EXPLORING THE RELATIONSHIP BETWEEN DELIVERY METHODS AND COGNITIVE STYLE IN RELATION TO THE AVAILABILITY OF PSYCHO-SOCIAL CONTENT IN SPACE LIFE SCIENCES EDUCATION MATERIAL

A Thesis

Presented to

The Faculty of the Department

of Health and Human Performance

University of Houston

In Partial Fulfillment

of the Requirements for the Degree of

Master of Science

By

Shayan Shirshekar

December, 2016

EXPLORING THE RELATIONSHIP BETWEEN DELIVERY METHODS AND COGNITIVE STYLE IN RELATION TO THE AVAILABILITY OF PSYCHO-SOCIAL CONTENT IN SPACE LIFE SCIENCES EDUCATION MATERIAL

Shayan Shirshekar

APPROVED:

Charles Layne, Ph.D.

Committee Chair

Lauren Merkle, Ed.D.

Larry Bell, M.F.A.

Lisa Alastuey, Ed.D.

Steven G. Craig, Ph.D.

Interim Dean, College of Liberal Arts and Social Sciences

Department of Economics

EXPLORING THE RELATIONSHIP BETWEEN DELIVERY METHODS AND COGNITIVE STYLE IN RELATION TO THE AVAILABILITY OF PSYCHO-SOCIAL CONTENT IN SPACE LIFE SCIENCES EDUCATION MATERIAL

An Abstract of a Thesis

Presented to

The Faculty of the Department

of Health and Human Performance

University of Houston

In Partial Fulfillment

of the Requirements for the Degree of

Master of Science

By

Shayan Shirshekar

December, 2016

ABSTRACT

Following a thorough online search, it is apparent there is a shortage of accessible material on the space life sciences, particularly with respect to the psycho-social field. Psycho-social topics such as isolation and confinement, along with crew cohesion, play a pivotal role in both crew mental health and mission success. Building an educational module centering on these topics addressed both the need for more accessible space life sciences content as well as provided a means for educating the general public. By developing two distinct formats of identical material, one consisting of purely text and the other with more visually stimulating material, this thesis also explored the relationship between the visualizer-verbalizer cognitive style model and methods of material delivery. The methodology for this study followed a screening phase, pretest phase, learning phase, and post-test phase. The Santa Barbara Learning Style Questionnaire (SBLSQ) was used to identify visualizers and verbalizers among undergraduate students at the University of Houston. Due to the inability to single out any verbalizers, this group was later replaced with neutral learners, who had a propensity for both forms of material delivery. It was expected optimal learning would occur when cognitive style was matched with a method of material delivery (e.g., visualizer learning visual material). Results indicated, while post-test scores improved significantly following a period of learning, cognitive style had no significant main effect in this study. There was no significant main effect of matching cognitive style with a method of material delivery. Post-test scores were significantly affected by the method of material delivery, with subjects receiving verbal material outperforming those receiving visual material. Cognitive overload and passivity of visual information modalities are proposed as justifications for this discrepancy. The results obtained from this study question the

effectiveness of modifying educational instruction methods to accommodate individual differences as it pertains to cognitive styles.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Despite the end of a successful Shuttle program and a constant battle for a share of the federal budget, NASA continues to be an important part of the future of human space exploration. NASA's remarkable past and present journeys into space have deepened mankind's understanding of the universe, lead to numerous technological breakthroughs, and expanded the frontiers of scientific research. All of these accomplishments stem from a common source: Education. Individuals who have received proper education in the fields of science, technology, engineering, and math (referred to as STEM disciplines) are essential in furthering our knowledge of space exploration and the universe. Following the successful Mars Curiosity Rover mission and the continued use of the International Space Station, NASA is investigating several potential exploration-class missions. These include an asteroid redirect mission and most notably, a manned mission to Mars. The success of these, and future proposed missions depend on continued education in the field of space exploration to nurture and inspire the young minds of today for the work of tomorrow. Educational degrees in the field of aerospace engineering and physics continue to be the most popular avenues to entering the space industry workforce. However, individuals with knowledge from other scientific disciplines will also be needed.

