes in length and includes the topics of copyright, Fair Use, public domain, and Creative Commons.

The game-based learning groups G1 and G2 played two different versions of Deadline: The Professor vs. Plagiarism, a single-player, virtual escape room game about using information responsibly. The G1 group played the G1 version of the game that includes minimally extraneous content. This version of the game included the following extraneous elements: background timer music and clickable items needed to obtain the code for opening the virtual escape room. The G1 game adheres to the coherence principle, meaning it has minimal extraneous content, and included only the extraneous material required to play the virtual escape room game. The final G1 version of the game included a timer allowing 40 minutes to complete the game.

The G2 group played the G2 version of the game which was the same as the G1 group version but with added extraneous content. The additional extraneous content included seven extra clickable items containing factoids about academic integrity, such as widely publicized news stories about plagiarism and statistics on cheating in higher education settings. This version of the game did not adhere to the coherence principle, meaning it had added interesting information that was irrelevant to the learning objectives (Clark & Mayer, 2016; Mayer, 2014b, 2021). For initial beta-testing, the G2 version included a timer that allowed 45 minutes to complete the game.

Beta-testing for the G1 version of the game was done in three phases over a three-week period during May 2021. All testers were asked to fill out an electronic form at the end of the experience asking for feedback on any issues that were encountered. In phase one, six people tested the game. Any reported issues were then corrected before the second phase of testing.

Phase two included five testers who reported any issues encountered during game play which were corrected prior to phase three. In phase three, six people tested the game with no further issues reported. In addition to reporting any issues with content not working as expected, testers reported how long it took them to complete the game and they rated their experience from one (not fun at all) to five (super fun).

Beta-testing for the G2 version of the game occurred during July 2021. Six testers were used for this version of the game. The testers played the G2 version of the game looking for any issues with the clickable items, instructions, and/or knowledge questions that were not clearly understandable or functioning properly. Three issues were reported via email to the researcher, which were corrected and the tester who reported the issue was asked to play the game again to ensure that the issue was fixed. It was determined after the beta-testing that 50 minutes was an appropriate amount of time to complete the G2 version of the game.

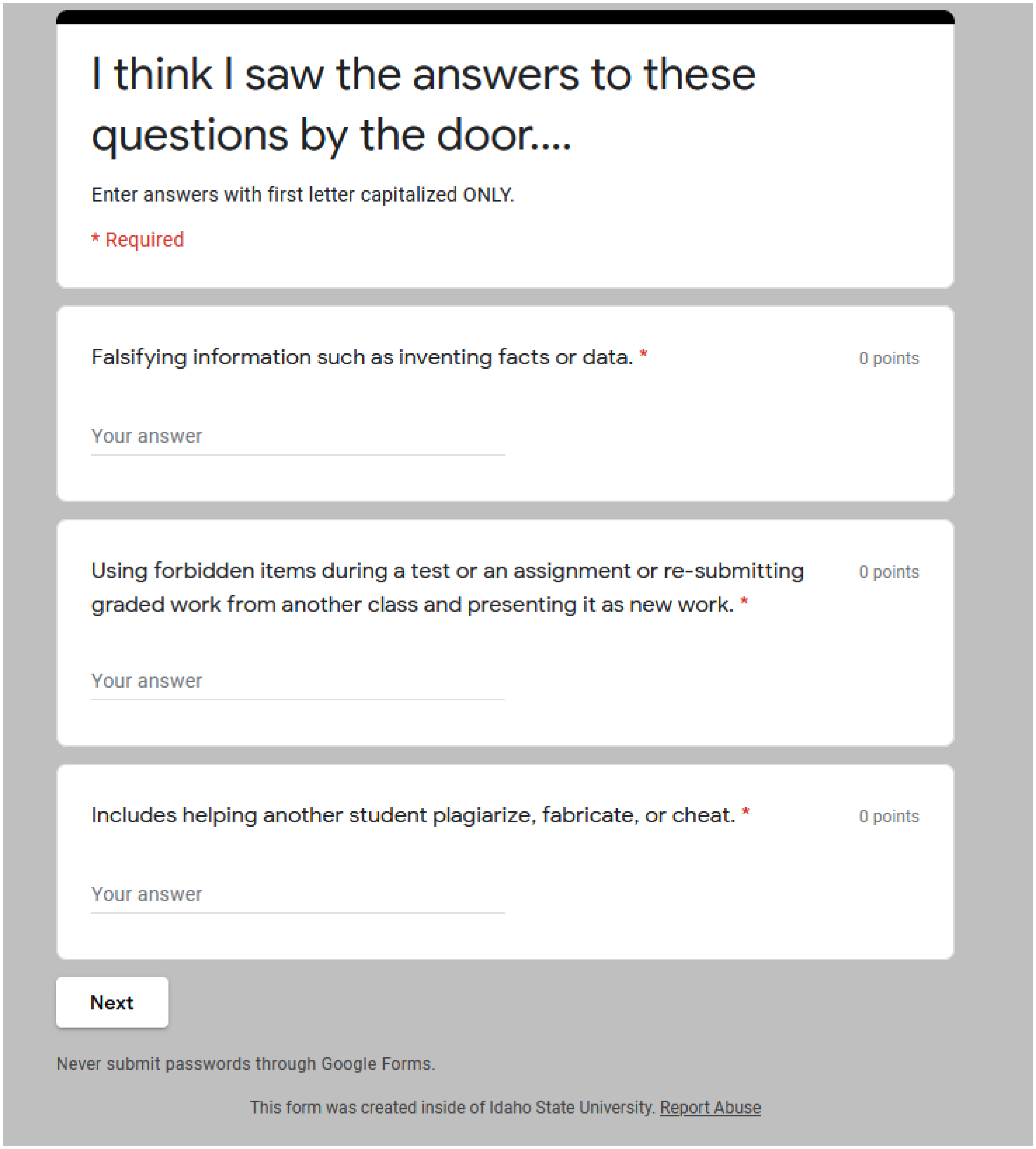
Games

Both G1 and G2 versions of the Deadline: The Professor vs. Plagiarism game are a timed, asynchronous, single-player, virtual escape room. The learning objectives for both versions of the game mirrored those in the Using Information Responsibly tutorials that was the treatment for the MT group.

The storyline is that of a professor (the player) and a group of students locked in the library and the professor is trying to identify which student in the group has not used information responsibly by committing an act of academic dishonesty. The player must learn about how to use information responsibly by clicking on the different items in the game to reveal the learning material and answering knowledge check questions to obtain the code for the room to be unlocked. Figure 1 is an example of the knowledge check questions that must be answered correctly to reveal a digit of the final code.

Figure 1

Example of Knowledge Check Questions



I think I saw the answers to these questions by the door....

Enter answers with first letter capitalized ONLY.

* Required

Falsifying information such as inventing facts or data. * 0 points

Your answer

Using forbidden items during a test or an assignment or re-submitting graded work from another class and presenting it as new work. * 0 points

Your answer

Includes helping another student plagiarize, fabricate, or cheat. * 0 points

Your answer

Next

Never submit passwords through Google Forms.

This form was created inside of Idaho State University. Report Abuse

Note. Knowledge check questions are for content sequence two.

G1 Version. The extraneous content included in the minimally extraneous game version is the game elements/mechanics used to create the virtual escape room, plus the timer background music. The subject matter of the clickable items in the G1 version of the game strictly adhere to the learning objectives discussed earlier; therefore, there is no violation of the coherence principle regarding instructional content for the G1 version of the game. The adherence to the coherence principle with the instructional content was verified by an instructional design expert (IDE) and SME.

Peters and Cornetti (2020) defined game elements/mechanics as a games' foundation, governing rules, and guiding actions for the players. Of the 159 game elements/mechanics described by Peters and Cornetti (2020), 24 were used in the creation of the G1 version of the game. The game elements/mechanics used included:

- **achievements: "**Virtual or physical representation of having accomplished something. Often 'locked' until a series of tasks have been accomplished" (p. 274).
- **backtracking:** Returning to a previous part of the game because a skill was not learned, or an item not obtained.
- **clues: "**Prompts that help the player progress" (p. 279).
- **countdown: "**Players are given a certain amount of time to complete a task" (p. 280).
- **cues: "**A signal that prompts an action" (p. 280).
- **deadline:** "The time the player has to attempt to finish a challenge" (p. 280).
- **didactic reference:** Players are allowed to see written and visual explanations of various aspects of the topic, procedures, and cognitive skills being taught.
- **discovery: "**Players examine their environments to uncover items and experiences" (p. 281).

- **exploration:** "Players examine their environment to uncover routes, items, or experiences" (p. 283).
- **goal: "**The conditions for victory or success. Usually set by the game, but players may have their own goals" (p. 284).
- **hints: "**Provide the players with suggestions or detailed information to keep play moving" (p. 284).
- **introductory scene: "**A scene that introduces the game or level to give context and reason for play" (p. 285).
- **lists: "**A set of tasks or challenges a player must finish, usually not in a specific order" (p. 286).
- **mission:** The overall reason or purpose for playing the game.
- **narrative:** The storyline that gives the background for the game.
- **puzzle guessing: "**The player who successfully guesses or deduces the answer to a puzzle wins the game" (p. 289).
- **puzzle pieces: "**Player is given puzzle pieces to complete a picture to win or to learn clues" (p. 289).
- **puzzles: "**A type of challenge that involves pattern organization to win or be given clues or level-ups" (p. 290).
- **quests: "**A journey of obstacles a player must overcome. A mission with an objective that leads to rewards. Creates epic meaning, camaraderie, justice, etc." (p. 290).
- **role-playing: "**Player acts or performs as an imaginary person" (p. 292).
- **story: "**A narrative that gives the player a role to play" (p. 294).

- **storyline: "**A story that guides the actions of the players and creates the challenges they must overcome" (p. 294).
- **time events: "**Anything related to time constraints, from countdowns to timed missions" (p. 295).
- **unlock:** Content or an experience that is unavailable until after a specific action is taken. (Peters & Cornetti, 2020)

Figure 2 is the home page for both the G1 and G2 versions of the game. The difference in the versions is the number of clickable items on the page for each version of the game. G1 has one directional arrow and six clickable items and G2 has one directional arrow and eight clickable items (six items from the G1 version and two additional items that contain extraneous content).

Figure 2

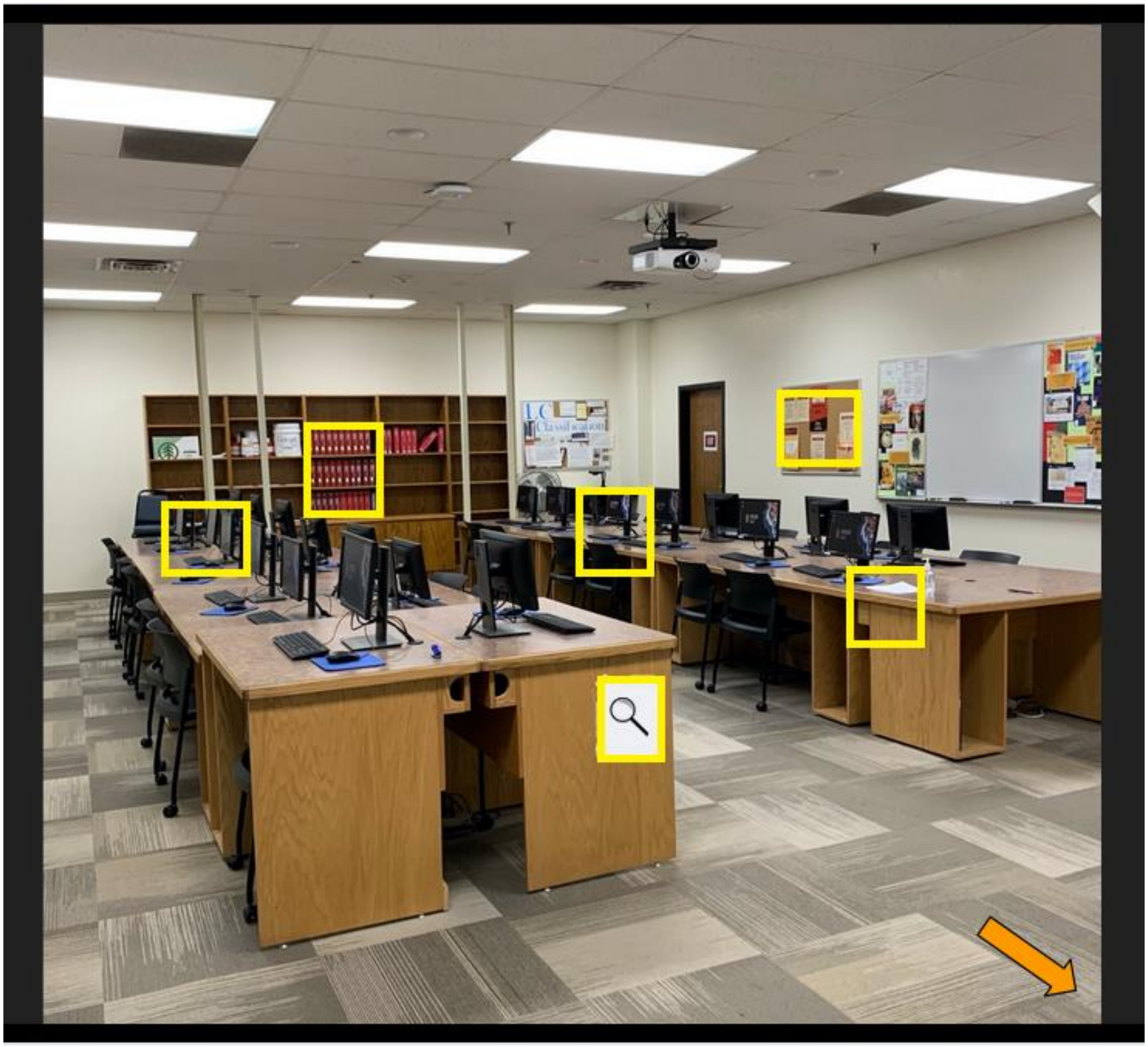
The Background Image of the G1 and G2 Versions of the Game

Note: Clickable items changed the computer cursor from an arrow to a hand to indicate to the player that they should click on the item. This background image was the same for both the G1 and G2 versions of the game.

Figure 3 shows the clickable items used in the G1 version of the game. The yellow rectangles shown in Figure 3 were not visible to the player during game play. Therefore, as the player moves the cursor over the page, the cursor changes from an arrow to a hand, indicating to the player that the item was clickable.

Figure 3

G1 Version of the Home Page Showing Clickable Items



Note: All six G1 clickable items are highlighted with yellow rectangles. The orange arrow is for directional purposes to lead the player to screens with additional content.

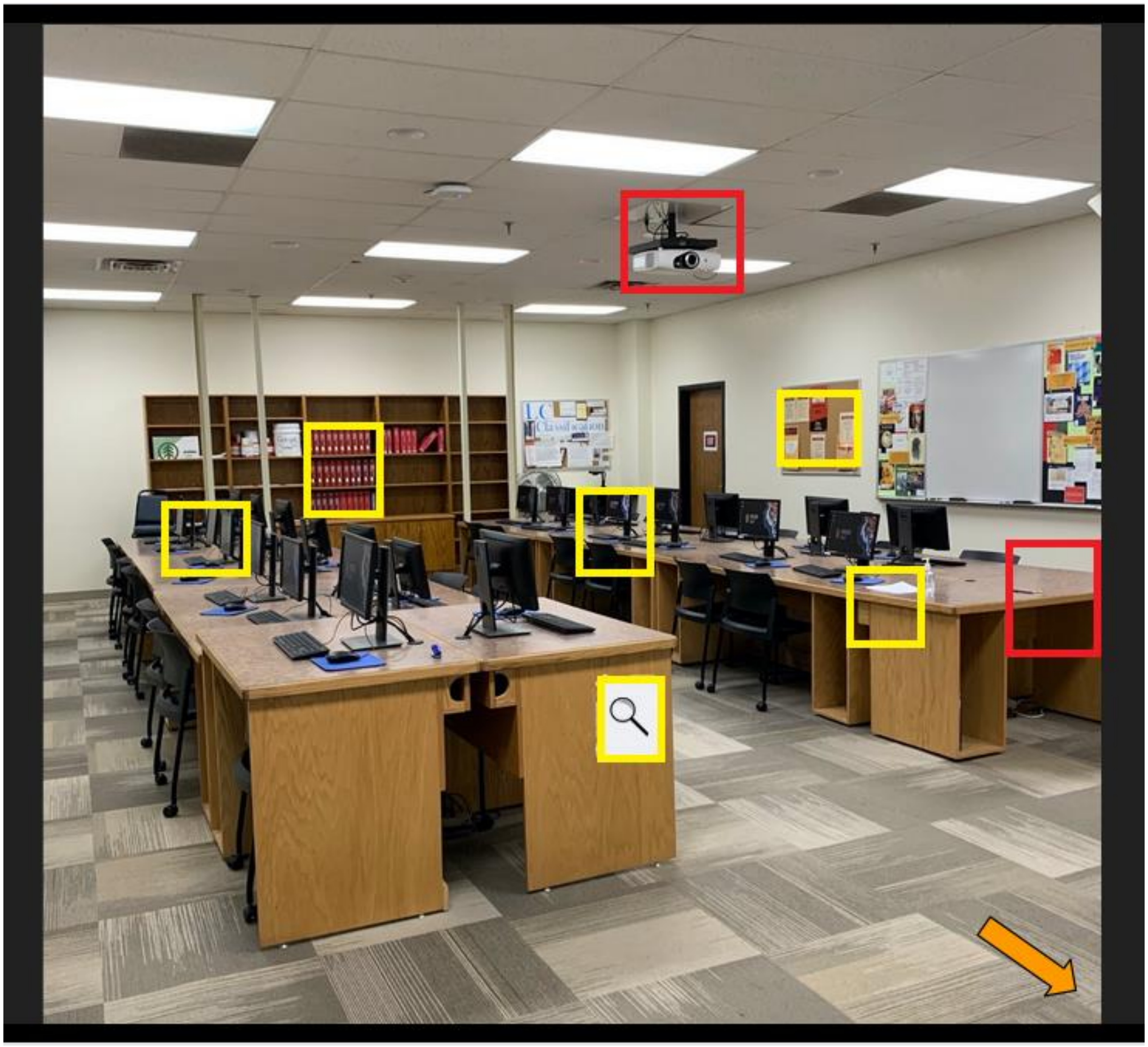
G2 Version. The more extraneous version of the game not only contains the same 24 game elements/mechanics and background music as the G1 version, but also includes additional clickable images that link to highly publicized and interesting but irrelevant news stories about using information responsibly. In terms of game elements/mechanics, these additional items are known as:

- **mystery boxes**: "A random reward or experience that can be 'opened' and enjoyed. It is not obviously related to play or achievement" (Peters & Cornetti, 2020, p. 287).

Figure 4 is an example of an added extraneous clickable item in the G2 version of the game. The added extraneous clickable items function the same as the clickable items in the G1 version. The yellow and red rectangles shown in Figure 4 were not visible to the player during game play; therefore, as the player moves the cursor over the page, the cursor changed from an arrow to a hand, indicating to the player that the item was clickable.