As future NASA missions focus on exploration at greater distances with extended stays in space, maintaining the health and safety of astronauts will be more challenging. Risks of musculoskeletal deconditioning, radiation exposure, and feelings of isolation and confinement will introduce unique challenges and obstacles for astronauts as they complete their mission objectives. As the human-centered approach to space exploration continues to grow, so does the need for more accessible space life sciences educational content. Providing more accessible space life sciences material focused on the human in space, will prove beneficial in both educating as well as inspiring students further into this field of study. Future space life scientists will be essential for designing new systems and countermeasures to protect against the physiological risks associated with long-duration spaceflight, such as bone and muscle loss. Beyond the physiological challenges, a major obstacle to successful long-duration spaceflight will be the psycho-social challenges. The psycho-social challenges of long-duration spaceflight present substantial risks to the success of future missions. The development of individual problems, sleep disruption, sensory deprivation, and interpersonal relations between crewmembers top the list of NASA social behavioral gaps necessitating the need for properly trained space life scientists in the psycho-social field.

After an extensive online search, it is apparent educational degrees focussing specifically on the life sciences side of space exploration are sparse, and those existing are limited to graduate level education. Of the programs found, the majority focus on engineering, astronomy, business, and law. Only a select few, such as those offered at the University of Houston and Kings College in London, focus primarily on the physiological aspects of space life sciences, with none focused on the psycho-social issues. With such few programs, it is no surprise there is also a lack of content such as textbooks and lectures available to educating students concerning the risks and challenges of human space exploration, particularly in the psycho-social field. As a result, should we want to continue to educate future scientists in the field of space exploration, there appears to be a need for more accessible human space exploration educational material, focusing particularly on the psycho-social issues of space life sciences.

With the rise of technology in the new millennium, more educational systems adopted the online classroom as their primary method of teaching. This transformation in higher education shifted the educational paradigm from an instructor-centered approach of traditional classrooms to the more student-centered approach of online teaching. This is driven by the need to adapt to these current technological advances (Mitchell, Parlamis, & Claiborne, 2015) including the rise in personal computers, the continuously improving resourcefulness of the internet, and a technologically savvy generation. Higher-education institutions have followed suit by implementing creative applications of online technology such as smartboards, blogs, Skype, and Facebook chat for both student-to-student and student-to-faculty interactions (Macduff, 2012). Online education has eliminated both temporal and geographical educational restrictions, allowing students the ability to access material from anywhere and at any time (McCormack & Jones, 1998). In addition, online education allows greater flexibility and autonomy, allowing students to learn at their own preferred pace (Mitchell et al., 2015). This has been pivotal in allowing younger students juggling multiple priorities to earn degrees part-time, and allowing working adults to return to school to earn degrees necessary for both job security and career advancement. Massive Open Online Courses (MOOCs) were first introduced in 2008 and emerged as a popular mode of online teaching in 2012. MOOCs are free online courses aimed at unlimited student enrollment. In addition to implementing traditional teaching materials, such as readings and videos, MOOCs also allow for dynamic interaction between professors and students via discussion forums. The New York Times labeled 2012 as the "Year of the MOOCs" as they were implemented at some of the nation's top institutions, with some believing continued use would one day replace traditional Universities (Chauhan, 2014, p. 8). However, due to low completion rates and backlash from traditional classroom educators, MOOCs have not yet taken over the forefront of education as was once believed (Zhu, 2012). Despite not meeting these expectations, the number of course offerings by current MOOC providers and student enrollments slowly continue to grow throughout the world (Chauhan, 2014). While the major MOOC providers are based in the United States, other countries like France, Germany, Australia, and most recently Italy are now global MOOC Providers (Chauhan, 2014).

The online method of teaching higher education courses and programs continues to expand across different academic disciplines at educational institutions (Mitchell et al., 2015). According to a recent survey from Allen & Seaman (2011), the total number of students enrolled in online classes has doubled since 2005. Moreover, 75% of institutions reported an increase in demand for online courses (Allen & Seaman, 2010). One reason for this increase in demand may be due to the customization of individual learning. Online learning allows the delivery of educational material to be tailored to each individual student in ways traditional face-to-face classroom education cannot accommodate. Individuals have unique cognitive styles and interests, and therefore increasing customization enables a more engaging and effective learning process for students (Mitchell et al., 2015). The term cognitive style refers to a psychological dimension defining the distinctive and observable ways in which individuals process information (Messick, 1984). The visualizer-verbalizer cognitive style model, first developed in 1971 by Allan Paivio, proposed the cognitive system to be divided into two components: a verbal system and a visual system. The verbal system deals with linguistic information, while the visual system processes and stores information as images or pictures (Paivio, 1971). Central to this model is the idea that individuals differ in the degree to which they depend on language or on imagery to process information (Paivio, 1971). Individuals who are visualizers may prefer learning through more stimulating and interactive means. This may include images, videos, and animations. On the other hand, verbalizers may thrive best with traditional text content (Kollöffel, 2012). Paivio was the first to create the Individual Differences Questionnaire (IDQ), used to measure an individual's primary style for cognitive processing. Following the work of Paivio, Richardson (1977) developed the Visualizer-Verbalizer Questionnaire (VVQ) implemented over the years as a tool to distinguish visualizers from verbalizers. The VVQ has received criticism over the years due to its lack of construct validity (Edwards & Wilkins, 1981) and low levels of internal consistency (Boswell & Pickett, 1991). Finally, Mayer and Massa (2003) developed the Santa Barbara Learning Style Questionnaire (SBLSQ), contrasting with the VVQ by asking more explicit statements regarding cognitive style. The SBLSQ is observed to have an acceptable level of internal consistency and validity.

Research dedicated to addressing the assumption that matching instructional mode to an individual's cognitive style leads to better learning outcomes remains somewhat ambiguous, with results favoring both ends of the spectrum. For example, one study reported students with strong visual skills were able to recall more details about a figure previously drawn than did students with poor visual skills (Casey, Winner, Hurwitz, & DaSilva, 1991). Riding, Burton, Rees, & Sharratt (1995) discovered children with strong visual skills learned better with pictures, while children with strong verbal skills learned better with text. Similarly, a study undertaken by Mendelson & Thorson (2004) examining the importance of cognitive style in memorization of newspaper articles, discovered students with strong verbalization skills remembered more details compared to students with weak verbalization skills. Finally, a study conducted by Riding & Staley (1998) in which the performance of first year university students divided into visualizer and verbalizers was compared in two different courses, supports the view a student is more likely to succeed when enrolled in a course matching their cognitive style. Visualizers outperformed verbalizers in an information technology course with a visual and space interface, while verbalizers outperformed visualizers in a management course more verbal in nature. In contrast to the previous studies, Kollöffel's (2012) attempt to address the question whether a match between a student's preference regarding the format of learning materials has any relation with performance when learning with a specific format, lead to findings suggesting cognitive style and learning outcomes were unrelated. Learners with a preference for visual material did not necessarily perform better with visual learning material and similarly learners with a preference for verbal material did not necessarily perform better with verbal learning material (Kollöffel, 2012). For additional details refer to page 35 in the literature review section.

The purpose of this thesis was to explore the relationship between cognitive styles and different material delivery methods as well as develop more accessible content on the psycho-social issues of human space exploration. This was explored by creating two online PowerPoint modules on the psycho-social issues of spaceflight. One consisted exclusively of text, and the other contained text supported by more visually stimulating material, such as images and videos. Topics included an overview of the conditions encountered during long-duration spaceflight, individual and interpersonal problems, spaceflight analogs, and countermeasures. By creating two distinct modules, this study attempted to determine whether a difference exists in the level of understanding of content when presented in alternative teaching methods. Though the modules differed in how material was delivered, all participants were presented with the same required information for a learning assessment. Gaining an increased understanding in this issue will assist in the development of more effective content for people with different cognitive styles.