Figure 4

G2 Version of the Home Page Showing Original and Extraneous Clickable Items



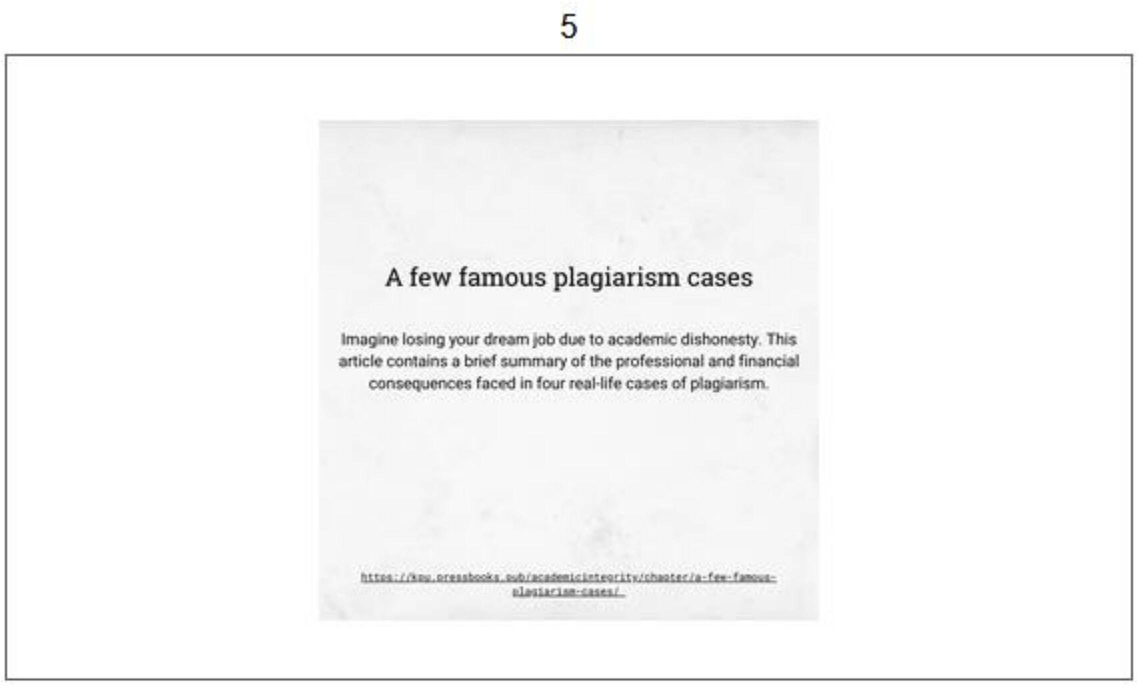
Note: Both G2 additional extraneous clickable items are highlighted with red rectangles. These items are not clickable in the G1 version of the game. The orange arrow is the same as in the G1 version and is for directional purposes to lead the player to screens with additional content.

Figure 5 is an example of the interesting, but irrelevant news stories from the G2 version of the game. When the player clicks on an added, extraneous clickable item illustrated in Figure

4, the player is taken to a summary page that contains a link to complete stories about people being fired from jobs due to plagiarism.

Figure 5

Example of a G2 Version Extraneous Content Item



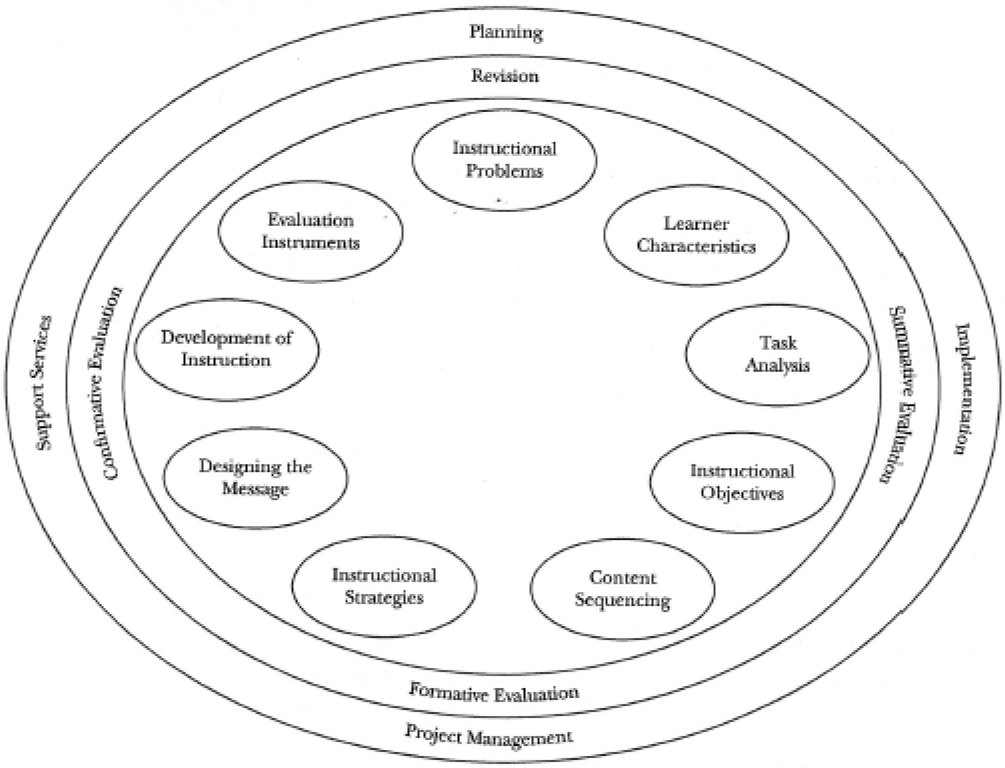
Note: In this example of G2 additional extraneous clickable, the player is taken to a summary of the extraneous content and given the option to click out to the complete story. Other extraneous content links may take the player directly to a complete story or an infographic that has statistics on academic dishonesty.

Instructional Design of Materials

Both the G1 and G2 versions of the game Deadline: The Professor vs. Plagiarism were designed following the Kemp instructional design (ID) model (Morrison et al., 2019). The goal of instructional design, including the use of ID models, is to “make learning more efficient, more effective, and less difficult” (Morrison et al., 2019, p. 4). Figure 6 illustrates the nine basic components of Kemp’s design process (inner ovals) and the eight ongoing processes (outer ovals) of the model. This model follows a three-phase design, including analysis, design, and evaluation. The first four components are the analyze phase: instructional problems, learner characteristics, task analysis, and instructional objectives. The second four components are the design phase: content sequencing, instructional strategies, designing the message, and development of instruction. The final component is the evaluate phase: evaluation instruments.

Figure 6

Components of the Kemp Instructional Design Model



Note. Nine instructional design steps and eight ongoing processes of the Kemp Instructional Design Model by G. R. Morrison, S. M. Ross, J. R. Morrison, and Designing H. K. Kalman, 2019, *Designing Effective Instruction* (8th ed.), p. 14.

The instructional problem became evident when it was decided at the end of the fall 2020 semester that it would be necessary to restructure the information literacy curriculum for the ROAR 1199 course in preparation for the fall 2021 semester. As part of the curriculum discussion with the committee, the researcher proposed to add game-based learning as a curriculum option for the using information responsibly module (module seven) of the information literacy portion of the course. The committee approved the game-based learning option and for the researcher to study the effectiveness of game-based learning as a possible permanent addition to the existing multimedia video instruction that had been used in previous semesters. Learners who enroll in this course are first-year freshmen, typically between 18 and 19 years of age, with no prior college experience and minimal prior knowledge on the using information responsibly topic. For the learning material for this study, the IDE and SMEs determined that a topic analysis was the most appropriate form of task analysis. The task analysis helped the IDE determine the learning objectives and any sub-objectives needed for the instruction. The researcher consulted with the head of instruction at University Libraries to determine the instructional objectives for the multimedia tutorials. The learning objectives were reviewed and validated for content by a group of seven SMEs from the University Libraries. See Appendix A for a detailed description of the instructional problem, learner characteristics, task analysis, and instructional objectives.

The sequence of the content was first determined by the multimedia tutorials. That sequence was then duplicated in the game-based learning instruction. The game-based learning content, the extraneous content, and the game elements were carefully considered and selected by the IDEs and five faculty and staff SMEs from University Libraries. A committee was formed that included the IDE, SME, and five faculty and staff from the University Libraries to create the game. The IDE and SME created the learning content. The IDE created instruments to measure both self-efficacy and student learning outcomes. The self-efficacy survey was used to evaluate what effect the learning material has on student’s perceived self-efficacy. For formative evaluation, SMEs validated the objectives and the instruments. Data collected in the study on the effectiveness of the learning material on learning outcomes and self-efficacy were used as the summative evaluation. See Appendix B for a detailed explanation of the content sequencing, design of the message, and development of the instruction. See Appendix C for a detailed description of the evaluation instruments.

Instrumentation

There are two dependent variables in this study: perceived self-efficacy and learning outcomes. Each dependent variable was measured by a separate instrument. The Using Information Responsibly Self-Efficacy Scale (UIRSES) survey was used to measure self-efficacy. The using information responsibly posttest assessment was used to measure student learning outcomes.

Self-Efficacy

Self-efficacy was measured using the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey on two occasions, both pre- and posttreatment. The survey was created by the researcher and contains 20 questions covering the eight learning objectives found in the multimedia instruction tutorial, the minimally extraneous game, and the more extraneous game. See Appendix D for the complete list of survey questions. The questions were answered using a five-point Likert scale where 5 = always true, 4 = usually true, 3 = occasionally true, 2 = rarely true, and 1 = never true. There was no existing survey covering only the using information responsibly topic. The researcher modified questions of similar structure and format from the Information Literacy Self-Efficacy Scale designed and validated by Kurbanoglu et al. (2006) when developing the UIRSES survey. The survey was created using the eight learning objectives created in the instructional design analyze phase discussed in Appendix A. In the end, there were two iterations of the survey. The first iteration of the survey was discussed with a panel of seven SMEs from the University Libraries. Edits to the survey were suggested by the SMEs and then performed by the researcher. The survey was examined by the SMEs post edit for content validity and the survey questions were considered appropriate and in line with the learning objectives discussed above (Litwin, 1995).

The first iteration of the survey was tested for internal reliability using the internal consistency method (Litwin, 1995). Seven survey testers were asked to complete the survey in the beginning of June 2021. The reliability (Cronbach's alpha, α) of the survey was calculated to determine the internal consistency among the question items. The Cronbach's alpha for the first version of the UIRSES survey was .97, showing high internal consistency. Upon closer examination of the survey, it was determined by the researcher that some changes were needed. The primary change was that five of the questions were restructured as reverse items. The second iteration of the survey was tested by an additional seven testers in the beginning of July 2021. The reliability on the second version of the survey was also calculated using Cronbach's alpha and was found to be .90, showing high internal consistency. When tested for internal consistency using the study participants pretreatment surveys, posttreatment surveys, and overall surveys, the internal consistency was good (Cronbach's alpha, $\alpha = .80$, $\alpha = .83$, $\alpha = .83$ respectively).

Student Learning Outcomes

Student learning outcomes were determined from the using information responsibly posttest assessment taken during week nine of the ROAR 1199 course. The posttest was created and validated by the researcher and a panel of seven SMEs from the University Libraries. The posttest consists of 19 questions covering the eight learning objectives discussed in Appendix A. The posttest has a mixture of supply-response items and select-response items (Thorndike & Thorndike-Christ, 2010). The breakdown of the question types are as follows: three true/false, four multiple-choice, two multiple-select, five fill in the blank, two ordering, one matching, and two short/long answers. See Appendix E for the complete list of posttest assessment questions.

The posttest assessment was discussed with a panel of seven SMEs from the University Libraries. Edits to the assessment were suggested by the SMEs and then performed by the researcher. The assessment was examined a second time by the SMEs post edit for content validity and the questions were considered appropriate (Litwin, 1995). The posttest was beta-tested by five testers in June 2021. No changes were required after the beta-testing was complete. All the questions except for the two short/long answer questions were automatically graded by the Moodle learning management system. The researcher created two rubrics which were used for the manual grading of the short/long answer questions. The researcher performed the manual grading. See Appendix F for the grading rubrics.

Data Collection

Prior to the data collection period, an application for project approval was submitted to the ISU's Institutional Review Board (IRB). After approval for the project was received, the data collection took place during weeks five through nine of the fall 2021 semester. All students who opted into the study did one of the treatments based on which group they were randomly assigned to (MT, G1, G2). Participants had the option to allow or not allow their data to be used in the study via an informed consent form available during weeks three through nine of the course. See Appendix G for the informed consent form. Participants also had the option to change their mind and opt-out of the study at any time during weeks three through nine of the course.

After consent had been given by the participants, they were given the pretreatment UIRSES survey during weeks five through eight of the course. During week nine of the course, all treatment groups were given a 15-minute introduction/discussion on using information responsibly that was scripted by the researcher for the instructor librarians to present in each section of the course. Participants were then given one of three treatments depending on their randomly assigned group. After the treatment had been completed, they were given the posttreatment UIRSES survey. Following their completion of the survey, they were given the using information responsibly posttest assessment.

The ROAR 1199 course instructors consisted of faculty from other departments at ISU. The instructor librarians were embedded in the class from the University Libraries and considered instructors for the information literacy portion of the course. They were responsible for curriculum development, teaching, and grading all information literacy related content. The information literacy portion made up approximately 40% of the course content.

The UIRSES surveys were distributed using the Qualtrics online survey platform prior to treatment (pretreatment) first, during week three through eight of the course, and second, during week nine of the course after the treatment (posttreatment) and prior to the posttest assessment. The second administration of the survey was a link that appeared in the Moodle learning management system in week nine of course after the treatment was completed. The collected data was stored on Qualtrics' secure servers (Idaho State University, n.d.).

The student outcomes portion of the data was collected through Moodle, ISU's learning management system. The researcher was added to each section of the ROAR 1199 course for the fall 2021 semester as an unlisted instructor by the Instructional Technology Resource Center (ITRC) who is the system administrator of the Moodle learning management system at ISU. This provided the researcher access to the Moodle gradebook for all course sections. Grades for the posttest assessment was recorded in Moodle and the grade data was exported from Moodle anonymously to be analyzed using SPSS statistics software.

Data Analysis

For research question 1, a one-way, between groups ANOVA design was used as the method of statistical analysis for this research question because there was one independent variable (method of instruction) with three treatment groups (MT, G1, and G2) and one dependent variable to be analyzed (student learning outcomes). A post hoc test was used, if needed, to compare the means between the three treatment groups to determine if there was a statistical difference (Myers et al., 2010).

For research question 2, data was analyzed using a one-way, repeated measures analysis of variance (RMANOVA) with a between groups factor of teaching method (MT, G1, G2). A RMANOVA design measured the changes of the subjects' perceived self-efficacy scores across and between the treatment groups. Post hoc analyses was used, if necessary, to compare the differences from pretreatment survey to posttreatment survey and to compare treatment groups' surveys (Myers et al., 2010).

For research question 3, data was computed using a Pearson's correlation coefficient to assess the linear relationship between test scores and posttreatment perceived self-efficacy surveys across all treatment groups. Additionally, correlation coefficients were computed within each treatment group. This determined the strength of the relationship both across and between the treatment groups (Myers et al., 2010).

Summary

While there is some extraneous content in all three treatment groups, the MT group tutorials contain the smallest amount of extraneous material of the three treatment groups. Studies have shown that the use of extraneous content in traditional multimedia presentations is detrimental to learning (Garner et al., 1991; Harp & Mayer, 1998; Mayer et al., 2001, 2007; Sung

& Mayer, 2012). The purpose of this study was to examine if extraneous content in a game-based learning environment affects learning outcomes and/or self-efficacy.

This chapter has described the methods used in this quantitative study. The study tested first, if method of instruction affected learning outcomes. Second, if method of instruction affected perceived self-efficacy. Lastly, if there was a relationship between perceived self-efficacy posttreatment and learning outcome scores for each of the three treatments. The research experiment was conducted during fall semester 2021. Chapter IV, Results, will present the findings of the experiment.

CHAPTER IV

Results

The first purpose of this quantitative study was to examine the effects of game-based learning, both minimally extraneous and more extraneous versions, on student learning outcomes compared to a multimedia tutorial presentation as measured by posttest grades for students in the information literacy portion of a first-year seminar course (ROAR 1199) at Idaho State University (ISU) during the fall 2021 semester. Secondly, this study measured the effects of game-based learning, both minimally extraneous and more extraneous versions, on perceived self-efficacy scores pre- to posttreatment compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course as measured by the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey. The third and final purpose of this study was to determine the relationship between perceived self-efficacy posttreatment and student outcomes in a game-based learning environment, both minimally extraneous and more extraneous versions, compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course.

Description of the Sample

The sample consisted of freshmen students enrolled in a first-year seminar course (ROAR 1199) at a rural, public university in the Intermountain West during the fall 2021 semester. A full description of the sample was provided by the department of Institutional Research for the university. The university reported 321 total enrolled students in the ROAR 1199 course for fall 2021. Of the total enrolled students 65% were female and 35% were male. The students were 65% White, 23% Hispanic/Latino, 3% Multi-racial, 2% Non-resident alien, 2% American Indian or Alaskan Native, 2% Native Hawaiian or other, 2% Unknown, 1% Asian, and 1% Black or

African American. Four percent were under 18, 96% were 18-24, 2% were 25-30, and 1% were 31-40 years of age (Miller, 2021).

Seventeen sections of the first-year seminar course participated in the study with a total potential sample of 321 students. Of those students, 180 opted to be included in the study and were randomly assigned to one of three groups (MT, G1, G2). Of the 180 who opted into the study, 79 did not complete either the first survey, the second survey, and/or the module test reducing the sample size to n = 101 participants (MT = 39, G1 = 36, and G2 = 26). A Tukey's Hinge test was performed for each of the three groups for the test scores in SPSS to check for outliers. The MT group's quartiles were 85.3550 (Q75) and 66.8200 (Q25). One outlier was identified (25.30) and removed from the MT data set. The G1 group's quartiles were 83.6300 (Q75) and 66.3100 (Q25). One outlier was identified (38.42) and removed from the G1 data set. No outliers were found for the G2 group. After removing the two outliers, one from each of the MT and G1 groups, the final sample size was n = 99 (MT = 38, G1 = 35, G2 = 26).

Descriptive Statistics

The descriptive statistics for the test scores by treatment group are presented in Table 2. The using information responsibly assessment consisted of 19 questions. The questions were a mix of short answer, matching, multiple choice, multiple selection, true/false, and short/long answer. The questions were worth one to five points each depending on the question type. For the short/ long answer, matching, and multiple selection questions there was a possibility of partial points awarded through the Moodle scoring system and manual grading by the researcher. The minimum and maximum possible scores were 0 and 48. The difference between the highest (MT group) and lowest (G1 group) means for the test scores was within 0.59 points.

Table 2

Using Information Responsibly Test Scores Descriptive Data

Groups	N	Mean	Standard Deviation	Minimum	Maximum	Min.-Max. Range
MT group	38	37.02	6.64	22.09	47.14	25.05
G1 group	35	36.45	6.08	25.41	46.21	20.80
G2 group	26	37.04	4.29	27.64	45.14	17.50
Overall	99	36.08	5.85	22.09	47.14	

Note: The Mean, Minimum, Maximum, and Minimum-Maximum Range data included in this table are represented in points.

The descriptive statistics for the pretreatment self-efficacy survey by treatment group are presented in Table 3. The Using Information Responsibly Self-Efficacy Scale (UIRSES) survey consisted of 20 questions using a five-point Likert scale format. Fifteen of the 20 questions were positively stated questions where 5 = always true, 4 = usually true, 3 = occasionally true, 2 = rarely true, and 1 = never true. The remaining five questions were negatively stated questions where the point values for each question were reversed accordingly. The minimum and maximum possible scores were 20 and 100 respectively. The difference between the highest (G1 group) and the lowest (G2 group) means for the pretreatment survey was within 1.17 points.

Table 3

Pretreatment Self-Efficacy Survey Descriptive Data

Groups	N	Mean	Standard Deviation
MT group	38	78.37	7.96
G1 group	35	78.94	9.30
G2 group	26	77.77	8.14
Overall	99	78.41	8.43

Note: The Mean data represented in table 3 are in points out of 100.

Table 4 reports the descriptive statistics for the posttreatment survey by treatment group. After treatment, all participants were then given the same Using Information Responsibly Self-Efficacy Scale (UIRSES) survey to measure changes in self-efficacy from pretreatment to posttreatment. The order of the questions was randomized for each student on each application of the survey; however, since this was a Likert-scale survey, randomizing the order of the responses was not done. The difference between the highest (MT group) and lowest (G1 group) means for the posttreatment survey was within 1.18 points.

Table 4

Posttreatment Self-Efficacy Survey Descriptive Data

Groups	N	Mean	Standard Deviation
MT group	38	83.61	8.22
G1 group	35	82.43	9.43
G2 group	26	83.31	7.44
Overall	99	83.11	8.41

Note: The Mean data represented in table 3 are in points out of 100.

Research Question 1 Results

Research question 1 asked: Does the method of instruction (MT, G1, G2) affect the learning outcomes of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the module test? The results will be examined below.

A one-way, between-groups analysis of variance (ANOVA) was conducted to compare the means of each of the three treatment groups. There were no statistically significant differences found between the three groups' using information responsibly posttest scores [$F(2, 96) = .109$, $p = .897$] at the $\alpha = .05$ level. Therefore, this study found no evidence that the three methods of instruction (MT, G1, G2) affected learning by the subjects. Further, the effect size (η^2

= .002), showed that the type of instruction had a minimal effect as described by Myers et al. (2010). Because the one-way ANOVA found no statistically significant differences between treatment method and test scores, a post hoc analysis was neither needed nor conducted.