For the experimental portion of this thesis, 40 participants were required; 20 of which were visualizers and 20 of which were verbalizers. To meet this criterion, over 200 undergraduate students from the University of Houston were recruited to participate in a two stage screening evaluation to determine cognitive style and prior knowledge of spaceflight psycho-social content. The screening implemented Mayer and Massa's 2003 Santa Barbara Learning Style Questionnaire (SBLSQ). Participants were initially administered the SBLSQ either in person or online. Those participants who classified as either visualizers or verbalizers on the first attempt were asked to complete the SBLSQ a second time for reliability purposes. Participants with a consistent score on both attempts on the SBLSQ were administered an identical pretest based on material from the modules to determine prior knowledge regarding the psycho-social issues of spaceflight. Participants scoring at 40% or lower met the criteria for the pretest screening. The participants meeting both screening criteria were eligible to participate in the intervention portion of the study. Table 1 shows how participants were divided into groups based on cognitive style and method of material delivery for the intervention. Following the intervention period, all students were required to complete two post-tests. The first was administered immediately following the learning period and the second was administered seven days later to test retention rates. The pretest and both post-tests were identical.

Statistical analysis of the test scores was conducted through a 2X2X3 mixed factorial repeated measures analysis of variance (ANOVA) using SPSS software. Cognitive style and method of material delivery represented the between-group independent variables, while the three different testing periods represented the within-subject repeated measures independent variable. This experiment attempted to determine whether participants' pre and post-test scores differed following a learning period, as well as whether matching a participant's cognitive style with a method of material delivery improved learning outcomes. It was expected there would be no differences based on cognitive style on the pretest scores, as no group would have been exposed to content of this nature. However, it was expected all participants' post-test scores would be significantly higher than pretest scores following a period of learning. Finally, it was expected participants paired with a method of material delivery matching their cognitive style would outperform their unmatched counterparts. Visualizers receiving visual material would score higher on the post-tests than visualizers receiving text-only material. Similarly, verbalizers receiving text-only material would score higher than verbalizers receiving visual material.

More formally, the three hypotheses for this study were as follows:

Hypothesis one—there will be no differences based on cognitive style on the pretest scores

Hypothesis two—all participants' post-test scores will be significantly higher than pretest scores following a period of learning.

Hypothesis three—participants paired with a method of material delivery matching their cognitive style will perform higher than participants paired with a method of delivery not matching their cognitive style.

Table 1. Match & mismatch of cognitive style and delivery method

Ten verbalizers receiving text-only material	Ten visualizers receiving text-only material
Ten verbalizers receiving visual material	Ten visualizers receiving visual material

In addition to analysing the relationship between cognitive style and method of material delivery, this thesis aimed to contribute accessible content on the psycho-social issues of spaceflight and raise awareness of the importance of this field of research for future manned spaceflight. Extended stays on the International Space Station, future moon landings, and an eventual manned Mars mission will test the boundaries of the human psyche. The impact of grouped isolation and confinement are just one of many gaps in NASA's Behavioral Health and Performance research program currently under investigation. It is to be hoped that future educational institutions may one day create curriculums and programs dedicated to these issues, inspiring future scientists who may one day challenge and address these gaps, leading to safer and successful manned space missions.

CHAPTER TWO

LITERATURE REVIEW

Overview of Current Space Life Sciences Content

There appears to be a shortage of traditional space life sciences educational materials readily available for use in college courses**.** Within the shortage, there were some materials available and used in college level courses. The initial step was to identify which universities offered degree programs and/or courses in this academic area. The next step determined the space life science classroom material available. Space life sciences programs included universities offering graduate degrees in space life sciences as well as holistic programs covering other areas of space sciences such as engineering and astronomy. Class room materials included space life sciences textbooks, holistic textbooks with small sections devoted to space life sciences, and online resources such as websites and videos. Extensive data mining was conducted through a variety of basic online search engines such as GOOGLE, DOGPILE, and through graduate program online search portals. Programs educating students in space life sciences, sample curriculums, textbooks, websites, and online videos pertaining to space life sciences are listed below.