Because the Levene's test of homogeneity of variance approached significance at the α = .05 level (p = .090), it was decided to further examine the results by conducting a Kruskal-Wallis test which does not assume homogeneity of variance. The Kruskal-Wallis test showed no statistically significant differences between test score means of the treatment groups (MT, n = 38; G1, n = 35; G2, n = 26), $\chi^2(2, n = 99) = .36$, p = .836. This test result simply adds confidence to the statement that this study found no evidence that treatments using multimedia tutorials (MT), a game with minimally extraneous content (G1), or a game with more extraneous content (G2) affected student test scores as measured by the using information responsibly module test.

This study found no evidence that instruction using games with minimally extraneous content (G1) or games with more extraneous content (G2) were more or less effective than the instruction using non-gamified, multimedia tutorials (MT). This finding agrees with several other studies (Blakely et al., 2009; Randel et al., 1992; Tham & Tham, 2014; Wronowski et al., 2020). The results and conclusion from research question 1 will be discussed further in Chapter V, Conclusions.

Research Question 2 Results

Research question 2 asked: Does the method of instruction (MT, G1, G2) affect self-efficacy scores from pretreatment to posttreatment of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the Using Information Responsibly Self-Efficacy Scale survey? The results will be examined below.

A one-way, repeated measures analysis of variance (RMANOVA) with the between groups factor of teaching method was conducted to compare the effect of teaching method (MT, G1, G2) on perceived self-efficacy from pretreatment to posttreatment surveys. The descriptive statistics showed all three methods of teaching resulted in gains in self-efficacy. The RMANOVA showed that there was a statistically significant difference in overall self-efficacy from pre- to posttreatment across the different methods of teaching (MT, G1, G2) on student's perceived self-efficacy at the $\alpha = .05$ level for the three treatments, $F(1,96) = 34.547$, $p < .001$. The partial eta squared value ($\eta^2 = .265$) indicated a large effect size (Myers et al., 2010). Therefore, this study found that the instruction caused a statistically significant increase between pretreatment and posttreatment perceived self-efficacy scores.

The RMANOVA also compared the main effect of teaching method between group means [$F(2,96) = .030$, $p = .970$]. Given these results, this study found no statistically significant differences between treatment groups (MT, G1, G2) for self-efficacy. The partial eta squared value ($\eta^2 = .001$) indicated a minimal effect size (Myers et al., 2010). Because the RMANOVA found no statistically significant differences between treatment groups, a post hoc analysis was not needed.

The RMANOVA also compared the interaction effect between time and teaching method [$F(2,96) = .641$, $p = .529$]. Given these results, there was no statistically significant interaction effect found between the teaching method (MT, G1, G2) and the time of the administration of the self-efficacy survey. The partial eta squared value ($\eta^2 = .013$) indicated a small effect size (Myers et al., 2010).

Two one-way ANOVAs were conducted to determine if there were any differences between groups pretreatment caused by something in the random assignment or if there were any differences posttreatment that caused the gains to average out any significant differences. The first one-way ANOVA was conducted to determine if there was a difference between groups for the pretreatment survey. There was no statistically significant difference found between groups for the pretreatment survey, $F(2,96) = .143$, $p = .867$, which confirms that the random assignment of participants worked appropriately. The second one-way ANOVA was used in a posttreatment survey comparison to determine if there were any differences in self-efficacy gains concealed within the data, meaning it was used to check that there was not a group that was low, but not statistically significantly low on the pretreatment survey scores or a group that was high, but not statistically significantly high on the posttreatment survey scores averaging out gain scores, $F(2,96) = .185$, $p = .832$. Since no statistically significant difference was found, this leads to the conclusion that the three treatment types (MT, G1, G2) caused statistically equivalent gains on participants posttreatment perceived self-efficacy scores.

In conclusion, this study found a statistically significant difference between the pretreatment self-efficacy scores and the posttreatment self-efficacy scores where each treatment group had a statistically equivalent gain in self-efficacy scores from pre- to posttreatment. However, the lack of differences between groups indicated that the MT, G1, and G2 groups had similar gains in participants perceived self-efficacy. The findings of this study agree with other studies that showed that both game-based learning and multimedia instruction had a positive effect on self-efficacy (Huang & Mayer, 2019; Hung et al., 2014; Say & Bag, 2015; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009; Zheng, Young, Brewer, & Wagner, 2009). The gaming groups, G1 and G2, scored neither better nor worse than the multimedia tutorial group (MT) in perceived self-efficacy gains. The results and conclusion from research question 2 will be discussed further in Chapter V, Conclusions.

Research Question 3 Results

Research question 3 asked: What is the relationship between perceived self-efficacy posttreatment and student outcome scores for each of the three treatments in the study?

a. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the MT group?
b. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G1 group?
c. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G2 group?

A correlation is used to describe three characteristics of a relationship between variables: the direction (positive or negative, the form (linear or cluster), and the strength or consistency (if one variable changes, does the other variable also change in a predictable and consistent manner) (Gravetter & Wallnau, 2017). A Pearson's correlation coefficient (r value) was computed in this study to assess the linear relationship between test scores and perceived self-efficacy posttreatment scores. An r value is used to determine how the two variables vary together and how they vary separately. Overall, across all three groups, the r value found a statistically significant, small, positive correlation (the accuracy of the student's perceived self-efficacy as related to their test scores) between the two variables, $r(97) = .23$, $n = 99$, $p = .021$. The coefficient of determination (r^2) value is used to determine how much of the variance in one variable is determined from its relationship with the other variable. In this study, the coefficient of determination overall posttreatment was computed to be $r^2 = .054$ which indicated that 5.4% of the variability in test scores may be explained by the participant's variability in posttreatment self-efficacy scores (Gravetter & Wallnau, 2017).

A Pearson's correlation coefficient was also computed to assess the linear relationship between test scores and perceived self-efficacy pretreatment scores, and test scores and perceived self-efficacy posttreatment scores for each individual treatment group. The comparison between r and r^2 values may be found in Table 5.

Table 5

Correlation Coefficient and Coefficient of Determination Value Comparisons Between Test Scores and Self-Efficacy Surveys

Groups	Pretreatment Survey r	Pretreatment Survey r^2 (%)	Posttreatment Survey r	Posttreatment Survey r^2 (%)
MT Group	-.063	.4%	.150	2.30%
G1 Group	.175	3.1%	.276	7.6%
G2 Group	.111	1.2%	.333	11.1%
Overall	.062	.4%	.232	5.4%

Note: This table compares the r and r^2 values for the pretreatment self-efficacy surveys and test scores, and the posttreatment self-efficacy surveys and test scores within each treatment group. The r^2 values have been converted to percentages.

Each individual subgroup's correlation was examined separately to see if they were all roughly similar or if some had higher and some had lower correlations between their perceived self-efficacy and their actual performance on this topic. For the multimedia tutorial (MT) group, while there was a small, positive correlation found between test scores and perceived self-efficacy posttreatment, it was not statistically significant, $r(36) = .15$, $n = 38$, $p = .370$. The coefficient of determination for the MT group posttreatment ($r^2 = .023$) indicated only 2.30% of the variability in test scores may be explained by the MT groups' variability in posttreatment self-efficacy scores (Gravetter & Wallnau, 2017).

For the game with minimally extraneous content (G1) group, there was a small, positive correlation found between the two variables, but it was of no statistical significance, $r(33) = .28$, $n = 35$, $p = .109$. The coefficient of determination for the G1 group posttreatment ($r^2 = .076$) indicated that 7.6% of the variability in test scores may be explained by the G1 groups' variability in posttreatment self-efficacy scores (Gravetter & Wallnau, 2017).

For the game with more extraneous content (G2) group, there was a small to medium, positive correlation found between test scores and perceived self-efficacy posttreatment, but it was not statistically significant, $r(24) = .33$, $n = 26$, $p = .097$. The coefficient of determination for the G2 group posttreatment ($r^2 = .111$) indicated that 11.1% of the variability in test scores may be explained by the G2 groups' variability in posttreatment self-efficacy scores (Gravetter & Wallnau, 2017).

All teaching methods (MT, G1, G2) showed an increase in perceived self-efficacy after the treatments. The G2 treatment had the largest agreement between the student's perceived self-efficacy and actual test scores. Based on the results of the Pearson's correlation, the treatments all seem to be responsible for the increased correlations of perceived self-efficacy from pretreatment to posttreatment. The game-based learning groups (G1 and G2) showed higher increases in the accuracy of perceived self-efficacy scores to predict test scores than the multimedia tutorial (MT) group.

In this study, the correlation between the participant's posttreatment surveys and test scores indicates a more accurate connection between learner self-awareness and final test score achievement. While all treatments strengthened the relationship between perceived self-efficacy posttreatment and test scores, the two game-based learning treatments (G1, G2) led to larger correlations which are interpreted as a more accurate self-understanding of learners' capabilities on the test. The game-based learning (G1, G2) treatments allowed students to better assess their own ability as measured by the test scores than did the multimedia tutorial (MT) treatment. This will be further discussed in Chapter V, Conclusions.

This study found that there was a statistically significant, small, positive correlation between test scores and perceived self-efficacy overall; however, no statistically significant difference was found between the individual groups test scores and the perceived self-efficacy posttreatment scores. This study agrees with other studies that found a positive correlation between self-efficacy and posttreatment performance in teaching methods that used either multimedia or game-based learning; however, this study’s results were not statistically significant (Huang & Mayer, 2019; Hung et al., 2014; Say & Bag, 2015; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009; Zheng, Young, Brewer, & Wagner, 2009). The results and conclusion from research question 3 will be discussed further in Chapter V, Conclusions.

Summary of Results

This study examined the effects of different teaching methods (MT, G1, G2) on test scores. Results from this study showed that teaching method did not have a statistically significant effect on overall test scores. This study found no evidence that instruction using games with minimally extraneous content (G1) or games with more extraneous content (G2) was more or less effective than the instruction using non-gamified, multimedia tutorials (MT).

This study found a statistically significant difference between the pretreatment self-efficacy scores and the posttreatment self-efficacy scores where each treatment group had a statistically equivalent gain in self-efficacy scores from pre- to posttreatment. However, the lack of differences between groups indicated that the MT, G1, and G2 groups caused similar gains in participants perceived self-efficacy. This study found no statistically significant differences in the self-efficacy of any of the groups before the treatments took place which was expected due to random assignment. No statistically significant differences for perceived self-efficacy were found after the treatments took place indicating the treatment groups posttreatment were also found to be equal.

Lastly, the study examined the correlational relationship between test scores and perceived self-efficacy posttreatment. The results showed that overall, there was a statistically significant, small, positive correlation between test scores and perceived self-efficacy posttreatment. Although there was a positive correlation found for the three treatment groups individually, the results were not statistically significant. Since the correlations were higher between the posttreatment self-efficacy scores and the test scores than the pretreatment self-efficacy scores and the test scores, it may be that the teaching method increased the accuracy of the self-efficacy scores and thus raised the correlations. This will be discussed more in Chapter V, Conclusions.

CHAPTER V

Conclusions

The first purpose of this quantitative study was to examine the effects of game-based learning, both minimally extraneous and more extraneous versions, on student learning outcomes compared to a multimedia tutorial presentation as measured by posttest grades for students in the information literacy portion of a first-year seminar course (ROAR 1199) at Idaho State University (ISU) during the fall 2021 semester. Secondly, this study measured the effects of game-based learning, both minimally extraneous and more extraneous versions, on perceived self-efficacy scores pretreatment to posttreatment compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course as measured by the Using Information Responsibly Self-Efficacy Scale (UIRSES) survey. The third and final purpose of this study was to determine the relationship between perceived self-efficacy posttreatment and student outcomes in a game-based learning environment, both minimally extraneous and more extraneous versions, compared to a multimedia tutorial presentation in the information literacy portion of the ROAR 1199 course.

Research Questions

The proposed study focuses on three main research questions. The research questions are listed below.

1. Does the method of instruction (MT, G1, G2) affect the learning outcomes of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the module test?
2. Does the method of instruction (MT, G1, G2) affect self-efficacy scores from pretreatment to posttreatment of undergraduate university students enrolled in a first-

year, information literacy course module on using information responsibly as measured by the Using Information Responsibly Self-Efficacy Scale survey?

3. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for each of the three treatments in the study?
    a. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the MT group?
    b. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G1 group?
    c. What is the relationship between perceived self-efficacy posttreatment and student outcome scores for the G2 group?

Conclusions and Discussion

This chapter will discuss the results of this study with explanations regarding the potential meaning of those results. The findings from each research question will be examined individually and potential explanations of those results will be discussed. In addition to providing discussion about the results of each research question, it will also include recommendations for future research and recommendations for future instructional design practices.

Discussion of Research Question 1 Results

The results of the one-way ANOVA found no statistically significant difference between test scores based upon teaching method. The most direct interpretation of this finding is that there are no differences between either game-based instruction or high-quality multimedia tutorial instruction on the topic of using information responsibly for the sample used in this study. The G1 and G2 treatments were found to be as equally effective for learning as the MT instruction.

Studies have found that game-based learning engages and motivates learners and improves their learning outcomes (Bodnar et al., 2016; Blakely et al., 2009; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020) Other studies have found that non-gamified multimedia learning is more engaging, motivating, and effective in increasing student outcomes (Chipangura & Aldridge, 2017; Ellis, 2004; Huang & Mayer, 2016, 2019; Junaidu, 2008; Liu et al., 2017; Liu & Elms, 2019; Mandernach, 2009; Moen, 2021; Sadik, 2008). This study's use of high-quality multimedia tutorials may have increased the baseline group's scores and therefore counteracted any increases in test scores from the game-based treatments.

The multimedia tutorials on this subject were created to adhere to all the multimedia principles discussed in the Multimedia Design Principles subsection of Chapter II. After the review of the multimedia tutorials for adherence to all the multimedia principles, it was determined that some of the instruction violated the redundancy principle by having graphics, printed text, and narration that repeated some of the text verbatim. An unpublished manuscript by Coffland and Hartgraves (2021) found that some level of redundancy is acceptable and does not harm learning. Their results found that a 50% redundancy group scored statistically equivalent to both 0% and 10% redundancy groups. The 0%, 10%, and 50% redundancy groups all scored statistically significantly higher than the 25% redundancy group. The fact that the multimedia tutorials used in this study have some redundancy may not have had any negative impact on learning.

The multimedia instruction was developed using research-based knowledge that has been studied for over 20 years (Mayer et al., 2001; Moreno & Mayer, 2002). Because game-based learning does not have the same breadth and depth of research as multimedia learning, it does not have a set of research-proven design principles suggesting what game types, mechanics, elements, etc. improve learning. In this study, while it was the first attempt by the G1 and G2 treatment developers at applying the coherence principle to game-based learning, specifically a virtual escape room game, the designers were more experienced in the application of research-based pedagogy for developing the MT treatment. This leaves open the possibility that improved game-based instruction might eventually outperform the more studied multimedia instruction in effectiveness to increase learning outcomes. The outcome of this study was consistent with other studies that found that using game-based learning did not increase learning (Blakely et al., 2009; Randel et al., 1992; Tham & Tham, 2014; Wronowski et al., 2020). However, this result was not consistent with other research that has shown that game-based learning may increase engagement and motivation in learners and improve learning outcomes (Blakely et al., 2009; Bodnar et al., 2016; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020).

Does the method of instruction (MT, G1, G2) affect the learning outcomes of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the module test? The descriptive statistics for the test scores by treatment group are presented in Table 2, which is repeated below for convenience. The difference between the highest (G2 group) and lowest (G1 group) means for the test scores was within 0.59 points. Since this value is approximately one tenth of the overall standard deviation, the effect size was minimal ($\eta^2 = .002$) (Myers et al., 2010). Because of the small sample size, the no statistically significant difference result was expected.

Table 2

Using Information Responsibly Test Scores Descriptive Data

Groups	N	Mean	Standard Deviation	Minimum	Maximum	Min.-Max. Range
MT group	38	37.02	6.64	22.09	47.14	25.05
G1 group	35	36.45	6.08	25.41	46.21	20.80
G2 group	26	37.04	4.29	27.64	45.14	17.50
Overall	99	36.08	5.85	22.09	47.14	

Note: The Mean, Minimum, Maximum, and Minimum-Maximum Range data included in this table are represented in points.

The game-based learning (G1, G2) treatment groups had higher minimum and lower maximum test scores than the multimedia (MT) treatment group. This may be a unique characteristic of this data set; however, it may be that this type of game-based treatment raises the lowest scores and limits the highest scores. A potential reason for higher minimum and lower maximum scores in the G1 and G2 groups might be that the virtual escape room games only require the player to learn the information necessary to obtain the codes needed to escape the room. The virtual escape room game may force the players to learn the minimum amount of information needed but does not provide an equal opportunity for them to obtain the maximum amount of learning. Therefore, the game-based learning treatments may compress the overall test scores.

The multimedia tutorials (MT group) content included the information relevant to the posttest assessment as well as examples of using information responsibly. This served as a type of baseline in terms of the variability of the group. The MT group's standard deviation was 6.64 with a minimum posttest score of 22.09 and a maximum posttest score of 47.14. While the multimedia tutorials contained knowledge checks, those knowledge checks did not cover all the content, but only the most important parts. The multimedia tutorial's knowledge checks allowed the learner to try again if they did not answer correctly the first time, but it did not require the learner to go back and watch the relevant part of the tutorial again. The learner was allowed to continue in the tutorial even if they did not pass the knowledge check.

Both game-based learning (G1, G2) groups had higher minimum and lower maximum scores and less variability, than the MT group. The game-based learning with minimal extraneous (G1 group) content (SD = 6.08) did not include any additional information except what was needed to play the game. In terms of content within the game, it presented what was necessary for the posttest without extraneous information which is a possible explanation for the G1 group's higher minimum score (25.41) when compared to the MT group (22.09). However, it may not have provided enough information to fully understand the topic as its maximum score was lower (46.21) than the MT group (47.14) causing the G1 group to have less variability than the MT group.

The game-based learning with more extraneous information (G2 group) content (SD = 4.29) had the same information as provided to the G1 group, but also included additional interesting but unnecessary topic-related information. Perhaps the more extraneous information was equivalent to the examples included in the multimedia tutorials allowing the lower scorers to score higher (minimum 27.64) than the MT and G1 groups. However, because the information was extraneous, perhaps this also did not provide enough information to fully understand the topic as its maximum score was lower (45.14) than the MT and G1 groups causing the G2 group to have less variability than the other two groups.

Since there was no difference between any of the group's test scores based upon treatment, it seems that any potential lowering of test scores due to violations of the coherence principle were counteracted by the benefits of game-based learning. Although there was less adherence to the coherence principle in the G1 and G2 teaching methods, the results from the test scores show that these teaching methods were statistically equal to the MT method.

Another possible explanation for the lack of significant differences may be sample sizes for the three groups were relatively small. The small size reduced the power and made it difficult to ascertain the effect of game-based learning and the coherence principle on student learning outcomes.

Another reason for the lack of significant results may be the short duration of the treatment. Participants were limited to one attempt to play the game during a one-week period of the course. Single game play sessions have been shown to be less effective than multiple game play sessions (Clark et al., 2016; Kim & Chang, 2010; Randel et al., 1992). Playing the game only once may limit the amount of knowledge obtained by the player and lower maximum test scores.

Finally, the lack of statistically significant results may be partially attributed to the compatibility of the game type and the content (Prensky, 2007). The Deadline game is a virtual escape room game. This type of puzzle game may not have been sufficiently motivating or engaging to some students, therefore, not increasing their motivation to learn (Blakely et al., 2009; Randel et al., 1992; Tham & Tham, 2014; Wronowski et al., 2020). Using a different game genre, such as action, adventure, role-playing, strategy, etc. might be more motivating and engaging for certain learners and therefore improve their learning outcomes (Blakely et al., 2009; Bodnar et al., 2016; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim &

Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Prensky, 2007; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020). This study was limited to the using information responsibly topic. Findings by Ellis (2004), Hays (2005), and Randel et al. (1992) have shown that improved learning using games may be dependent on subject matter. It may be that this study's combination of subject matter and game type did not promote learning like other game types or topics might.