Conducting search for available programs implemented generic terms such as:

- Space life sciences graduate program
- Space life sciences master's program
- Space life sciences doctoral program

Conducting search for available programs also implemented key terms such as:

- Space psychology
- Space sociology
- Space physiology

Programs

Space life sciences programs within North America:

- University of Houston (Houston, Texas) Master of Science and Ph.D. in Human Space Exploration Sciences
- University of Colorado, Boulder (Boulder, Colorado) Master of Science and Ph.D. programs in Aerospace Engineering Sciences with focus in Bioastronautics.
- Texas A&M University (College Station, Texas) Certificate in Space Life Sciences (while pursuing Ph.D. or M.D.)
- Harvard MIT (Cambridge, Massachusetts) Ph.D. program in Bioastronautics
- UTMB (Galveston, Texas) Health/NASA Aerospace Medicine residency program

Holistic programs within North America

- University of North Dakota (Grand Forks, North Dakota) Space Studies Master of Science
- Embry-Riddle Aeronautical University (Daytona Beach, Florida) Master of Aeronautical Science and Ph.D. in Human Factors
- Rice University (Houston, Texas) Master of Science in Space Studies
- American Public University (Charles town, West Virginia) Master of Science in Space Studies

- American Military University (Charles Town, West Virginia) Bachelor and Master of Science in Space Studies
- Florida Institute of Technology (Melbourne, Florida) Human Factors in Aeronautics Master of Science
- Regis University (Denver, Colorado) Master of Education: Space Studies

Other Space Life Sciences programs

- King's College (London, England) Space Physiology & Health Master of Science

Other Holistic programs

- International Space University (Strasbourg, France) Master of Space Studies program and summer Space Studies program

Sample Curriculums:

University of Houston's Human Space Exploration Sciences Master of Science program

- PEP 6310 Physiology of Exercise
- PEP 6305 Measurement in Health and Physical Education
- PEP 7320 Research in Human Performance
- SOCW 8325 Applied Multivariate Statistics
- PEP 7318 Space Physiology I
- PEP 7319 Space Physiology II
- PEP 7320 Spaceflight Research Models
- PEP 7322 Spaceflight Habitat
- TEPM 6301 Framework of Project Management
- TEPM 6307 Advanced Project Management

King's College Space Physiology & Health Master of Science program

- Cardiovascular and Respiratory Physiology from Rest to Exhaustive to Exercise
- Human Aerospace Physiology
- Library Project in Space Physiology and Health
- Muscle and Exercise Physiology
- Research Project in Space Physiology & Health
- Space Physiology & Health

<u>Space Life Sciences Materials:</u>

Generic search terms included:

- Space life sciences textbook
- Space life sciences website
- Space life sciences video

Key search terms included:

- Space/Aerospace physiology
- Space/Aerospace medicine
- Space psychology
- Space sociology

Space life sciences textbooks

- *Psychology of Space Exploration* 2011—Vakoch (editor)
- *Space Psychology and Psychiatry* 2008—Kanas and Manzey
- *Space Physiology* 2006—Buckey

- *Biological and Medical Research in Space: An Overview of Life Sciences Research in Microgravity* 2011—Springer
- *Space Physiology and Medicine* 1989—Nicogossian
- *Human Physiology in Space Students Manual* 1994—Lujan and White
- *Fundamentals of Space Life Sciences* 1997—Oser
- *Fundamentals of Space Medicine* 2011—Clement
- *Space and Life: An Introduction to Space Biology and Medicine* 2007—Planel
- *Physiology of Man in Space* 1963—Brown
- *Stress Challenges and Immunity in Space: From Mechanisms to Monitoring and Preventive Strategies* 2012—Chouker
- *Psychology and Space* 2003—Gagarin and Lebedev

Other textbooks

- *From Antarctica to Outer Space: Life in Isolation and Confinement* 2013—Harrison, Clearwater, & McKay
- *Human Physiology in Extreme Environments* 2014—Gunga
- *Space Faring: The Human Dimension* 2002—Harrison
- *Fundamentals of Aerospace Medicine* 4th edition 2008—Lippincott Williams and Wilkins
- *21st Century Psychology: A Reference Handbook* 2008—Davis and Buskist
- *ACSM's Advanced Exercise Physiology* 2011—American College of Sports Medicine