Discussion of Research Question 2 Results

A one-way RMANOVA with between groups factor of teaching method found a statistically significant difference in perceived self-efficacy from pre- to posttreatment across the different methods of teaching (MT, G1, G2). The most straightforward interpretation of this finding is that overall, teaching method did affect student's perceived self-efficacy pre- to posttreatment across all treatment groups. When looked at individually, results also found all three methods of teaching resulted in gains in self-efficacy. However, when the main effect of teaching method between group means was compared, no statistically significant differences between groups (MT, G1, G2) for perceived self-efficacy were found. This study also compared the interaction effect between time and teaching method and found no statistically significant differences between the teaching method (MT, G1, G2) and the time of the administration of the perceived self-efficacy survey. The effect size was minimal ($\eta^2 = .013$) (Myers et al., 2010). While not statistically significant, these results were consistent with other studies that found that both game-based learning and multimedia instruction had a positive effect on self-efficacy (Huang & Mayer, 2019; Hung et al., 2014; Say & Bag, 2015; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009; Zheng, Young, Brewer, & Wagner, 2009).

Does the method of instruction (MT, G1, G2) affect self-efficacy scores from pretreatment to posttreatment of undergraduate university students enrolled in a first-year, information literacy course module on using information responsibly as measured by the using information responsibly Self-Efficacy Scale survey? The descriptive statistics for the pretreatment survey by treatment group are presented in Table 3 which is repeated below for convenience. The lowest possible survey score students might receive was 20 and the highest possible was 100. The difference between the highest and lowest means for the pretreatment survey was within 1.17.

Table 3

Pretreatment Self-Efficacy Survey Descriptive Data

Groups	N	Mean	Standard Deviation
MT group	38	78.37	7.96
G1 group	35	78.94	9.30
G2 group	26	77.77	8.14
Overall	99	78.41	8.43

Note: The Mean data represented in table 3 are in points out of 100.

The descriptive statistics for the posttreatment survey by treatment group are presented in Table 4 which is repeated below for convenience. The difference between the highest and lowest means for the posttreatment survey was within 1.18. The effect size was large ($\eta^2 = .265$) (Myers et al., 2010).

Table 4

Posttreatment Self-Efficacy Survey Descriptive Data

Groups	N	Mean	Standard Deviation
MT group	38	83.61	8.22
G1 group	35	82.43	9.43
G2 group	26	83.31	7.44
Overall	99	83.11	8.41

Note: The Mean data represented in table 3 are in points out of 100.

Of the individual groups from pre- to posttreatment, the G1 group had the smallest gain in mean self-efficacy scores of 3.49. The G2 group had the largest gain in self-efficacy of 5.54. The MT group had a gain in self-efficacy of 5.24. The G1 group received less information in their treatment than did the other two groups in their respective treatments. Due to the lack of extraneous information, this might be interpreted as the more information presented to the learner, even if it is extraneous information, the more they feel they know about the topic.

There are several possible explanations of the results found in this study for research question 2. The sample size for the three groups in this study is small. The small sample size reduced the power and might have made it difficult to determine the effect of game-based learning and the coherence principle on perceived self-efficacy. A larger sample size might help determine if the 40% smaller gain in self-efficacy from pre- to posttreatment for the G1 group was due to randomness or something that might be resolved as statistically significant with a larger sample.

An additional reason for the lack of statistically significant results might be the fact that this study compared multimedia learning with game-based learning and did not include a comparison using traditional lecture-based instruction. Studies have shown that game-based learning increases self-efficacy more than traditional instruction (Hung et al., 2014; Say & Bag, 2015; Zheng, Young, Brewer, & Wagner, 2009). Other studies have shown that multimedia learning increases self-efficacy (Huang & Mayer, 2019; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009). Therefore, game-based learning and multimedia learning may be relatively equal in their ability to increase perceived self-efficacy.

Another reason for the results may be the short duration of the treatment. Participants were limited to one attempt to play the game during a one-week period of the course. More opportunities to play over a longer period might allow for small differences in learning to grow over time and potentially affect perceived self-efficacy positively. Self-efficacy is an individual characteristic and like confidence, may need time to develop or be modified.

Another possible explanation is that the findings from this study were produced using only quantitative data (test scores and self-reported rating scores) (Huang & Mayer, 2019). Including qualitative data to the research, such as participant interviews and focus groups, would add insight into the participant's subjective experiences and how they interpreted the process (Leavy, 2017).

Discussion of Research Question 3 Results

Research question 3 examined the relationship between perceived self-efficacy posttreatment and student outcome scores both across all groups as well as for the three groups individually. The Pearson's correlation coefficient (r) across all three groups found a small, statistically significant, positive correlation between the students posttreatment perceived self-efficacy scores and their test scores ($r = .23$, $n = 99$). However, there was no similar, statistically significant correlation found for pretreatment perceived self-efficacy scores and the actual test scores ($r = .062$, $p = .543$). It could be said that the learners' posttreatment perceived self-efficacy scores were somewhat more predictive of their actual test scores than their pretreatment self-efficacy scores. However, this increase in the correlation was small ($r^2 = 0.054$) (Myers et al., 2010).

A Pearson's correlation coefficient was also computed within each group. A very small, positive correlation between test scores and posttreatment perceived self-efficacy scores was found for the MT group ($r = .15$, $n = 38$), but it was not statistically significant. There was no statistically significant correlation ($p = .706$) between the pretreatment perceived self-efficacy scores and the actual test scores ($r = -.063$, $r^2 = 0.004$). Student's posttreatment perceived self-efficacy scores predicted less than 3% of the variability of the actual test scores ($r^2 = 0.023$) for the MT group (Myers et al., 2010). The MT treatment caused the coefficient of determination to increase from 0.4% to 2.30%.

Results found a small, positive correlation between test scores and posttreatment perceived self-efficacy scores for the G1 group ($r = .28$, $n = 35$). However, it was not statistically significant. No statistically significant correlation ($p = .314$) was found between the pretreatment perceived self-efficacy scores and actual test scores ($r = .175$, $r^2 = 0.031$). The posttreatment perceived self-efficacy predicted less than 8% of the variability of the actual test scores ($r^2 = 0.076$) for the G1 group (Myers et al., 2010). The G1 treatment caused the coefficient of determination to increase from 3.1% to 7.6%.

A small, positive correlation between test scores and posttreatment perceived self-efficacy scores was also found for the G2 group ($r = .33$, $n = 26$), but it also had no statistical significance. No statistically significant correlation ($p = .591$) was found between the pretreatment perceived self-efficacy scores and the actual test scores ($r = .111$, $r^2 = 0.012$). For the G2 group, the posttreatment perceived self-efficacy scores predicted approximately 11% of the variability of the actual test scores ($r^2 = 0.111$) (Myers et al., 2010). The G2 treatment caused the coefficient of determination to increase from 1.2% to 11.1%. While no statistically significant differences were found for the three groups individually, the learners in all groups were able to better predict their performance on the test after they received their respective treatments. These results were similar to the findings in previous research which showed that self-efficacy has a positive correlation with student achievement (Austin et al., 2018; Chemers et al., 2001; Huang & Mayer, 2019; Travis et al., 2020; Wasylkiw et al., 2020). The r and r^2 values for the pretreatment and posttreatment surveys by treatment group are presented below in Table 5, which is repeated below for convenience.

Table 5

Correlation Coefficient and Coefficient of Determination Value Comparisons Between Test Scores and Self-Efficacy Surveys

Groups	Pretreatment Survey r	Pretreatment Survey r^2 (%)	Posttreatment Survey r	Posttreatment Survey r^2 (%)
MT Group	-.063	.4%	.150	2.30%
G1 Group	.175	3.1%	.276	7.6%
G2 Group	.111	1.2%	.333	11.1%
Overall	.062	.4%	.232	5.4%

Note: This table compares the r and r^2 values for the pretreatment self-efficacy surveys and test scores, and the posttreatment self-efficacy surveys and test scores within each treatment group. The r^2 values have been converted to percentages.

There are several possible reasons for the results found in this study for research question 3. Sample size is one possible explanation. A larger sample size, with more statistical power, might have shown a statistically significant relationship between perceived posttreatment self-efficacy and student outcome scores for the individual treatment groups. A statistically significant correlation found in a study with a larger sample would increase the researcher's confidence level to be able to generalize the findings into the broader population. The increased power from the larger sample size in the overall finding was what made that result statistically significant when the results for the individual groups were not significant. The sample size needed for significant results in the individual groups was calculated using G*Power statistical power analysis software. In order to produce statistically significant results at the correlations found in research question 3 of this study, the MT group ($r = .15$) sample size would need to be $n = 346$, the G1 group ($r = .28$) sample sized would need to be $n = 97$, and the G2 group ($r = .33$) sample size would need to be $n = 69$.

An additional explanation for the lack of statistically significant results might be the fact that this study compared multimedia learning with game-based learning instead of a comparison using traditional lecture-based instruction. As stated on research questions 1 and 2, research has found that game-based learning engages and motivates learners and improves their learning outcomes (Bodnar et al., 2016; Blakely et al., 2009; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020) However, other studies have found that non-gamified multimedia learning is also more engaging, motivating, and effective in increasing student outcomes (Chipangura & Aldridge, 2017; Ellis, 2004; Huang & Mayer, 2016, 2019; Junaidu, 2008; Liu et al., 2017; Liu & Elms, 2019; Mandernach, 2009; Moen, 2021; Sadik, 2008). Similarly, studies have shown that game-based learning increases self-efficacy (Hung et al., 2014; Say & Bag, 2015; Zheng, Young, Brewer, & Wagner, 2009) while other research has also shown that multimedia learning also increases self-efficacy (Huang & Mayer, 2019; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-

Evans, & Williamson, 2009). The use of multimedia learning as the comparison treatment method may have obscured any increase in learning outcomes and self-efficacy due to the game-based learning treatment with equivalent gains due to multimedia tutorial treatment.

Again, the benefits of game-based learning may have been obscured by slightly lowered learning due to the violation of the coherence principle. While the G1 and G2 teaching methods violated the coherence principle more than the MT teaching method, the results from the test scores show that the three teaching methods were equal statistically in their effect on learning.

Lastly, ~~t~~he results may be due to the short duration of the treatment. Participants were limited to one attempt to play the game during a one-week period of the course. Single game play sessions have been shown to be less effective than multiple game play sessions (Clark et al., 2016; Kim & Chang, 2010; Randel et al., 1992). Allowing for multiple game play sessions may give the learner time to acquire more information on the topic and increase test scores. More opportunities to play over a longer period might also allow students the time they might need to develop self-efficacy on the topic and to become better predictors of their own performance.

Recommendations for Future Research

While the minimum requirement of sample size was met for this study, sample sizes were still relatively small. Replicating this study with a larger sample size will increase the power of the study, provide more generalizable results, and may confirm the results of this research (Bodnar et al., 2016; Tham & Tham, 2014). Repeating this study with a larger sample size might also help to determine if the compressed test scores found in the game-based learning treatments in research question 1 are unique characteristics of this study’s data set. For research question 2, a larger sample size might increase the chance of getting a statistically significant result from pre- to posttreatment self-efficacy scores between the three treatment groups. Using a larger sample size may also result in a statistically significant correlation between perceived self-efficacy posttreatment and actual test scores or more confidence in the level of predictive ability due to that relationship as discussed in research question 3.

This study included both game-based learning and multimedia learning, but not traditional lecture-based learning. As stated previously, past studies have found that game-based learning engages and motivates learners and improves their learning outcomes (Bodnar et al., 2016; Blakely et al., 2009; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020). Other research has found that non-gamified multimedia learning is more engaging, motivating, and effective in increasing student outcomes (Chipangura & Aldridge, 2017; Ellis, 2004; Huang & Mayer, 2016, 2019; Junaidu, 2008; Liu et al., 2017; Liu & Elms, 2019; Mandernach, 2009; Moen, 2021; Sadik, 2008). However, research has shown that game-based learning also increases self-efficacy (Hung et al., 2014; Say & Bag, 2015; Zheng, Young, Brewer, & Wagner, 2009). Other studies have shown that multimedia learning increases self-efficacy as well (Huang & Mayer, 2019; van der Meij et al., 2018; Zheng, McAlack, Wilmes, Kohler-Evans, & Williamson, 2009). Future studies might use different types of teaching methods other than multimedia tutorials and/or a more traditional lecture approach as the control group (Ellis, 2004; Liu & Elms, 2019; Moen, 2021). This could help determine if game-based learning and/or the type of multimedia learning used is more effective in improving test scores (research question 1) and perceived self-efficacy (research question 2).

There are no established boundary conditions for the coherence principle (Clark & Mayer, 2016; Mayer, 2014c, Mayer & Fiorella, 2014). Further research might test larger violations of the coherence principle in the game to determine if, even in game-based learning, there is a point when extraneous content does detract from test scores.

This study was limited to the using information responsibly topic. Studies have shown that the effectiveness of game-based learning may be influenced by subject matter (Ellis, 2004; Hays, 2005: Randel et al., 1992). Future studies might include gamification of different topics in a course to determine if the subject of this study did not improve learning (research question 1).

The potential interaction effect between topic and game type might be studied. Prensky (2007) suggests that certain content types are better suited to specific game types. Table 6 illustrates different types of content and the possible game types associated with them.

Table 6

Prensky's (2007) Content Type versus Game Type

Content Type	Game Type
Facts	Game show competitions; flashcard games; mnemonics; action games; sport games
Skills	Persistent state games; role-play games; adventure games; detective games
Judgment	Role-play games; detective games; multiplayer interaction; adventure games; strategy games
Behaviors	Role-playing games
Theories	Open ended simulation games; building games; construction games; reality testing games
Reasoning	Puzzle games
Process	Strategy games; adventure games; simulation games
Procedures	Timed games; reflex games
Creativity	Puzzle games; invention games
Language	Role-playing games; reflex games; flashcard games
System	Simulation games
Observation	Concentration games; adventure games
Communication	Role-playing games; reflex games

Note: This table is adapted from Prensky, 2007, p.156.

The game type should also match the skills the learner needs to meet the learning objectives. Boller and Kapp (2017) have associated the six levels of Bloom's Taxonomy with different game types. The game type should enable the player to achieve the cognitive skill required. Learning objectives should map to the instructional goal, and the game type should enable the players to achieve the objectives (Boller & Kapp, 2017). Table 7 illustrates the different cognitive skills and the associated game types to consider.

Table 7

Boller and Kapp's (2017) Bloom's Taxonomy and Game Type

Cognitive Skill	Game Type
Level 1: Knowledge (remember facts, ideas)	Quiz, arcade, matching games, game show
Level 2: Comprehension (understand/explain facts, ideas)	Quiz, collection and classification games, exploration games, storytelling games
Level 3: Application (use facts, ideas to solve problems/respond to situations)	Story/scenario-based quiz, matching games, role-playing games, decision making scenario games, simulations
Level 4: Analysis (identify causes, make inferences, form generalizations)	Strategy games
Level 5: Synthesis (organize, combine information to form alternative solutions)	Building games, simulations
Level 6: Evaluation (judge information and facts against criteria, form opinions based on judgment, defend judgments)	Simulations, role-playing games

Note: This table is adapted from Boller & Kapp, 2017, p.42.

The game-based learning portion of the course was limited to a one-week period in which only one attempt at play was allowed. Prior research suggests frequency of game play effects learning outcomes (Clark et al., 2016; Kim & Chang, 2010; Randel et al., 1992). As discussed in research questions 1, 2, and 3, future research might add game-based learning to additional modules of a course to determine if its effects accrue over a longer period. Allowing multiple attempts at game play might also be considered to determine if repeated exposure to the learning content increases student performance, perceived self-efficacy, and possibly, the relationship between student performance and perceived self-efficacy.

The game used in this study was a virtual escape room or puzzle type game. This type of game genre may not be motivating and engaging for some learners. Future research might include a game with a different genre, such as action, adventure, strategy, etc. to investigate if the change in game genre increases student motivation, engagement, and achievement (Blakely et al., 2009; Bodnar et al., 2016; Bodzin et al., 2020; Clark et al., 2016; Hays, 2005; Khan et al., 2017; Kim & Chang, 2010; Nadolny & Halabi, 2016; Ozturk & Korkmaz, 2020; Prensky, 2007; Randel et al., 1992; Sabirli & Coklar, 2020; Tham & Tham, 2014; Wronowski et al., 2020).

Game type, learning objectives, and Bloom's Taxonomy might also be examined. The game type should align with the learning objectives that are mapped to the instructional goal. The game type should enable the players to achieve the learning objectives (Boller & Kapp, 2017). Future research might compare different game types with different cognitive skills to determine which game type is best suited to acquiring those particular abilities.

Future research might also include examining which instructional design aspects of game-based learning are more motivating and engaging to students (Tham & Tham, 2014). Additional studies on game type may also help determine if game type is related to the lower maximum scores found in the game-based learning treatments discussed in the results of research question 1. Perhaps other game types would not limit the maximum amount of information that is learned by the player.

Finally, this study's results were generated using only quantitative data. Further research may be done including qualitative data, such as participant interviews and focus groups, to provide further understanding of participant's perceptions of self-efficacy.

Recommendations for Future Instructional Design Practice

This study examined the effects of game-based learning and the coherence principle on student learning outcomes, perceived self-efficacy, and the relationship between test scores and self-efficacy compared to multimedia instruction. Since the results for research question 1 found no difference between the teaching methods on learning outcomes, the most direct interpretation of this result is that instructional designers may create game-based instruction with no fear that high quality multimedia would have led to higher test scores.

As discussed in research questions 1 and 3, there are no established boundary conditions for the coherence principle. While the extra benefits from game-based learning seem to offset some losses in learning due to the coherence principle, designers should exercise caution when including extraneous content and game elements in game development.

As discussed in research questions 1 and 2, instructional designers may consider making the game-based learning portion of the instruction repeatable. This will provide multiple opportunities for game play that may be one of the advantages to game-based learning (Clark et al., 2016; Kim & Chang, 2010; Randel et al., 1992). As discussed in research questions 1, 2, and 3, instructional designers might add game-based learning to additional modules of a course to determine if its effects accrue over a longer period.

Instructional designers may design the game-based learning content using a different game genre (action, adventure, strategy, etc.) which might increase student engagement, motivation, and performance. Designers should pay close attention when choosing the appropriate game type for its content type, making sure that the game type is suitable for the content type being taught (research question 1).

Learning objectives and the cognitive skills needed to meet those objectives should also be considered when investigating game genres. Instructional designers must ensure that the learners are enabled to meet the learning objectives by choosing the game type best suited to acquire those skills.

Perhaps game-based learning instruction that is well designed could offer learners a choice of the type of game they play. Creating multiple game types for the same instructional content, while increasing development costs, might increase learner engagement and motivation and, therefore, lead to improved student outcomes and perceived self-efficacy.

The time and cost invested to develop a game might initially be higher than what is needed to create a multimedia tutorial. However, designers should consider that over time, multimedia tutorials might need to be updated for content, aesthetics, and modernization, and there will be costs and time investment incurred for those updates. A game may essentially be designed where it is timeless and except for perhaps updating content, the upkeep costs might be considerably less than with multimedia tutorials. Costs might also be recouped in increased student motivation and engagement.

As discussed in research question 2, results found that both the multimedia (MT) and the game-based learning (G1, G2) instruction increased student’s perceived self-efficacy. Therefore, instructional designers may confidently use either form of teaching method to increase a learner’s perceived self-efficacy.

Summary

This study was conducted to examine the effects of game-based learning, in both minimally extraneous and more extraneous versions, on student learning outcomes and self-efficacy compared to a multimedia tutorial presentation. The relationship between perceived self-efficacy posttreatment and student outcomes was also explored. The Cognitive Theory for Multimedia Learning (CTML) and Self-Efficacy Theory (SET) were used as the frameworks for this study. This study included three different treatments: (a) a multimedia tutorial (MT), (b) a game with minimally extraneous content (G1), and (c) a game with more extraneous content (G2). The Kemp model was used to design the treatments based on the instructional design process. All three treatments taught the same learning objectives. All treatments and instruction were delivered asynchronously online.

Research question 1 investigated the effects of teaching method on test scores. No statistically significant difference was found between test scores based on teaching method. The G1 and G2 treatments were found to be as equally effective for learning as the MT instruction.

Research question 2 examined the effects of teaching method on perceived self-efficacy pre- to posttreatment. Results found a statistically significant difference overall in perceived self-efficacy from pre- to posttreatment across the different teaching methods. When looked at individually, all three teaching methods resulted in gains in perceived self-efficacy, however, none of the comparisons between groups were statistically significant.

Research question 3 explored the relationship between perceived self-efficacy posttreatment and test scores. Overall, a small, statistically significant correlation was found between perceived self-efficacy posttreatment scores and test scores. When examined individually, all three treatment groups showed a positive correlation between posttreatment perceived self-efficacy scores and test scores, but none were found to be statistically significant. The treatments seem to cause, although not statistically significant, higher correlations between posttreatment perceived self-efficacy scores and actual test scores compared to the pretreatment perceived self-efficacy scores and actual test scores correlations.

While there may be boundary conditions for the coherence principle that have yet to be established, the amount of extraneous content and game elements used in this study resulted in no loss of learning for the students. Due to the benefits of using game-based learning (e.g., increased student motivation and engagement), it may be acceptable to have some coherence violations especially if it doesn't detract from learning.

References

Adkins, S. S. (2019, July 26). *The 2019-2024 global game-based learning market: Serious games industry in boom phase* [PowerPoint slides]. Metaari Advanced Learning Technology Research. https://www.slideshare.net/SeriousGamesAssoc/the-20192024-global-gamebased-learning-market

Ajayi, P. O., & Ajayi, L. F. (2020). Use of online collaborative learning strategy in enhancing postgraduates' learning outcomes in science education. *Educational Research and Reviews, 15*(8), 504-510. https://doi.org/10.5897/ERR2020.4023

Alessi, S. M., & Trollip, S. R. (2001). *Multimedia for learning: Methods and development* (3rd ed.). Allyn and Bacon.

Alhamwi, N., Al Jarbou, F., Ourfhli, A., Alfaris, F., Algannass, T., AlSaffan, A., & Ansari, S. H. (2020). Perception and experience of dental students regarding e-learning education in the universities of Riyadh. *Pharmacophore, 11*(6), 67-73.

Allen, I. E., & Seaman, J. (2015). *Grade level: Tracking online education in the United States.* Babson Survey Research Group. https://files.eric.ed.gov/fulltext/ED572778.pdf

Allen, I. E., & Seaman, J. (2017). *Digital Learning Compass: Distance Education Enrollment Report 2017*. Babson Survey Research Group. http://publicservicesalliance.org/wp-content/uploads/2018/01/digtiallearningcompassenrollment2017.pdf

Alsubhi, M. A., Ashaari, N. S., & Wook, T. S. M. T. (2019). The challenge of increasing student engagement in e-learning platforms. *2019 International Conference on Electrical Engineering and Informatics (ICEEI)*, 266–271. https://doi.org/10.1109/ICEEI47359.2019.8988908

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Abridged edition). Longman.

Atkinson, R. K., Mayer, R. E., & Merrill, M. M. (2005) Fostering social agency in multimedia learning: Examining the impact of an animated agent's voice. *Contemporary Educational Psychology, 30*(1), 117-139. https://doi.org/10.1016/j.cedpsych.2004.07.001

Austin, A. C., Hammond, N. B., Barrows, N., Gould, D. L. and Gould, I. R. (2018). Relating motivation and student outcomes in organic chemistry. *Chemistry Education Research and Practice, 19*(1), 331-341. https://doi.org/10.1039/c7rp00182g

Ayres, P., & Sweller, J. (2014). The split-attention principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 206-226). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Baddeley, A. (2007). *Working memory, thought, and action*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198528012.001.0001

Bailey, A., Vaduganathan, N., Henry, T., Laverdiere, R., & Pugliese, L. (2018). *Making digital work: Success strategies from six leading universities and community colleges.* The Boston Consulting Group. https://edplus.asu.edu/sites/default/files/BCG-Making-Digital-Learning-Work-Apr-2018%20.pdf

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall, Inc.

Bandura, A. (1992). Exercise of personal agency through the self-efficacy mechanism. In R. Schwarzer (Ed.), *Self-efficacy: Thought control of action* (pp. 3-38). Hemisphere Publishing Corporation.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). Academic Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman and Company.

Bains, M., Reynolds, P. A., McDonald, F., & Sherriff, M. (2011). Effectiveness and acceptability of face-to-face, blended and e-learning: A randomized trial of orthodontic undergraduates. *European Journal of Dental Education, 15*(2), 110-117. https://doi.org/10.1111/j.1600-0579.2010.00651.x

Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education, 41*, 77-86. https://doi.org/10.1016/S0360-1315(03)00027-7

Bauhoff, V., Huff, M., & Schwan, S. (2012). Distance matters: Spatial contiguity effects as trade-off between gaze switches and memory load. *Applied Cognitive Psychology, 26*(6), 863-871. https://doi.org/10.1002/acp.2887

Baylor, A. L., & Kim, S. (2009). Designing nonverbal communication for pedagogical agents: When less is more. *Computers in Human Behavior, 25*(2), 450-457. https://doi.org/10.1016/j.chb.2008.10.008/

Beffa-Negrini, P. A., Cohen, N. L., & Miller, B. (2002). Strategies to motivate students in online learning environments. *Journal of Nutrition Education & Behavior, 34*(6), 334–340. https://doi.org/10.1016/s1499-4046(06)60116-4

Bell, K. (2018). *Game on!: Gamification, gameful design, and the rise of the gamer educator*. Johns Hopkins University Press.

Beylefeld, A. A., & Struwig, M. C. (2007). A gaming approach to learning medical microbiology: Students' experiences of flow. *Medical Teacher*, *29*(9/10), 933-940. https://doi.org/10.1080/01421590701601550

Blakely, G., Skirton, H., Cooper, S., Allum, P., & Nelmes, P. (2009). Educational gaming in the health sciences: Systematic review. *Journal of Advanced Nursing, 65*(2), 259-269. https://doi.org/10.1111/j.1365-2648.2008.04843.x

Bodnar, C. A., Anastasio, D., Enszer, J. A., & Burkey, D. D. (2016). Engineers at play: Games as teaching tools for undergraduate engineering students. *Journal of Engineering Education, 105*(1), 147-200. https://doi.org/10.1002/jee.20106

Bodzin, A., Araujo, R., Hammond, T., & Anastasio, D. (2020). An immersive virtual reality game designed to promote learning engagement and flow. *6th International Conference of the Immersive Learning Research Network (iLRN)* (193-198). Immersive Learning Research Network. https://doi.org/10.23919/iLRN47897.2020.9155132

Boeker, M., Andel, P., Vach, W., & Frankenschmidt, A. (2013). Game-based e-learning is more effective than a conventional instructional method: A randomized controlled trial with third-year medical students. PLOS ONE, 8(12), 1-11. https://doi.org10.1371/journal.pone.0082328/

Boller, S., & Kapp, K. (2017). *Play to learn: Everything you need to know about designing effective learning games.* ATD Press.

Botturi, L., & Loh, C. S. (2008). Rediscovering the roots of games in education. In C. T. Miller (Ed.), *Games: Purpose and potential in education* (pp.1-22). Springer.

Bracht, G. H., & Glass, G. V. (1968). The external validity of experiments. *American Educational Research Journal*, *5*(4), 437-474. https://doi.org/10.3102/00028312005004437

Bradley, R. L., Browne, B. L., & Kelley, H. M. (2017). Examining the influence of self-efficacy and self-regulation in online learning. *College Student Journal*, *51*(4), 518-530.

Brady, M., & Devitt, A. (2016). *The role of winning and losing within games in higher education settings*. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2738083

Budasi, I. G., Ratminingsih, N. M., Agustini, K., & Risadi, M. Y. (2020). Power Point game, motivation, achievement: The impact and student's perception. *International Journal of Instruction*, *13*(4), 509-522. https://doi.org/10.29333/iji.2020.13432a

Butcher, K. R. (2014). The multimedia principle. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 174-205). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Cagir, S., & Oruc, S. (2020). Intelligence and mind games in concept teaching in social studies. *Participatory Educational Research*, *7*(3), 139-160. https://doi.org/10.17275/per.20.39.7.3

Cai, H., & Gu, X. (2019). Supporting collaborative learning using a diagram-based visible thinking tool based on cognitive load theory. *British Journal of Educational Technology*, *50*(5), 2329-2345. https://doi.org/10.1111/bjet.12818

Camilleri, M. A., & Camilleri, A. C. (2017). The students' perceptions of digital game-based learning. *Proceedings of the European Conference on Games Based Learning*, 56-62.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Rand McNally & Company.

Canty, D., Barth, J., Yang, Y., Peters, N., Palmer, A., Royse, A., & Royse, C. (2019). Comparison of learning outcomes for teaching focused cardiac ultrasound to physicians: A supervised human model course versus an elearning guided self-directed simulator course. *Journal of Critical Care, 49,* 38-44. https://doi.org/10.1016/j.jcrc.2018.10.006

Carver, D. L., & Kosloski, M. F. (2015). Analysis of student perceptions of the psychosocial learning environment in online and face-to-face career and technical education courses. *Quarterly Review of Distance Education*, *16*(4), 7-21.

Castelijn, J. T. F. (2017). *Improving massive courses with micro games: The effect of small serious games on student retention in MOOCs*. [Unpublished master's thesis]. Delft University of Technology. http://resolver.tudelft.nl/uuid:fe27c4c0-a809-446f-8dbd-57ea2a340fc1

Chemers, M. M., Hu, L-t., & Garcia, B. F. (2001). Academic self-efficacy and first-year college student performance and adjustment. *Journal of Educational Psychology*, *93*(1), 55-64. https://doi.org/10.1037//0022-0663.93.1.55

Chen, P-S. D., Gonyea, R., & Kuh, G. (2008). Learning at a distance: Engaged or not?, *Innovate: Journal of Online Education*, *4*(3).

Chen, P-S. D., Lambert, A. D., & Guidry, K. R. (2010). Engaging online learners: The impact of web-based learning technology on college student engagement. *Computers & Education*, *54*(4), 1222-1232. https://doi.org/10.1016/j.compedu.2009.11.008

Chiang, H-H. (2020). Kahoot! in an EFL reading class. *Journal of Language Teaching and Research*, *11*(1), 33-44. https://doi.org/10.17507/jltr.1101.05

Chickering, A. W., & Gamson, Z. F. (1987, March). Seven principles for good practice in undergraduate education. *American Association for Higher Education Bulletin*, 2-6. https://files.eric.ed.gov/fulltext/ED282491.pdf

Chipangura, A., & Aldridge, J. (2017). Impact of multimedia on students' perceptions of the learning environment in mathematics classrooms. *Learning Environments Research*, *20*(1), 121-138. https://doi.org/10.1007/s10984-016-9224-7

Clark, C. M. (2019). Extended reality in informal learning environments. In K. J. Varnum (Ed.), *Beyond reality: Augmented, virtual, and mixed reality in the library* (pp. 17-29). ALA Editions.

Clark, R. C., & Mayer, R. E. (2016*). e-Learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning* (4th ed.). John Wiley & Sons, Inc.

Clark, B. C., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79-122. https://doi.org/10.3102/0034654315582065

Clarke, T., Ayres, P, & Sweller, J. (2005). The impact of sequencing and prior knowledge on learning mathematics through spreadsheet application. *Educational Technology Research and Development*, *53*(3), 15-24.

Clayton, K., Blumberg, F., & Auld, D. P. (2010). The relationship between motivation, learning strategies and choice of environment whether traditional or including an online component. *British Journal of Educational Technology, 41*(3), 349-364. https://doi.org/10.1111/j.1467-8535.2009.00993.x/

Coffland, D., & Hartgraves, G. (2021). *The boundary conditions of the redundancy principle.* [Unpublished manuscript]. College of Education, Idaho State University.

College Crisis Initiative (C2i). (2020, September 9). *Welcome to the C2i dashboard*. The College Crisis Initiative @ Davidson College. https://collegecrisis.shinyapps.io/dashboard/

Colliot, T., & Jamet, E. (2018). Understanding the effects of a teacher video on learning from a multimedia document: An eye-tracking study. *Educational Technology Research & Development*, *66*(6), 1415-1433. https://doi.org/10.1007/s11423-018-9594-x

Community College Research Center. (2013). *What we know about online course outcomes.* Community College Research Center, Teacher's College Columbia University. https://ccrc.tc.columbia.edu/media/k2/attachments/what-we-know-about-online-course-outcomes.pdf

Contreras-Espinosa, R. S., & Gomez, J. L. E. (2020). How could the use of game elements help students' affective and cognitive engagement during game play? *Journal of Information Technology Research*, *13*(1), 17-29. https://doi.org/10.4018/JITR.2020010102

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design & analysis issues for field settings.* Houghton Mifflin Company.

Craig, S. D., & Schroeder, N. L. (2017). Reconsidering the voice effect when learning from a virtual human. *Computers & Education*, *114*, 193-205. https://doi.org/10.1016/j.compedu.2017.07.003

Craig, S. D., Twyford, J., Irigoyen, N., & Zipp, S. A. (2015). A test of spatial contiguity for virtual human's gestures in multimedia learning environments. *Journal of Educational Computing Research*, *53*(1), 3-14. https://doi.org/10.1177/0735633115585927

Crooks, S. M., Cheon, J., Inan, F., Ari, F., & Flores, R. (2012). Modality and cueing in multimedia learning: Examining the cognitive and perceptual explanations for the modality effect. *Computers in Human Behavior, 28*(3), 1063-1071. https://doi.org/10.1016/j.chb.2012.01.010

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* Harper Perennial.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22*(14), 1111-1132. https://doi.org/10.1111/j.1559-1816.1992.tb00945.x

Davis, R. O., Vincent, J., & Park, T. (2019). Reconsidering the voice principle with non-native language speakers. *Computers & Education, 140*, 132-143. https://doi.org/10.1016/j.compedu.2019.103605

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification: Using game-design elements in non-gaming contexts. *Conference on Human Factors in Computing Systems Proceedings*, 2425-2428.

Dobbs, R. R., del Carmen, A., & Waid-Lindberg, C. A. (2017). Students' perceptions of online courses: The effect of the online course experience. *The Quarterly Review of Distance Education, 18*(1), 93-109.

Doolittle, P. E., & Altstaedter, L. L. (2009). The effect of working memory capacity on multimedia learning: Does attentional control result in improved performance? *Journal of Research in Innovative Teaching, 2*(1), 7-25.

Draus, P. (2020). Impact of student engagement strategies on video content in learning computer programming and attitudes towards video instruction that was developed based on the cognitive theory of multimedia learning. *Issues in Information Systems, 21*(3), 126-134. https://doi.org/10.48009/3_iis_2020_126-134

Education Commission of the States. (2007). Student engagement. *The Progress of Education Reform 2007, 8*(3). http://www.ecs.org/clearinghouse/75/77/7577.pdf

Elbasuony, M. M. M., Gangadharan, P., Janula, R., Shylaja, J., & Gaber, F. A. (2018). Undergraduate nursing students' perception and usage of e-learning and Blackboard learning system. *Middle East Journal of Nursing, 12*(2), 3-13. https://doi.org/10.5742/MEJN.2018.93394

E-learning. (n.d.) Power Thesaurus. Retrieved March 6, 2021, from https://www.powerthesaurus.org/e-learning

Elias, J., Troop, D., & Wescott, D. (2020, October 1). *Here's our list of colleges' reopening models*. The Chronicle of Higher Education. https://www.chronicle.com/article/Here-s-a-List-of-Colleges-/248626?cid=cp275

Ellis, T. (2004). Animating to build higher cognitive understanding: A model for studying multimedia effectiveness in education. *Journal of Engineering Education, 93*(1), 59-64. https://doi.org/10.1002/j.2168-9830.2004.tb00788.x

Eltahir, M. E., Alsalhi, N. R., Al-Qatawneh, S., AlQudah, H. A., & Jaradat, M. (2021). The impact of game-based learning (GBL) on students' motivation, engagement and academic performance on an Arabic language grammar course in higher education. *Education and Information Technologies, 26*(3), 3251-3278. https://doi.org/10.1007/s10639-020-10396-w

Fenesi, B., Heisz, J. J., Savage, P. D., Shore, D. I., & Kim, J. A. (2014). Combining best-practice and experimental approaches: Redundancy, images, and misperceptions in multimedia learning. *The Journal of Experimental Education, 82*(2), 253-263. https://doi.org/10.1080/00220973.2012.745472

Fenesi, G., Kramer, E., & Kim, J. A. (2016). Split-attention and coherence principles in multimedia instruction can rescue performance from learners with lower working memory capacity. *Applied Cognitive Psychology, 30*(5), 691-699. https://doi.org/10.1002/acp.3244

Fidalgo, P., Thormann, J., Kulyk, O., & Lencastre, J. A. (2020). Students' perceptions on distance education: A multinational study. *International Journal of Educational Technology in Higher Education, 17*, 1-18. https://doi.org/10.1186/s41239-020-00194-2

Finn, J. D. (1993). *School engagement & students at risk.* National Center for Education Statistics. https://nces.ed.gov/pubs93/93470a.pdf

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of evidence. *Review of Educational Research, 74*(1), 59-109.

Garner, R. (1992). Learning from school texts. *Educational Psychologist, 27*(1), 53-63. https://doi.org/10.1207/s15326985ep2701_5

Garner, R., Alexander, P. A., Gillingham, M. G., Kulikowich, J. M., & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal*, *28*(3), 643-659. https://doi.org/10.2307/1163152

Garner, R., Gillingham, M. G., & White, C. S. (1989). Effects of "seductive details" on macroprocessing and microprocessing in adults and children. *Cognition and Instruction, 6*(1), 41-57.

Gee, J. P. (2007). *What video games have to teach us about learning and literacy*. Palgrave Macmillan.

Gee, J. P. (2013). Good video games + good learning: Collected essays on video games, learning and literacy (2nd ed.). Peter Lang. https://doi.org/10.3726/978-1-4539-1162-4

Gee, J. P., & Hayes, E. R. (2010). *Women and gaming: The Sims and 21st century learning*. Palgrave Macmillan.

Gemino, A., Parker, D., & Kutzschan, A. O. (2005). Investigating coherence and multimedia effects of a technology-mediated collaborative environment. *Journal of Management Information Systems, 22*(3), 97-121.

Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education*, *68*, 429-439.

Global $2.4 bn game-based learning market 2019-2024: Industry trends, share, size, growth, opportunity and forecasts. (2019, February 20). *Research and Markets*. Retrieved January 16, 2021, from https://www.globenewswire.com/news-release/2019/02/20/1738527/0/en/Global-2-4-Bn-Game-Based-Learning-Market-2019-2024-Industry-Trends-Share-Size-Growth-Opportunity-and-Forecasts.html

Gravetter, F. J., & Wallnau, L. B. (2017). *Statistics for the behavioral sciences* (10th ed.). Cengage Learning.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In L. Corno and E. M. Anderman (Eds.), *Handbook of educational psychology* (3rd ed., pp. 15-46). Routledge.

Gunnell, J. (2017). *Relevant versus extraneous music in multimedia instruction: A study of the coherence principle* [Unpublished doctoral dissertation]. Duquesne University.

Hanney, M., & Newvine, T. (2006). Perceptions of distance learning: A comparison of online and traditional learning. *MERLOT Journal of Online Learning and Teaching, 2*(1), 1-11. https://jolt.merlot.org/documents/MS05011.pdf

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102. https://doi.org/10.1037/0022-0663.89.1.92

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology, 90*(3), 414-434. https://doi.org/10.1037/0022-0663.90.3.414

Hays, R. T. (2005). *The effectiveness of instructional games: A literature review and discussion*. Naval Air Warfare Center Training Systems Division.

Hess, R. D., & Takanishi, R. (1974). *The relationship of teacher behavior and school characteristics to student engagement* (Technical Report No. 42). Stanford Center for Research and Development in Teaching. https://files.eric.ed.gov/fulltext/ED098225.pdf

Hildmann, J., & Hildmann, H. (2011). Augmenting initiative game worlds with mobile digital devices. In M. Ma, A. Oikonomou, & L. C. Jain (Eds.) *Serious games and edutainment applications* (pp. 125-148). Springer.

Honey, M. A., & Hilton, M. L. (Eds.). (2011). *Learning science through computer games and simulations.* The National Academies Press.