Websites and online videos

Table 2. Sample websites

Name	URL
NASA's Space Life Sciences Educational Website	http://www.nasa.gov/audience/foreducators/spacelife/home/
NASA's Human Research Program Website	http://www.nasa.gov/exploration/humanresearch/areas_study/physiology/
Human Physiology and Anatomy in Space 2013	http://www.slideshare.net/FJHScience/2013-space-human-phys-and-anatomy
Japanese Aerospace Exploration Agency Website	http://iss.jaxa.jp/med/index_e.html
PBS The Psychology of Spaceflight	http://www.pbs.org/wgbh/nova/space/holland-space-au.html
American Psychological Association – Mental Preparation for Mars	http://www.apa.org/monitor/julaug04/mental.aspx

Table 3. Sample videos

Name	URL
NASA Life Sciences Program	https://www.youtube.com/watch?v=azgddKfbvkQ
Living in Space–hosted by Astronaut Suni Williams	https://www.youtube.com/watch?v=hyn1We0wOT8
Living in Space Documentary	https://www.youtube.com/watch?v=cEWGcHIq4Po
Introduction to Bioastronautics	https://www.youtube.com/watch?v=cI4ajl5axug
Space Medicine –Challenges and Countermeasures	https://www.youtube.com/watch?v=tZSeJWTsmM0
Dan Burbank Educational Talk – Working in Space	https://www.youtube.com/watch?v=My_afjtseks
André Kuipers Physiological Demonstration in Weightlessness	https://www.youtube.com/watch?v=GOo5zjH8GgA
Psychology of Spaceflight –Nick Kanas Talk	https://www.youtube.com/watch?v=7l1L7PVRWaU
Manned Spaceflight to Mars 1997	https://www.youtube.com/watch?v=-2sD1Pvz-JI
PBS Documentary –Learning to live on the Moon	https://www.youtube.com/watch?v=J_ZfChSwHIE

Psycho-Social Issues of Spaceflight

Spending a prolonged period of time in the absence of gravitational forces causes major changes in the human body. Alterations occur in many physiological systems, such as the cardiovascular, musculoskeletal, chronobiological, and immune system (Connors, Harrison, & Atkins, 1985). Environmentally induced changes in physiological function can also initiate a stress response and lead to modifications in human behavior. For example, it is well-recognized astronauts sleep poorly in space (Barger et al., 2014). The amount and quality of sleep experienced in space is affected by several parameters. Highly variable light and dark cycles on flight decks and poor illumination during daytime hours, can send altered messages to the brain leading to circadian desynchronization. Noise levels and weightlessness may also affect qualify of sleep in space. Disturbances in sleep wake cycles can have profound effects on the behavioral responses of crewmembers and can aggravate the psychological stresses already present (Connors et al., 1985). For example, a study examining sleep dysfunction in space revealed when sleep is restricted to the level commonly present among astronauts (approximately four to six hours daily), a sleep debt accrues over time leading to performance deficits in as little as one week (Dinges et al., 1997).

Other environmental factors in space include sensory deprivation, confinement, and isolation. Sensory deprivation is defined as a reduction of stimuli to one or more senses (Kubzansky, 1961) and has been increasingly identified as a unique stressor for long-duration spaceflight. In long-duration missions, environments are likely to have little in the way of novelty. In this context, astronauts may experience restrictions to several senses over a prolonged period of time, such as the visual, auditory, olfactory, kinesthetic, tactile, and even gustatory system (Bachman, Otto, & Leveton, 2012). Prolonged sensory monotony is linked to biological changes to the neurological structure of the brain and to several behavioral outcomes including anxiety and hallucinations (Merabet et al., 2004). Confinement is defined as a restriction within a highly limited and sharply demarcated physical and social environment (Connors et al., 1985). The constant lack of privacy and cohabiting in a relatively small area with others for a prolonged period of time can negatively affect psychological well-being (Kanas & Manzey, 2008). For example, crews inhabiting the international space station for six months at a time have reported high levels of stress caused by living and working in cramped conditions with people from different cultures (Simon, Whitmire, Otto, & Neubek, 2011).