Horspool, A., & Lange, C. (2012). Applying the scholarship of teaching and learning: Student perceptions, behaviours and success online and face-to-face. *Assessment & Evaluation of Higher Education, 37*(1), 73-88. https://doi.org/10.1080/02602938.2010.496532

Huang, X., & Mayer, R. E. (2016). Benefits of adding anxiety-reducing features to a computer-based multimedia lesson on statistics. *Computers in Human Behavior, 63*, 293-303. https://doi.org/\10.1016/j.chb.2016.05.034

Huang, X., & Mayer, R. E. (2019). Adding self-efficacy features to an online statistics lesson. *Journal of Educational Computing Research, 57*(4), 1003-1007. https://doi.org/10.1177/0735633118771085

Huda, M., Maseleno, A., Atmotiyoso, P., Siregar, M., Ahmad, R., Jasmi, K. A. & Muhamad. N. H. N. (2018). Big data emerging technology: Insights into innovative environment for online learning resources. *International Journal of Emerging Technologies in Learning (IJET), 13*(01), 23–36. https://doi.org/10.3991/ijet.v13i01.6990

Hung, C-M., Huang, I., & Hwang G-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education, 1*(203), 151-166. https://doi.org/10.1007/s40692-014-0008-8

Idaho State University. (n.d.). *About Qualtrics*. https://www.isu.edu/qualtrics/

Isiaq, S. O., & Jamil, M. G. (2018). Enhancing student engagement through simulation in programming sessions. *The International Journal of Information and Learning Technology, 35*(2), 105-117. https://doi.org/10.1108/IJILT-09-2017-0091

Iten, N., & Petko, D. (2016). Learning with serious games: Is fun playing the game a predictor of learning success. *British Journal of Educational Technology, 47*(1), 151-163. https://doi.org/10.1111/bjet.12226

Johnson, N., Donovan, T., Seaman, J., & Bates, T. (2019). *Canadian national survey of online and digital learning* [Conference presentation]. Global Online Learning Summit. Canada.

http://www.cdlra-acrfl.ca/wp-content/uploads/2020/07/2019_presentation_national_en.pdf

Johnson, C. I., & Mayer, R. E. (2012). An eye movement analysis of the spatial contiguity effect in multimedia learning. *Journal of Experimental Psychology: Applied, 18*(2), 178-191. https://doi.org/10.1037/a0026923

Junaidu, S. (2008). Effectiveness in multimedia in learning and teaching data structures online. *Turkish Online Journal of Distance Education, 9*(4), 97-107.

Kalyuga, S., Chandler, P., & Sweller, J. (2000). Incorporating learner experience into the design of multimedia instruction. *Journal of Educational Psychology*, *92*(1), 126-136. https://doi.org/10.1037/0022-0663.92.1.126

Kanthan, R., & Senger, J-L. (2011). The impact of specially designed digital games-based learning in undergraduate pathology and medical education. *Archives of Pathology & Laboratory Medicine, 135*(1), 135-142. https://doi.org/10.5858/2009-0698-oar1.1

Kaplan, G., Bolat, Y. I., Goksu, I., & Ozdas, F. (2021). Improving the positive behavior of primary school students with the gamification tool "ClassDojo". *Elementary Education Online*, *20*(1), 1193-1201. https://doi.org/0.17051/ilkonline.2021.01.108

Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and instruction*. Pfeiffer.

Kapp, K. M., Blair, L., & Mesch, R. (2014). *The gamification of learning and instruction fieldbook*. John Wiley & Sons, Inc.

Karapetian, A. O. (2020). Creating ESP-based language learning environment to foster critical thinking capabilities in students' papers. *European Journal of Educational Research, 9*(2), 717-728.

Khaleel, F. L., Ashaari, N. S., Wook, T. S. M. T., & Ismail, A. (2017). Gamification-based learning framework for a programming course. *2017 6th International Conference on Electrical Engineering and Informatics (ICEEI)*, 1–6. https://doi.org/10.1109/ICEEI.2017.8312377

Khan, F. (1997). Lessons learned from an NSF pilot project on minority student retention. *Proceedings Frontiers in Education 1997 27th Annual Conference. Teaching and Learning in an Era of Change Frontiers in Education Conference, USA, 3,* 1418-1422. https://doi.org/10.1109/FIE.1997.632689

Khan, A., Ahmad, F. H., & Malik, M. M. (2017). Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. *Education and Information Technologies*, *22*(6), 2767-2804. https://doi.org/10.1007/s10639-017-9622-1

Kiili, K. (2005). Participatory multimedia learning: Engaging learners. *Australasian Journal of Educational Technology, 21*(3), 303-322.

Kim, S., & Chang, M. (2010). Computer games for the math achievement of diverse students. *Educational Technology & Society, 13*(3), 224-232.

Kiron, N., Adaji, I., Long, J., & Vassileva, J. (2020). Engaging students in a peer-quizzing game to encourage active learning and building a student-generated question bank. *Electronic Journal of e-Learning, 18*(3), 235-247. https://doi.org/10.34190/EJEL.20.18.3.003

Krause, M., Mogalle, M., Pohl, H., & Williams, J. J. (2015). A playful game changer: Fostering student retention in online education with social gamification. *Proceedings of the Second ACM Conference on Learning, Canada,* 95-102. https://doi.org/10.1145/2724660.2724665

Kumar, R., & Lightner, R. (2007). Games as an interactive classroom technique: Perceptions of corporate trainers, college instructors and students. *International Journal of Teaching and Learning in Higher Education, 19*(1), 53-63.

Kurbanoglu, S. S., Akkoyunla, B., & Umay, A. (2006). Developing the information literacy self-efficacy scale. *Journal of Documentation, 62*(6), 730-743. https://doi.org/10.1108/00220410610714949

Kurt, S. C., & Yildirim, I. (2018). The students' perceptions on blended learning: A Q method analysis. *Educational Sciences: Theory & Practice, 18*(2), 427-446. https://doi.org/10.12738/estp.2018.2.0002

Landrum, B. (2020). Examining students' confidence to learn online, self-regulation skills and perceptions of satisfaction and usefulness of online classes. *Online Learning, 24*(3), 128-146. https://doi.org/10.24059/olj.v24i3.2066

Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community based participatory research approaches*. The Guilford Press.

Lee, H., & Mayer, R. E. (2018). Fostering learning from instructional video in a second language. *Applied Cognitive Psychology, 32*(5), 648-654. https://doi.org/10.1002/acp.3436

Lehman, S., Schraw, G., McCrudden, M. T., & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology, 32*(4), 569-587. http://doi.org/10.1016/j.cedpsych.2006.07.002

Lehman, J. A. M., & Seufert, T. (2017). The influence of background music on learning in the light of different theoretical perspectives and the role of working memory capacity. *Frontiers in Psychology, 8*, 1-11. https://doi.org/10.3389/fpsyg.2017.01902

Levy, Y. (2007). Comparing dropouts and persistence in e-learning courses. *Computers & Education, 48*(2), 185-204. https://doi.org/10.1016/j.compedu.2004.12.004

Li, L-Y. (2019). Effect of prior knowledge on attitudes, behavior, and learning performance in video lecture viewing. *International Journal of Human-Computer Interaction, 35*(4-5), 415-426. https://doi.org/10.1080/10447318.2018.1543086

Li, Y. W., Neo, M., & Neo, T-K. (2013). Using Mayer's design principles in online learning modules: Implementation in a student centered learning environment. *2013 International Conference on Informatics and Creative Multimedia (ICICM)*, 304-309. https://doi,org/10.1109/ICICM.2013.57

Li, W., Wang, F., Mayer, R E., & Liu, H. (2019). Getting to the point: Which kinds of gestures by pedagogical agents improve multimedia learning? *Journal of Educational Psychology, 111*(8), 1382-1395. https://doi.org/10.1037/edu0000352

Litwin, M. S. (1995). *How to measure survey reliability and validity.* Sage Publications, Inc. https://doi.org/10.4135/9781483348957

Liu, C-C., Chen, W-C., Lin, H-M., & Huang, Y-Y. (2017). A remix-oriented approach to promoting student engagement in a long-term participatory learning program. *Computers & Education, 110,* 1-15. https://doi.org/10.1016/j.compedu.2017.03.002

Liu, C., & Elms, P. (2019). Animating student engagement: The impacts of cartoon instructional videos on learning experience. *Research in Learning Technology, 27,* 1-31. https://doi.org/10.25304/rlt.v27.2124

Liu, M., Toprac, P., & Yuen, T. T. (2009). What factors make a multimedia learning environment engaging: A case study. In R. Z. Zheng (Ed.), *Cognitive effects of* *multimedia learning* (pp. 173-192). IGI Global. https://doi.org/10.4018/978-1-60566-158-2.ch010

Low, R., & Sweller, J. (2014). The modality principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 227-246). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Luch, D. (2018). *Retention and gamification: A quantitative study* (Publication No. 10930867) [Doctoral dissertation, University of Phoenix]. ProQuest.

Lusk, D. L., Evans, A. D., Jeffrey, T. R., Palmer, K. R., Wikstrom, C. S., & Doolittle, P. E. (2009). Multimedia learning and individual differences: Mediating the effects of working memory capacity with segmentation. *British Journal of Educational Technology, 40*(4), 636-651. https://doi.org/10.1111/j.1467-8535.2008.00848.x

Maki, R. H., Maki, W. S., Patterson, M., & Whittaker, P. D. (2000). Evaluation of a web-based introductory psychology course: I. Learning and satisfaction in on-line versus lecture courses. *Behavior Research Methods, Instruments, & Computers, 32*(2), 230-239.

Malkawi, E., Bawaneh, A. K., Bawa'aneh, M. S. (2020). Campus off, education on: UAEU students' satisfaction and attitudes towards e-learning and virtual classes during COVID-19 pandemic. *Contemporary Educational Technology*, *13*(1), 1-14. https://doi.org/10.30935/cedtech/8708

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science*, *5*(4), 333-369. https://doi.org/10.1207/s15516709cog0504_2

Mandernach, B. J. (2009). Effect of instructor-personalized multimedia in the online classroom. *International Review of Research in Open and Distance Learning, 10*(3), 1-19.

Mansouri, P., Sayari, R., Dehghani, Z., Hosseini, F. N. (2020). Comparison of the effect of multimedia and booklet methods on quality of life of kidney transplant patients: A randomized clinical trial study. *International Journal of Community Based Nursing & Midwifery*, *8*(1), 12-22. https://doi.org/10.30476/IJCBNM.2019.73958.0. /

Marcus, V. B., Atan, N. A., Yusof, S. M., & Mastura, U. (2021). Students' perception towards engaging factors of extreme e-service learning design for computer network course. *International Journal of Interactive Mobile Technologies*, *15*(5), 100-115. https://doi.org/10.3991/ijim.v15i05.20901

Marinoni, G., van't Land, H., & Jensen, T. (2020). *The impact of COVID-19 on higher education around the world: IAU global survey report*. International Association of Universities. https://www.iau-aiu.net/IMG/pdf/iau_covid19_and_he_survey_report_final_may_2020.pdf

Mayer, R. E. (1989). Systematic thinking fostered by illustrations in scientific text. *Journal of Educational Psychology*, *81*(2), 240-246. https://doi.org/10.1037/0022-0663.81.2.240

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist*, *32*(1), 1-19. https://doi.org/10.1207/s15326985ep3201_1

Mayer, R. E. (2011). *Applying the science of learning.* Pearson.

Mayer, R. E. (Ed.). (2014a). *Cambridge handbook of multimedia learning* (2nd ed.). Cambridge University. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E. (2014b). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 43-71). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E. (2014c). *Computer games for learning: An evidence-based approach*. The MIT Press.

Mayer, R. E. (2014d). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 1-24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E. (2014e). Principles based on social cues in multimedia learning: Personalization, voice, image, and embodiment principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 345-368). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781316941355

Mayer, R. E. & Anderson, R. B. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, *83*(4), 484-490. https://doi.org/10.1037/0022-0663.83.4.484

Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology*, *84*(4), 444-452. https://doi.org/10.1037/0022-0663.84.4.444

Mayer, R. E., & DaPra, C. S. (2012). An embodiment effect in computer-based learning with animated pedagogical agents. *Journal of Experimental Psychology: Applied*, *18*(3), 239-252. https://doi.org/10.1037/a0028616

Mayer, R. E., DeLeeuw, K. E., & Ayres, P. (2007). Creating retroactive and proactive interference in multimedia learning. *Applied Cognitive Psychology, 21*(6), 795-809. https://doi.org/10.1002/acp.1350

Mayer, R. E., Fennell, S., Farmer, L., & Campbell, J. (2004). A personalization effect in multimedia learning: Students learn better when words are in conversational style rather than formal style. *Journal of Educational Psychology*, *96*(2), 389-395. https://doi.org/10.1037/0022-0663.96.2.389

Mayer, R. E., & Fiorella, L. (2014). Principles for reducing extraneous processing in multimedia learning: Coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 279-315). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E., & Gallini, J. K. (1990). When is an illustration worth ten thousand words? *Journal of Educational Psychology*, *82*(4), 715-726. https://doi.org/10.1037/0022-0663.82.4.715

Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details leads to decreased learning. *Journal of Experimental Psychology: Applied*, *14*(4), 329-339. http://doi.org/10.1037/a0013835

Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, *93*(1), 187-198. https://doi.org/10.1037//0022-0663.93.1.187

Mayer, R. E., & Jackson, J. (2005). The case for coherence in scientific explanations: Quantitative details can hurt qualitative understanding. *Journal of Experimental Psychology: Applied*, *11*(1), 13-18. https://doi.org/10.1037/1076-898X.11.1.13

Mayer, R. E., & Johnson, C. (2008). Revising the redundancy principle in multimedia learning. *Journal of Educational Psychology*, *100*(2), 380-386. https://doi.org/10.1037/0022-0663.100.2.380

Mayer, R. E., Mathias, A., Wetzell, K. (2002). Fostering understanding of multimedia messages through pre-training: Evidence for a two-stage theory of mental model construction. *Journal of Experimental Psychology: Applied, 8*(3), 147-154. https://doi.org/10.1037//1076-898X.8.3.147

Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology*, *94*(1), 171-185. https://doi.org/10.1037//0022-0663.94.1.171

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 43-52. https://doi.org/10.1207/S15326985EP3801_6

Mayer, R. E., Moreno, R., Boire, M., & Vagge, S. (1999). Maximizing constructivist learning from multimedia communications by minimizing cognitive load. *Journal of Educational Psychology*, *91*(4), 638-643. https://doi.org/10.1037/0022-0663.91.4.638

Mayer, R. E., & Pilegard, C. (2014). Principles for managing essential processing in multimedia learning: Segmenting, pre-training, and modality principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 316-344). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, *86*(3), 389-401. http://doi.org/10.1037/0022-0663.86.3.389

Mayer, R. E., Wells, A., Parong, J., & Howarth, J. T. (2019). Learner control of the pacing of an online slideshow lesson: Does segmenting help? *Applied Cognitive Psychology*, *33*(5), 930-935. https://doi.org/10.1002/acp.3560

McDonough, M., & Marks, I. M. (2002). Teaching medical students exposure therapy for phobia/panic – randomized, controlled comparison of face-to-face tutorial in small groups vs. solo computer instruction. *Medical Education*, *36*(5), 412-417. https://doi.org/10.1046/j.1365-2923.2002.01210.x

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. Penguin Group.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones., K. (2010). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. U. S. Department of Education. https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

Michael, D., & Chen, S. (2006). *Serious games: Games that educate, train, and inform*. Course Technology, Cengage Learning.

Miller, V. (2021). *Students enrolled in the ROAR course – Fall 2021 census day*. [data set]. Idaho State University Office of Institutional Research.

Miner, S., & Stefaniak, J. E. (2018). Learning via video in higher education: An exploration of instructor and student perceptions. *Journal of University Teaching & Learning Practice, 15*(2).

Moen, K. C. (2021). The impact of multi-media presentation format: Student perceptions and learning outcomes. *Scholarship of Teaching and Learning in Psychology*, 1-10. https://doi.org/10.1037/stl0000265

Moreno, R. (2007). Optimising learning from animations by minimizing cognitive load: Cognitive and affective consequences of signalling and segmentation methods. *Applied Cognitive Psychology*, *21*(6), 765-781. https://doi.org/10.1002/acp.1348

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology, 91*(2), 358-368. https://doi.org/10.1037/0022-0663.91.2.358

Moreno, R., & Mayer, R. E. (2000a). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia messages. *Journal of Educational Psychology*, *92*(1), 117-125. https://doi.org/10.1037//0022-0663.92.1.117

Moreno, R., & Mayer, R. E. (2000b). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*(4), 724-733. https://doi.org/10.1037//0022-0663.92.4.724

Moreno, R., & Mayer, R. E. (2002). Verbal redundancy in multimedia learning: When reading helps listening. *Journal of Educational Psychology, 94*(1). 156-163. https://doi.org/10.1037//0022-0663.94.1.156

Morrison, G. R., Ross, S. M., Morrison, J. R., & Kalman, H. K. (2019). *Designing effective instruction* (8th ed.). John Wiley & Sons, Inc.

Muller, D. A., Lee, K. J., & Sharma, M. D. (2008). Coherence or interest: Which is most important in online multimedia learning? *Australasian Journal of Educational Technology*, *24*(2), 211-221.

Myers, J. L., Well, A. D., & Lorch, R. F. (2010). *Research design and statistical analysis* (3rd ed.). Routledge.

Nadolny, L., & Halabi, A. (2016). Student participation and achievement in a large lecture course with game-based learning. *Simulation & Gaming*, *47*(1), 51-72. https://doi.org/10.1177/1046878115620388

Nafukho, F., & Chakraborty, M. (2014). Strengthening student engagement: What do students want in online courses? *European Journal of Training and Development*, *38*(9), 782-802. https://doi.org/10.1108/EJTD-11-2013-0123

National Center for Education Statistics. (2020, April). *Undergraduate retention and graduation rates*. Institute of Education Sciences. https://nces.ed.gov/programs/coe/indicator_ctr.asp

Nelson, L. M. (1999). *Increasing retention of adult learners in telecourses through the incorporation of learning-centered instructional strategies and the use of multiple modalities for content delivery and interaction* (Publication No. ED438469) [Doctoral dissertation, Nova Southeastern University]. ERIC.

Neo, M., & Neo, T-K. (2010). Students' perceptions in developing a multimedia project within a constructivist learning environment: A Malaysian experience. *The Turkish Online Journal of Educational Technology*, *9*(1), 176-184.

Neo, M., Neo, T-K., & Yap, W-L. (2008). Students' perceptions of interactive multimedia mediated web-based learning: A Malaysian perspective. In *Hello? Where are you in the landscape of educational technology? Proceedings ascilite Melbourne 2008*. Melbourne, Australia. https://www.ascilite.org/conferences/melbourne08/procs/neo.pdf

Neves da Nova Fernandes, S., Couto, G., & Afonso, A. (2019). An aging simulation game's impact on attitudes of nursing students. *Nursing Practice Today*, *6*(3), 142-151.

Nortvig, A-M., Petersen, A. K., & Balle, S. H. (2018). A literature review of the factors influencing e-learning and blended learning in relation to learning outcomes, student satisfaction and engagement. *Electronic Journal of e-Learning*, *16*(1), 46-55.

Ozturk, C., & Korkmaz, O. (2020). The effect of gamification activities on students' academic achievements in social studies course, attitudes towards the course and cooperative learning skills. *Participatory Educational Research, 7*(1), 1-15. https://doi.org/10.17275/per.20.1.7.1

Paas, F., & Sweller, J. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 27-42). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Lawrence Erlbaum Associates, Inc.

Pajeres, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

Pawar, S., Tam, F., & Plass, J. L. (2019). Emerging design factors in game-based learning: Emotional design, musical score, and game mechanics design. In J. L. Plass, R. E. Mayer, & B. D. Homer (Eds.), *Handbook of game-based learning* (pp. 347-365). MIT Press.

Pechenkina, E., Laurence, D., Oates, G., Eldridge, D., & Hunter, D. (2017). Using a gamified mobile app to increase student engagement, retention and academic achievement. *International Journal of Educational Technology in Higher Education, 14*(31), 1-12. https://doi.org/10.1186/s41239-017-0069-7

Peck, L., Stefaniak, J. E., Shah, S. J. (2018). The correlation of self-regulation and motivation with retention and attrition in distance education. *The Quarterly Review of Distance Education*, *19*(3), 1-15.

Pellas, N., & Kazanidis, I. (2015) On the value of Second Life for students' engagement in blended and online courses: A comparative study from the higher education in Greece. *Education and Information Technologies, 20*(3), 445-466. https://doi.org/10.1007/s10639-013-9294-4

Peters, J., & Cornetti, M. (2020). *Deliberate fun: A purposeful application of game mechanics to learning experiences.* Sententia.

Phipps, R., & Merisotis, J. (1999). *What's the difference: A review of contemporary research on the effectiveness of distance learning in higher education.* Institute for Higher Education Policy. https://files.eric.ed.gov/fulltext/ED429524.pdf

Pintrich, P. R., & de Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33-40. https://doi.org/10.1037/0022-0663.82.1.33

Prensky, M. (2005). Computer games and learning: Digital game-based learning. In J. Raessens & J. Goldstein (Eds.), *Handbook of computer game studies* (pp. 97-122). The MIT Press.

Prensky, M. (2006). *"Don't bother me mom – I'm learning".* Paragon House.