Until their addition, lack of individual private crew quarters was ranked the biggest habitability impact on the International Space Station (Simon et al., 2011).

As mission duration increases, crewmembers are vulnerable to developing feelings of isolation. Isolation is defined as a separation from the normal or daily physical and social environment (Connors et al., 1985), and is perhaps the most unavoidable of all stressors in spaceflight. Isolation in spaceflight can be best demonstrated when exploring a potential Mars mission. For example, communication delays of up to 20 minutes can be expected on Mars and at times complete blackouts. In other words, a simple question and answer may take up to 40 minutes or longer to be completed between mission control and the crew. Since resupply missions would take up to six months or more, crews will be expected to be much more autonomous, making use of the resources brought with them, prestaged on the planet, or present on the Martian surface. The crew will have to become increasingly independent over time and this may serve to compound the sense of isolation. It's expected conditions of isolation and confinement begin to be the most psychologically challenging at approximately the mid-point of a mission; for example, the end of month 15 for a 30 month Mars mission (Bechtel & Berning, 1991). This is based on the third quarter phenomenon stating that during isolated and confined conditions, the third quarter of a mission of fixed time correlates with the most discomfort (Kanas & Manzey, 2008). Morale, performance, and mood are all believed to reach their low point during this phase of the mission as crewmembers realize that although 50% of the mission has been completed, an equal length of time remains to be endured (Kanas & Manzey, 2008).

Anecdotal reports of previous spaceflight missions have documented increases in the prevalence and severity of symptoms of depression, insomnia, irritability/anger, anxiety, fatigue, and decrements in cognitive performance (Palinkas, 2001). For example, Soyuz 21 (1976), Soyuz T-14 (1985), and Soyuz TM-2 (1987) were all shortened because of mood and performance (Burrough, 1998). In addition, psychological factors contributed to the early evacuation of a Salyut 7 crew (Harvey, 1996). In order to prevent these types of problems from occurring in future missions, astronaut candidates are carefully selected on the basis of possessing specific skills and traits deemed as essential to any spaceflight mission. Some of these traits have been identified through assessments, performance tests, and other screening methods. For example, an individual who is either primarily introverted or exceedingly extroverted may be eliminated from the selection process, while an individual whose personality is somewhat between both extremes may be preferred (Kanas & Manzey, 2008; Santy, 1994). Above all, the most sought-out characteristics by mission specialists in search of potential crewmembers is resilience, leadership, motivation, support, and flexibility (Santy, 1994).

Beyond individual problems, the social dynamic between crewmembers also remains an important area of study. A universal theme in social behavioral research having direct implications on the success of future long-duration missions is crew cohesion. Connors, Harrison, and Atkin’s (1985) *Living Aloft: Human Requirements for Extended Spaceflight* defines cohesion as the unity and strength of a group of individuals. As it relates to spaceflight, a crew is said to be in a state of cohesion when members have a strong sense of liking for one another and share positive attitudes about the group as a whole. In addition, Connors et al. (1985) suggest a crew is cohesive when crewmembers (1) enjoy flight and adventure, (2) subscribe to the mission's overall goals, (3) encourage each other, and (4) help fulfill each other's needs in areas both related to and unrelated to the mission. A crew in a state of cohesion is better able to communicate, work together, and therefore complete mission tasks more readily. Lack of cohesiveness can impede these abilities and create interpersonal conflict, both detrimental to mission success (Schmidt, Keaton, Slack, Leveton, & Shea, 2008). Factors that may affect crew cohesion include gender, experience, professional background as well as cultural differences; e.g., potential language barriers**.** Further to this point, increases in social tension frequently occur under prolonged conditions of isolation and confinement, potentially compromising the integrity and cohesiveness of a crew (Harrison, 2001). Palinkas' (2001) *Psychosocial Issues in Spaceflight: Overview* notes a number of Russian cosmonauts who participated in extended duration missions reported conflicts and disruptions in cohesion as a common feature of the missions. Russian Cosmonaut Valerie Ryumin once suggested "All the necessary conditions to perpetrate murder are met by locking two men in a cabin of 18 by 20 feet for two months" (Seedhouse, 2009, p. 152). Finally, in 1982, Soyuz cosmonauts Valentin Vitalyevich and Anatoli Berezovoi spent a 211-day flight in near silence due to an unresolved conflict (Evans, 2012).