Prensky, M. (2007). *Digital game-based learning*. Paragon House.

Putra, A. K., Alfi, S. S., Fajrilia, A., Islam, M. N., & Yembuu, B. (2021). Effect of mobile-augmented reality (MAR) in digital encyclopedia on the complex problem solving attitudes of undergraduate student. *International Journal of Emerging Technologies in Learning, 16*(7), 119-134. https://doi.org/10.3991/ijet.v16i07.21223

Quinn, C. N. (2005). *Engaging learning: Designing e-learning simulation games.* Pfeiffer.

Rachels, J. R., & Rockinson-Szapkiw, A. J. (2018). The effects of a mobile gamification app on elementary students' Spanish achievement and self-efficacy. *Computer Assisted Language Learning*, *31*(1-2), 72-89. https://doi.org/10.1080/09588221.2017.1382536

Randel, J. M., Morris, B. A., Wetzel, C. D., & Whitehall, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation & Gaming, 23*(3), 261-276. http://doi.org/10.1177/1046878192233001

Rasmussen, K., Belisario, J. M., Wark, P. A., Molina, J. A., Loong, S. L., Cotic, Z., Papachristou, N., Riboli-Sasco, E., Car, L. T., Musulanov, E. M., Kunz, H., Zhang, Y., George, P. P., Heng, B. H., Wheeler, E. L., Al Shorbaji, N., Svab, I., Atun, R., Majeed, A., & Car, J. (2014). Offline elearning for undergraduates in health professions: A systemic review of the impact on knowledge, skills, attitudes and satisfaction. *Journal of Global Health*, *4*(1), 90-107. https://doi.org/10.7189/jogh.04.010405

Reed, K. N., & Miller, A. (2020). Applying gamification to the library orientation: A study of interactive user experience and engagement preferences. *Information Technology & Libraries*, *39*(3), 1-26. https://doi.org/10.6017/ital.v39i3.12209

Reeves, T. C. (1998). *The impact of media and technology in schools: A research report prepared for the Bertelsmann Foundation*. Bertelsmann Foundation. http://treeves.coe.uga.edu/Bertlesmann_Impact_Report.pdf

Richter, J., Scheiter, K., & Eitel A. (2018). Signaling text-picture relations in multimedia learning: The influence of prior knowledge. *Journal of Educational Psychology*, *110*(4), 544-560. https://doi.org/10.1037/edu0000220

Robinson, C. C., & Hullinger, H. (2008). New benchmarks in higher education: Student engagement in online learning. *Journal of Education for Business, 84*(2), 101-109. https://doi.org/10.3200/JOEB.84.2.101-109

Robinson, R., Wiley, K., Rezaeivahdati, A., Klarkowski, M., & Mandryk, R. L. (2020). ‘Let’s get physiological, physiological!’: A systematic review of affective gaming. *CHI PLAY '20: Annual symposium on computer-human interaction in play*, ACM, Canada, 132-47. https://doi.org/10.1145/3410404.3414227

Rondon, S., Sassi, F. C., de Andrade, C. R. F. (2013). Computer game-based and traditional learning method: A comparison regarding students' knowledge retention. *BMC Medical Education*, *13*, 1-8. https://doi.org/10.1186/1472-6920-13-30

Rop, G., Schuler, A., Verkoeijen, P. P. J. L., Scheiter, K., Van Gog, T. (2018). The effect of layout and pacing on learning from diagrams with unnecessary text. *Applied Cognitive Psychology*, *32*(5), 610-621. https://doi.org/10.1002/acp.3445

Rosenberg, H., Sander, M., & Posluns, J. (2005). The effectiveness of computer-aided learning in teaching orthodontics: A review of the literature. *American Journal of Orthodontics and Dentofacial Orthopedics*, 27(5), 599-605. https://doi.org/10.1016/j.ajodo.2004.02.020

Ryan, R. M., & Rigby, C. S. (2019). Motivational foundations of game-based learning. In J. L. Plass, R. E. Mayer, & B. D. Homer (Eds.), *Handbook of game-based learning* (pp. 153-176). MIT Press.

Sabirli, Z. E., & Coklar, A. N., (2020). The effect of educational digital games on education, motivation and attitudes of elementary school students against course access. *World Journal on Educational Technology*, *12*(4), 326-338. https://doi.org/10.18844/wjet.v12i4.5142

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology Research and Development, 56*(4), 487-506. https://doi.org/10.1007/s11423-008-9091-8

Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. The MIT Press.

Sammons, M. (1995). Students assess computer-aided classroom presentations. *T H E Journal*, *22*(10).

Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & Cognition, 34*(2), 344-355. https://doi.org/10.3758/BF03193412

Sankey, M. D., Birch, D., & Gardiner, M. W. (2011). The impact of multiple representations of content using multimedia on learning outcomes across learning styles and modal preferences. *International Journal of Education and Development using Information and Communication Technology, 7*(3), 18-35.

Say, S., & Bag, H. (2015). The effect of the computer game developed for the 7th grade science lesson, on student's self-efficacy toward science [Special Issue 2]. *The Turkish Online Journal of Educational Technology*, 594-600.

Schnotz, W. (2014). Integrated model of text and picture comprehension. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 72-103). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Schunk, D. H. (1989). Self-efficacy and achievement behaviors. *Educational Psychology Review, 1*(3), 173-208.

Seaman, J. E., Allen, I. E., & Seaman, J. (2018). *Grade increase: Tracking distance education in the United States*. Babson Survey Research Group. https://files.eric.ed.gov/fulltext/ED580852.pdf

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology, 59*(3), 623-664.

Smalley, A. (2020, December 28). *Higher education responses to Coronavirus (COVID-19)*. National Conference of State Legislatures.

https://www.ncsl.org/research/education/higher-education-responses-to-coronavirus-covid-19.aspx

Smeltzer, L. R., Vance, C. M. (1989). An analysis of graphic use in audio-graphic teleconferences. *Journal of Business Communication, 26*(2), 123-141. https://doi.org/10.1177/002194368902600203

Sorenson, C., & Donovan, J. (2017). An examination of factors that impact the retention of online students at a for-profit university. *Online Learning, 21*(3), 206-221. https://doi.org/10.24059/olj.v21i3.935

Souza, V., Maciel, A., Nedel, L., Kopper, R., Loges, K., & Schlemmer, E. (2020, November 7-10). The effect of virtual reality on knowledge transfer and retention in collaborative group-based learning for neuroanatomy students. In F. Nunes, I. Thouvenin, & P. Figueroa (Chairs), *2020 22nd Symposium on Virtual and Augmented Reality (SVR)* [Symposium]. Virtual. https://doi.org/10.1109/SVR51698.2020.00028

Stewart, W. H., & Lowenthal, P. R. (2021). Distance education under duress: A case study of exchange students' experience with online learning during the COVID-19 pandemic in the Republic of Korea. *Journal of Research on Technology in Education*, 1-15. https://doi.org/10.1080/15391523.2021.1891996

Strmecki, D., Bernik, A., & Radosevic, D. (2015). Gamification in e-learning: Introducing gamified design elements into e-learning systems. *Journal of Computer Sciences, 11*(12), 1108-1117. https://doi.org/10.3844/jcssp.2015.1108.1117

Su, C-H., & Cheng, C-H. (2013). 3d game-based learning system for improving learning achievement in software engineering curriculum. *The Turkish Online Journal of Educational Technology, 12*(2), 1-12.

Summerlee, A., & Murray, J. (2010). The impact of enquiry-based learning on academic performance and student engagement. *Canadian Journal of Higher Education*, *40*(2), 78-94.

Summers, J. J., Waigandt, A., & Whittaker T. A. (2005). A comparison of student achievement and satisfaction in an online versus traditional face-to-face statistics class. *Innovative Higher Education*, *29*(3), 233-250. https://doi.org/10.1007/s10755-005-1938-x

Sung, E., & Mayer, R. E. (2012). When graphics improve liking but not learning from online lessons. *Computers in Human Behavior*, *28*(5), 1618-1625. https://doi.org/10.1016/j.chb.2012.03.026

Sung, E., & Mayer, R. E. (2013). Online multimedia learning with mobile devices and desktop computers: An experimental test of Clark's methods-no-media hypothesis. *Computers in Human Behavior*, *29*(3), 639-647. https://doi.org/10.1016/j.chb.2012.10.022

Tham, R., & Tham, L. (2014). The effectiveness of game-based learning as an instructional strategy to engage students in higher education in Singapore. *International Journal on E-Learning, 13*(4), 483-496.

Thompson, W. F., Schellenberg, E. G., & Letnic, A. K. (2012). Fast and loud background music disrupts reading comprehension. *Psychology of Music*, *40*(6), 700-708. https://doi.org/10.1177/0305735611400173

Thorndike, R. M., & Thorndike-Christ, T. (2010). *Measurement and evaluation in psychology and education* (8th ed.). Pearson.

Torun, E. D. (2020). Online distance learning in higher education: E-learning readiness as a predictor of academic achievement. *Open Praxis, 12*(2), 191-208.

Travis, J., Kaszycki, A., Geden, M., & Bunde, J. (2020) Some stress is good stress: The challenge-hindrance framework, academic self-efficacy, and academic outcomes. *Journal of Educational Psychology*, *112*(8), 1632-1643. https://doi.org/10.1037/edu0000478

Tseng, H., & Walsh, E. J. (2016). Blended versus traditional course delivery: Comparing students' motivation, learning outcomes, and preferences. *Quarterly Review of Distance Education*, *17*(1), 43-52.

Vaibhav, A., & Gupta, P. (2014, December 19-20). *Gamification of MOOCs for increasing user engagement.* 2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE), Patiala, India. https://doi.org/10.1109/MITE.2014.7020290

Vankus, P. (2021). Influence of game-based learning in mathematics education on students' affective domain: A systematic review. *Mathematics, 9*(9), 1-10. https://doi.org/10.3390/math9090986

van der Meij, H., van der Meij, J., Voerman, T., & Duipmans, E. (2018). Supporting motivation, task performance and retention in video tutorials for software training. *Educational Technology Research and Development*, *66*(3), 597-614. https://doi.org/10.1007/s11423-017-9560-z

van Gog, T. (2014). The signaling (or cueing) principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 263-278). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

van Merrienboer, J. J. G., & Kester, L. (2014). The four-component instructional design model: Multimedia principles in environments for complex learning. In R. E. Mayer (Ed.), *The*

Cambridge handbook of multimedia learning (2nd ed., pp. 104-148). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369

Vaughan, T. (2014). *Multimedia: Making it work* (9th ed.). McGraw-Hill Education.

Wade, S. E., Schraw, G., Buxton, W. M., & Hayes, M. T. (1993). Seduction of the strategic reader: Effects of interest on strategies and recall. *Reading Research Quarterly*, *28*(2), 92-114. https://doi.org/10.2307/747885

Wang, N., Johnson, W. L., Mayer, R. E., Rizzo, P., Shaw, E., & Collins, H. (2008). The politeness effect: Pedagogical agents and learning outcomes. *International Journal of Human – Computer Studies*, *66*(2), 98-112. https://doi.org/10.1016/j.ijhcs.2007.09.003

Wang, F., Li, W., Mayer, R. E., & Liu, H. (2018). Animated pedagogical agents as aids in multimedia learning: Effects on eye-fixations during learning and learning outcomes. *Journal of Educational Psychology*, *110*(2), 250-268.

Wankel, L. A., & Blessinger, P. (2013). Inventive approaches in higher education: An introduction to using multimedia technologies. In L. A. Wankel & P. Blessinger (Eds.), *Increasing student engagement and retention using multimedia technologies: Video annotation, multimedia applications, videoconferencing, and transmedia storytelling* (pp. 3-16). Emerald Group Publishing Limited.

Wasylkiw, L., Hanson, S., Lynch, L. M., Vaillancourt, E., & Wilson, C. (2020). Predicting undergraduate student outcomes: Competing or complementary roles of self-esteem, self-compassion, self-efficacy, and mindsets? *Canadian Journal of Higher Education: 50*(2), 1-14. https://doi.org/10.47678/cjhe.v50i2.188679

Watkins, N. D., Fedesco, H. N., & Marshall, M. (2019). Student perceptions and performance in fully online versus flipped diversity courses: Is there too much distance in distance learning? *Journal on Excellence in College Teaching, 30*(3), 97-120.

Wiggins, B. E. (2013). Flexible coherence: Re-thinking e-learning design principles for linguistically and culturally diverse students. *Contemporary Educational Technology, 4*(1), 30-49.

Wilson, A. S., Broadbent, C., McGrath, B., & Prescott, J. (2017). Factors associated with player satisfaction and educational value of serious games. In M. Ma & A. Oikonomou (Eds.), *Serious games and edutainment applications* (Vol. II, pp. 513-535). https://doi.org/10.1007/978-3-319-51645-5

Wotto, M. (2020). The future of high education distance learning in Canada, the United States, and France: Insights from before COVID-19 secondary data analysis. *Journal of Educational Technology, 49*(2), 262-281. https://doi.org/10.1177/0047239520940624

Wronowski, M., Urick, A., Wilson, A. S. P., Thompson, W., Thomas, D., Wilson, S., Elizondo, F. J., & Ralston, R. (2020). Effect of a serious educational game on academic and affective outcomes for statistics instruction. *Journal of Educational Computing Research, 57*(8), 2053-2084. https://doi.org/10.1177/0735633118824693

Xie, H., Mayer, R. E., Wang, F., & Zhou, Z. (2019). Coordinating visual and auditory cueing in multimedia learning. *Journal of Educational Psychology*, *111*(2), 235-255. https://doi.org/10.1037/edu0000285

Yesilbag, S., Korkmaz, O., & Cakir, R. (2020). The effect of educational computer games on students' academic achievements and attitudes towards English lesson. *Education and Information Technologies, 25*(6), 5339-5356. https://doiorg/10.1007/s10639-020-10216-1

Zehnder, S. M., & Lipscomb, S. D. (2006). The role of music in video games. In P. Vorderer & J. Bryant (Eds.), *Playing video games: Motives, responses, and consequences* (pp. 241-258). Lawrence Erlbaum Associates.

Zhang, C., van Gorp, P., Derksen, M., Nuijten, R., IJsselsteijn, W.A., Zanutto, A., Melillo, F., Pratola, R. (2021). Promoting occupational health through gamification and e-coaching: A 5-month user engagement study. *International Journal of Environmental Research and Public Health, 18*(6), 1-17. https://doi.org/10.3390/ijerph18062823

Zheng, R., McAlack, M., Wilmes, B., Kohler-Evans, P., & Williamson, J. (2009). Effects of multimedia on cognitive load, self-efficacy, and multiple rule-based problem solving. *British Journal of Educational Technology, 40*(5), 790-803. https://doi.org/10.1111/j.1467-8535.2008.00859.x

Zheng, D., Young, M. F., Brewer, R. A., & Wagner, M. (2009). Attitude and self-efficacy change: English language learning in virtual worlds. *CALICO Journal, 27*(1), 205-231.

Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology*, 1-8. https://doi.org/10.1155/2019/4797032

Zimmer, S. (2019). Blended learning. In *Salem Press encyclopedia*. Salem Press. http://libpublic3.library.isu.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ers&AN=108690527&site=eds-live&scope=site

Zimmerman, B. J. (1995). Self-efficacy and educational development. In A. Bandura (Ed.), *Self-efficacy in changing societies* (pp. 202-231). Cambridge University Press. https://doi.org/10.1017/CBO9780511527692

Appendix A

Kemp ID Model Analysis Phase Deadline: The Professor vs. Plagiarism Game

The analysis phase of the Kemp ID Model consists of four components: instructional problems, learner characteristics, task analysis, and instructional objectives. These four components for the Deadline: The Professor vs. Plagiarism game are explained in detail below.

Instructional Problem

The information literacy curriculum for the ROAR 1199 course was being revised for the fall 2021 semester by the Idaho State University Libraries (University Libraries) ROAR 1199 information literacy curriculum committee in spring 2021. As part of the curriculum discussion with the committee, the researcher proposed to add game-based learning as a curriculum option for information literacy module seven, using information responsibly. The committee approved the game-based learning option and the researcher's study of the effectiveness of game-based learning as a possible permanent addition to the existing multimedia video instruction that had been used in previous semesters.

Learner Characteristics

The ROAR 1199 first-year seminar course is designed for learners who are first-year freshman, typically between 18 and 24 years of age, with no prior college experience and minimal prior knowledge on the using information responsibly topic. ROAR 1199 is a pilot course and has been part of Idaho State University's (ISU) general education curriculum since fall 2020 semester.

Based on current demographics at ISU, there should be a relatively equal number of males and females enrolled in the course. The learner ethnicity will be primarily Caucasian with some representation from other ethnicities.

The ROAR 1199 course is a hybrid design. The information literacy portion of the course is primarily asynchronous online. To limit the threat of the experimenter effect, module seven, using information responsibly, was designed to be entirely asynchronous online.

Students will use their own computers to access the surveys, treatments, and assessment. If they do not have access to their own computer, the computers in the University Libraries or in the ISU computer labs are available for use.

Morrison et al. (2019) stated that “a goal of any instruction should be the continual application of knowledge and skills learned” (p. 65). All three treatments provide the participants with the opportunity to learn how to use information responsibly, which is a skillset that they will be able to use during the entirety of their academic career.

Task Analysis

Morrison et al. (2019) consider task analysis as the “most critical step in the instructional design (ID) process” (p. 74). For the learning material for this study, the instructional design expert (IDE) and subject matter experts (SME) determined that a topic analysis was the most appropriate form of task analysis. In a topic analysis, the primary focus is to determine the facts, concepts, and principles required for the instruction (Morrison et al., 2019). The task analysis also helps the IDE to determine the learning objectives and any sub-objectives needed for the instruction.

The IDE and SMEs analyzed the topic tasks required of the students in the multimedia tutorials. Those tasks were then duplicated for the game-based learning instruction. The instructional objectives are listed below in this appendix.

The topic analysis was taken from the tutorials that the MT group watched and was mirrored in the game that the other groups G1 and G2 will be playing.

1. Define:
    a. Plagiarism
        i. Copying or stealing someone else’s work and claiming it as your own original work.
        ii. Copying, pasting, or purchasing work from another author without proper citations.
    b. Paraphrasing
        i. Taking a section of original text and summarizing the ideas or points of an argument.
    c. Citing
        i. Giving credit to the authors of the ideas you have borrowed by using a notation that identifies information such as who you quoted or whose ideas you paraphrased, the book, article, or other source where you found the material, and when the original material was published.
2. Explain:
    a. Academic integrity
        i. Committing to and demonstrating honest and moral behavior in an academic environment.
    b. Academic dishonesty
        i. Plagiarism
            1. Copying, stealing, or purchasing someone else’s work and claiming it as your own original work.
        ii. Fabrication

1. The falsifying of information by inventing, suppressing, or distorting sources, facts, or data.
2. A form of lying and students will be held accountable for giving false information or handing in work under false pretenses.

iii. Cheating

1. Using forbidden items during tests or assignments.
2. Obtaining test questions or answers beforehand.
3. Hiring someone to do homework and take exams.
4. Re-submitting graded work and presenting it as new work (self-plagiarism).
5. Obstructing or changing grades received.

iv. Aiding & Abetting

1. Helping another student plagiarize, fabricate, or cheat.
2. Failing to report plagiarism, fabrication, or cheating.
3. Set sufficient time aside to study for exams.

3. Discuss:

a. Copyright

i. Copyright gives the creator, or owner of the copyright, control over the use of a work. You cannot freely use a copyrighted work without the owner's permission. You need to either ask for permission to use and copy the work freely or you need to pay to use the work.

b. Fair Use

i. Provides exceptions and limitations to the use copyrighted works. The following criteria must be met for “Fair Use”:

1. The purpose and character of use.
2. The nature of the copyrighted work.
3. The amount and substantiality of portion taken.
4. The effect and use upon potential markets.

c. Public Domain

i. Works created in the public domain are not subject to copyright. They can be freely used to create new materials. Works enter the public domain when:

1. The copyright expires.
2. The copyright is not formally maintained.
3. The work was never entitled to protection.
4. The creator dedicates their work to the public domain before copyright expiration.

d. Creative Commons

i. Creative Commons bridges the gap between Copyright and Public Domain. Creators can state which rights they retain or how their work can be used.

4. Select correct:

a. Paraphrasing.

b. Quotations.

c. Identify where to go for help:

d. University Libraries

   i. Pocatello.

   ii. Meridian.

   iii. Idaho Falls.

e. ISU Writing Center

   i. Pocatello.

   ii. Meridian.

   iii. Idaho Falls.

f. Online

5. Demonstrate the ability to correctly:

   a. Cite a source in-text.

   b. Cite a source in a reference list.

   c. Analyze examples of plagiarism.

6. Create an academic paragraph with proper:

   a. Paraphrasing.

   b. Quotation use.

   c. Citations.

Instructional Objectives

The researcher consulted with the head of instruction at University Libraries to determine the instructional objectives for the multimedia tutorials. It was determined that the game-based learning options would mirror the learning objectives in the multimedia tutorials. The learning objectives were reviewed and validated by a group of seven SMEs from the University Libraries. The learning objectives include the following:

1. Define plagiarism, paraphrasing, and citation.
2. Explain academic integrity and academic dishonesty.
3. Discuss copyright, fair use, public domain, and creative commons.
4. Select correct paraphrasing and quotations.
5. Identify where to go for writing and research help.
6. Demonstrate the ability to correctly cite a source both in-text and in a reference list.
7. Analyze examples of plagiarism.
8. Create an academic paragraph with proper paraphrasing/quotation use, and citations.

Appendix B

Kemp ID Model Design Phase Deadline: The Professor vs. Plagiarism Game

The design phase of the Kemp ID Model consists of four components: content sequencing, instructional strategies, designing the message, and development of instruction. These four components for the Deadline: The Professor vs. Plagiarism game are explained in detail below.

Content Sequencing

The sequence of the content was first determined by the multimedia tutorials. That sequence was then duplicated in the game-based learning instruction. The sequence follows an increase in the level of difficulty according to Bloom's revised taxonomy (Anderson et al., 2001). Table B1 illustrates the relationship between the content sequence and the learning objective.

Table B1

Content Sequence for Using Information Responsibly Module

Sequence	Description	Objective
1	Define plagiarism, paraphrasing, and citation.	1
2	Explain academic integrity and academic dishonesty	7
3	Discuss copyright, fair use, public domain, and creative commons.	6
4	Select correct paraphrasing and quotations.	4
5	Identify where to go for writing and research help.	5
6	Demonstrate the ability to correctly cite a source both in-text and in a reference list.	3
7	Analyze examples of plagiarism.	2
8	Create an academic paragraph with proper paraphrasing, quotation use, and citations.	8

Designing the Message

Following the analysis, the IDE and five faculty and staff SMEs from University Libraries created and selected the instructional content, extraneous content, images, and clues to be used in the virtual escape room game G1 and G2 versions. The game-based learning content, the extraneous content, and the game elements were carefully considered and selected to keep the three treatments comparable in length.

Both the G1 and G2 versions of the game were created using applications from Google Suite and existing University Library software. Example storyboards for the G1 and G2 versions of the game illustrating design decisions are shown below.

Figure B1

Title Storyboard

Title	*Deadline: The Professor vs. Plagiarism*
Background	*titlepic.png*
Heading	
Font Style	*PT Sans*
Font Size	*64*
Font Color	*White*
Effects	*Fade in; slide remains for 5 seconds; fades out*
Content	
Font Style	*none*
Font Size	*none*
Font Color	*none*

Links/Action buttons		
Button	**Objects**	**Destination**
Narration	*Deadline -- A virtual escape room*	*Will fade out and auto-advance to Intro slide*

Figure B2

Introduction Storyboard

Title	*Deadline: The Professor vs. Plagiarism*
Background	*video (https://youtu.be/kUTpmjnPiYg)*
Heading	
Font Style	*American typewriter*
Font Size	*various*
Font Color	*black*
Effects	*fade in; video will autoplay; fade out*
Content	
Font Style	*none*
Font Size	*none*
Font Color	*none*

Links/Action buttons

Button	**Objects**	**Destination**
Video narration	*Help the group undo the damage and save their semester project. Beat the deadline and defeat the plagiarist.*	*Will fade out and auto-advance to Instructions slide*

Figure B3

Instructions Storyboard

Title	*Deadline: The Professor vs. Plagiarism*
Background	*Plain white background*
Heading	
Font Style	*Calibri*
Font Size	*16*
Font Color	*black*
Effects	*fade in; narration; fade out*
Content	
Font Style	*Calibri*
Font Size	*14*
Font Color	*black*

Deadline Virtual Escape Room: How to Play

1. This game is best experienced on a computer.
2. There are hidden clickable items on each screen. When your mouse pointer changes to a hand, you have found a hidden item.
3. Have scrap paper and a writing utensil handy. You'll want to write things down.
4. Have fun!

Links/Action buttons

Button	**Objects**	**Destination**
Click Here to Enter	*Black rectangular button with orange letters in lower center of slide*	*Will advance to game slide 1*
Narration	*Click on the hidden items on each screen. Write down the clues. Have fun!*	

Development of Instruction

Google Sites, Google Slides, Google Forms, and Springshare LibWizard were used to create the virtual escape room game. A committee was formed that included the IDE, SMEs, and five faculty and staff from the University Libraries to create the game. The IDE and SMEs created the learning content. The committee created the storyline and decided which game elements/mechanics should be used. Two committee members selected the images, chose the clues, and created the game in Google Sites.

Appendix C

Kemp ID Model Evaluate Phase Deadline: The Professor vs. Plagiarism Game

The evaluate phase of the Kemp ID Model consists of one component: evaluation instruments. This final component for the Deadline: The Professor vs. Plagiarism game is explained in detail below.

Evaluation Instruments

The IDE created instruments to measure both self-efficacy and student learning outcomes. The self-efficacy survey was used to evaluate what effect the learning material had on student perceived self-efficacy. A variety of supply-response and select-response questions were used to create the evaluation instrument that was used to determine if the learners met the learning objectives of the course. For formative evaluation, SMEs validated the objectives and the instruments. Data collected in the study on the effectiveness of the learning material on learning outcomes and self-efficacy was used as the summative evaluation.

Appendix D

Using Information Responsibly Self-Efficacy Scale (UIRSES) Survey

5-point Likert scale to be used:

- 5 = always true
- 4 = usually true
- 3 = occasionally true
- 2 = rarely true
- 1 = never true

UIRSES survey questions:

1. I feel that I can successfully define paraphrasing.
2. I feel that I can successfully explain why I would use a citation.
3. I feel that I am unable to correctly explain the concept of copyright.
4. I feel that I can successfully define plagiarism.
5. I feel that I can successfully define academic integrity.
6. I feel that I can successfully recognize academic dishonesty.
7. I feel that I am unable to correctly explain the concept of fair use.
8. I feel that I can successfully differentiate between public domain and creative commons.
9. I feel that I can successfully summarize information gathered from a source.
10. I feel that I can successfully use direct quotations when writing a paper.
11. I feel that I can successfully find writing help from the ISU writing center.
12. I feel that I am unable to correctly use a source without plagiarizing.
13. I feel that I can successfully find research help from university libraries.
14. I feel that I can successfully find citation help online.

15. I feel that I can successfully cite a source in-text in APA format.
16. I feel that I am unable to correctly create a reference in APA format.
17. I feel that I can successfully credit an author's work used for my research.
18. I feel that I can successfully directly quote a source in-text.
19. I feel that I can successfully create a citation.
20. I feel that I am unable to correctly paraphrase information from a source.

Appendix E

Using Information Responsibly Posttest Assessment

1. Fill in the blank with the correct response.
    a. Anne wrote a paper for a sociology class about the link between poverty and voting in elections. Ben, a friend of Anne's, has a paper due in his government class but he doesn't have much time to complete the paper. Ben asks Anne to let him use her paper for his class. If Anne agrees, her behavior is an example of ______________________________.
        i. Aiding and abetting (answer)
2. Fill in the blank with the correct response.
    a. Facts, such as the sky is blue, are considered ______________________________ and do not need to be cited in a research paper.
        i. common knowledge (answer)
3. Choose the correct example of paraphrasing of the original text in APA format.
    a. If the existence of a signing ape was unsettling for linguists, it was also startling news for animal behaviorists (Davis, 1978, p. 26).
    b. The existence of a signing ape unsettled linguists and startled animal behaviorists (Davis, 1978, p. 26).
    c. If the presence of a sign-language-using chimp was disturbing for scientists studying language, it was also surprising to scientists studying animal behavior (Davis, 1978, p. 26).

d. According to Flora Davis, linguists and animal behaviorists were unprepared for the news that a chimp could communicate with its trainers through sign language (Davis, 1978, p. 26). (answer)

4. Fill in the blank with the correct response.
   a. Creative Commons helps copyright _______________ share how their work can be used by the public.
      i. owners; holders (answer)
5. Paraphrase **one sentence** from the following text and include an in-text citation in APA format from the bibliographic information listed (short/long answer, manually grade):
   a. We know that human beings are not merely smaller, slower, better-smelling donkeys trudging after that day's carrot. We know - if we've spent time with young children or remember ourselves at our best - that we're not destined to be passive and compliant. We're designed to be active and engaged. And we know that the richest experiences in our lives aren't when we're clamoring for validation from others, but when we're listening to our own voice - doing something that matters, doing it well, and doing it in the service of a cause larger than ourselves.
      i. Bibliographic information:
         1. Author: Pink, D. H.
         2. Publication date: 2009
         3. Title: Drive: The surprising truth about what motivates us. Riverhead Books.
         4. Publisher: Riverhead Books
         5. Page: 145

6. Fill in the blank with the correct response.
    a. Using a copyrighted work in a classroom for education purposes is considered ____________________.
        i. Fair use; teach act (answer)
7. Quote **one sentence** from the following text and include an in-text citation in APA format from the bibliographic information listed (short/long answer, manually grade):
    a. We know that human beings are not merely smaller, slower, better-smelling donkeys trudging after that day's carrot. We know – if we've spent time with young children or remember ourselves at our best – that we're not destined to be passive and compliant. We're designed to be active and engaged. And we know that the richest experiences in our lives aren't when we're clamoring for validation from others, but when we're listening to our own voice – doing something that matters, doing it well, and doing it in the service of a cause larger than ourselves.
        i. Bibliographic information:
            1. Author: Pink, D. H.
            2. Publication date: 2009
            3. Title: Drive: The surprising truth about what motivates us.
            4. Publisher: Riverhead Books.
            5. Page: 145
8. Choose the correct quotation example in APA format from the following text.

a. Rewards can deliver a short-term boost - just as a jolt of caffeine can keep you cranking for a few more hours. But the effect wears off - and, worse, can reduce a person's longer-term motivation to continue the project.

    i. Bibliographic information:

        1. Author: Pink, D. H.
        2. Publication date: 2009
        3. Title: Drive: The surprising truth about what motivates us
        4. Publisher: Riverhead Books
        5. Page: 8

b. Rewards can deliver a short-term boost - just as a jolt of caffeine can keep you cranking for a few more hours. But the effect wears off - and, worse, can reduce a person's longer-term motivation to continue the project (Pink, 2009, p. 8).

c. "Rewards can deliver a short-term boost - just as a jolt of caffeine can keep you cranking for a few more hours. But the effect wears off - and, worse, can reduce a person's longer-term motivation to continue the project."

d. "Rewards can deliver a short-term boost - just as a jolt of caffeine can keep you cranking for a few more hours. But the effect wears off - and, worse, can reduce a person's longer-term motivation to continue the project" (Pink, 2009, p. 8). (answer)

9. Fill in the blank with the correct response.

    a. Public domain refers to works that are no longer protected by ________________________ and can be used freely by anyone.

        i. Copyright (answer)

10. Read the passage below and then choose from the three responses the one that best paraphrases the passage.

    a. Students must learn to paraphrase information when writing research papers for class. Paraphrasing is restating an author's ideas in the student's own words. The paraphrase can be the same length as or longer than the author's stated ideas. A paraphrase is different from summarizing when a student would restate only the main ideas of the author's writing. When using the author's words exactly as they are written, the student needs to use quotation marks. Finally, students must learn that paraphrasing an author's ideas does not mean to change just a few of the words in the passage or excerpt. As stated in the beginning, the author's ideas must be restated in the student's own words.

    b. Students should learn to paraphrase information when doing a research paper. Paraphrasing means to restate the author's idea in your own words. The paraphrase can be about the same length or more expanded than the original ideas. A paraphrase is different from summarizing where you only restate the important ideas of the author's writing. If you use all of the author's words exactly as written, you need to use quotation marks. When you paraphrase, do not just change a few of the author's words with synonyms, instead just restate the author's words with your own.

    c. When doing a research paper, students need to learn the skill of paraphrasing, or putting the words of a passage into their own words. Paraphrasing differs from summarizing, when only the main ideas of the work or passage are stated. It also differs from a quotation when the words of the author are placed in quotation marks. Changing just a few words of the passage by using synonyms is not paraphrasing; students must use their own words. (answer)

   d. Learning to paraphrase is important in doing research papers for class. To paraphrase, restate the author's ideas in your own words. To summarize the author's ideas, just restate the main ideas. Finally, if you use the author's words as written, then you must use quotation marks.

11. Answer True or False.
    a. Paraphrasing is taking original text and summarizing the ideas or points of an argument.
        i. True (answer)
        ii. False
12. Using the information below, create an in-text citation. Order the components from left (1) to right (2).
    a. 2011
    b. McGonigal
        i. McGonigal, 2011 (answer)
13. Answer True or False.
    a. Citing is giving credit to other people's ideas only when they have been directly quoted.
        i. True
        ii. False (answer)
14. Select all answers that apply.
    a. Academic dishonesty is:

i. Plagiarism (answer)

ii. Fabrication (answer)

iii. Cheating (answer)

iv. Aiding and abetting (answer)

v. Plagiarism and Fabrication only

vi. Fabrication and Cheating only

vii. Plagiarism and Cheating only

viii. Aiding and abetting and Plagiarism only

ix. Cheating and Aiding and abetting only

x. Aiding and abetting and Fabrication only

15. Using the information below, create a reference in APA format. Order them left (1) to right (4).

    a. McGonigal, J.

    b. (2011).

    c. Reality is broken: Why games make us better and how they can change the world.

    d. Penguin Group.

        i. McGonigal, J. (2011). Reality is broken: Why games make us better and how they can change the world. Penguin Group. (answer)

16. Which of the following items are protected under copyright (select all that apply):

    a. Printed materials (answer)

    b. Ideas

    c. Items in the public domain

    d. Movies (answer)

e. Music lyrics, scores, and performances (answer)

f. Images (answer)

17. From the choices below, choose the sentence that best describes the process of paraphrasing.

a. Paraphrasing means to restate the idea of the excerpt or passage by changing a few words in the excerpt with synonyms.

b. Paraphrasing means to restate the idea of the excerpt or passage in your own words. (answer)

c. Paraphrasing means to use the exact words of the excerpt or passage and use quotation marks.

d. Paraphrasing means to use the exact words of the excerpt or passage.

18. Please match the scenario with where to go for writing and/or research help.

a. I go to school on the Pocatello campus and need help with properly forming citations for an essay for my English class.

i. Writing Center (Pocatello -- REND 323)

b. I go to school in Pocatello and would like to talk to someone in person about finding sources for my ENGL1102 paper.

i. University Libraries (Pocatello -- Eli M. Oboler Library)

c. I am on the Idaho Falls campus and need help with my biology lab report.

i. University Libraries (Idaho Falls – TAB)

d. I am in Idaho Falls and need help knowing where to look for sources for my COMM1101 speech.

i. Writing Center (Idaho Falls -- CHE 220)

e. I am in Meridian and need help writing a paper.

    i. Writing Center (Meridian – contact the CAT office)

f. I am in Meridian and need help understanding a systematic review.

    i. University Libraries (Meridian – room 844)

g. I would like to find help online for creating citations in APA format.

    i. Purdue OWL

19. Answer True or False.

a. Plagiarism is when you present someone else’s work as your own.

    i. True (answer)

    ii. False

Appendix F

Scoring Rubric for the Using Information Responsibly Posttest Assessment Questions 5 and 7

There were two questions that needed to be manually graded on the posttest. The following lists those graded questions and their associated grading rubrics for the Using Information Responsibly (UIR) posttest assessment.

Question 5. (five points) Paraphrase one sentence from the following text and include an in-text citation in APA format from the bibliographic information listed:

We know that human beings are not merely smaller, slower, better-smelling donkeys trudging after that day's carrot. We know - if we've spent time with young children or remember ourselves at our best - that we're not destined to be passive and compliant. We're designed to be active and engaged. And we know that the richest experiences in our lives aren't when we're clamoring for validation from others, but when we're listening to our own voice - doing something that matters, doing it well, and doing it in the service of a cause larger than ourselves.

- Bibliographic information:
  - Author: Pink, D. H.
  - Publication date: 2009
  - Title: Drive: The surprising truth about what motivates us. Riverhead Books.
  - Publisher: Riverhead Books
  - Page: 145

Table F1

UIR Posttest Question 5 Rubric

Possible Points	Rubric Criteria
5	Paraphrases using their own words. No errors on in-text citation according to APA 7th edition.
4/4.5	Paraphrases using their own words. One to two errors on in-text citation according to APA 7th edition.
3/3.5	Paraphrases using their own words. Two to three errors on in-text citation according to APA 7th edition.
2/2.5	Paraphrasing attempt was mediocre (i.e., repeated the sentence just using synonyms or did a direct quote). Two to three errors on in-text citation according to APA 7th edition.
1/1.5	Paraphrasing attempt was poor (i.e., used own words, but changed the meaning of the sentence or used a direct quote). Three or more errors on in-text citation according to APA 7th edition.
0	Makes no attempt to answer the question.

Question 7. (five points) Quote **one sentence** from the following text and include an in-text citation in APA format from the bibliographic information listed:

We know that human beings are not merely smaller, slower, better-smelling donkeys trudging after that day's carrot. We know – if we've spent time with young children or remember ourselves at our best – that we're not destined to be passive and compliant. We're designed to be active and engaged. And we know that the richest experiences in our lives aren't when we're clamoring for validation from others, but when we're listening to our own voice – doing something that matters, doing it well, and doing it in the service of a cause larger than ourselves.

- Bibliographic information:
    - Author: Pink, D. H.
    - Publication date: 2009
    - Title: Drive: The surprising truth about what motivates us
    - Publisher: Riverhead Books

- Page: 145

Table F2

UIR Posttest Question 7 Rubric

Possible Points	Rubric Criteria
5	Quotes verbatim and uses quotation marks appropriately. No errors on in-text citation according to APA 7th edition.
4/4.5	Quotes verbatim and uses quotation marks appropriately. One to two errors on in-text citation according to APA 7th edition.
3/3.5	Quotes verbatim and but uses quotation marks inappropriately. Two to three errors on in-text citation according to APA 7th edition.
2/2.5	Did not use a direct quote but used quotation marks appropriately. Paraphrases instead of using a direct quote. Two to three errors on in-text citation according to APA 7th edition.
1/1.5	Did not use a direct quote and did not use quotation marks appropriately. Three or more errors on in-text citation according to APA 7th edition.
0	Makes no attempt to answer the question.

Appendix G

Informed Consent Form to Participate in Research

My name is Tania Harden, and I am a librarian here at Idaho State University as well as a doctoral candidate in the Instructional Design Technology program. The purpose of this research is to examine if teaching the using information responsibly module in different ways affects your learning and self-confidence.

As part of the ROAR 1199 class, you will be taking two surveys and a test on using information responsibly. This research is asking if we can use your data with no names attached to improve this class for future semesters. Choosing to allow your data to be used or choosing to not allow your data to be used will not affect your grade in any way. If you choose to participate in the study, your name will not even be given to the researchers. Only anonymous data will be given to the researchers, and no one will contact you with further questions.

Anticipated time required to complete the study components includes 20 minutes for the two surveys, 40-50 minutes for the instruction method, and 25 minutes for the test.

You can change your mind to participate as many times as you want until Wednesday 10/6/2021 at 11:55 pm.

You are eligible to take part in this research if:

- You are enrolled in ROAR 1199 for the first time during the fall 2021 semester at Idaho State University.
- You are 18 years of age or older.
- You have no visual impairments that require the use of a screen reader. Wearing glasses or contacts is fine.

For further information regarding this research, please contact Tania Harden at (940) 453-5643 or taniaharden@isu.edu or David Coffland at (208) 282-3658 or davidcoffland@isu.edu.

If you have any questions about your rights as a research participant, you may contact the Idaho State University Institutional Review Board at (208) 282-3134.

Please print out a copy of this form for your records. Thank you in advance for your cooperation and support.

Please indicate your agreement to participate in this research by checking a box below.

- I am 18 years or older and have read and understood the consent form and eligibility requirements.