The organizational structure of a crew, which denotes the hierarchical arrangement of lines of authority, has direct implications on crew cohesion. For example, lack of authority, improper communication, and uncertainty of job duties can all lead to instability as well as crew factionalization (Stuster, 1996). The organizational structure of a crew depends heavily on the type of management structure set in place and leadership dynamics. Historically, there are typically two types of management structures: (1) a military/maritime management structure consisting of one authority figure having the ultimate decision making power (most prevalent in spaceflight) and (2) an alternative management structure typically referred to as a loose style consisting of a more flat hierarchical arrangement, with every individual having a voice in important decision making. Leadership is a critical element of organizational structure in isolated and confined settings and is crucial in regard to total group unity (Rasmussen, 2007). Finally, as mission duration increases, there is a tendency within isolated groups for formal authority structures to be less tolerated, and for group structure to become less complex (Stuster, 1996). For example, Kanas and Manzey's (2008) *Space Psychology and Psychiatry* recounts the 96 day Salyut 6 mission wherein the commander was younger and less experienced than his elder crewmate in the engineering skills required to repair the space station. Though occupying different ranks, they decided to share decision-making in order to successfully accomplish the goals of the mission.

Due to limited research concerning the psycho-social issues of long-duration spaceflight, terrestrial analogs such as winter-over missions in Antarctica and other long-duration expeditions in remote environments, provide some understanding of how individuals cope under various extreme conditions. Antarctica serves as an excellent avenue for understanding the psychological effects of long term isolation and confinement. Harsh winters characterized by extreme temperatures, high winds, low levels of oxygen, and continuous darkness parallel many aspects of long-duration spaceflight. Depression and deviations in mood are well documented in participants in Antarctic winter-over missions, as well as a tendency to regress further into their own rooms as harsh winters progress (Stuster, 1996). In addition, observational studies of the use of space in small Antarctic stations found 60% of participants' waking time was spent away from others, magnifying the significance of personal space under conditions of long term isolation and confinement (Suedfeld & Steel, 2000). Other analogs such as the MARS 500 simulator have provided an outstanding opportunity to research the changes in psycho-social adaptation over a prolonged period of isolation and confinement. The Mars 500 project took place at the Institute for Biomedical Problems in Moscow and was designed to simulate a 520-day round trip expedition to Mars. Final results of the all-male crew indicated large differences on how the men responded to long term isolation and confinement. Depression, deviations in mood, altered sleep cycles, and boredom were all apparent in crewmembers, with at least four crewmembers exhibiting an issue that would have been deemed dangerous during a real Mars mission (Basner et al., 2014).

These analogs are valuable to behavioural health and performance experts tasked with identifying, characterizing, and preventing behavioural health problems and performance risks associated with space exploration. First and foremost, selected astronauts undergo extensive training in analogous environments to promote teamwork strategies and cohesion under stressful circumstances. Examples include underwater team training at NASA Extreme Environment Mission Operations (NEEMO), and Cooperative Adventure for Valuing and Exercising (CAVES) where astronauts spend up to six days in caves conducting a variety of activities encouraging teamwork and bonding. NASA's Team Dimensional Training is structured around four core teamwork components: 1) information exchange 2) communication delivery 3) supporting behavior and 4) leadership (Smith-Jentsch et al., 2015). This type of training methodology focusses on positive and negative events and encourages participation from all team members. With regards to personal well-being, engineers and design experts have been evaluating the overall adequacy of spaceflight habitability in order to provide the best living accommodations for crewmembers. Investigators studied the implementation of windows as a psychological countermeasure tool. Windows, both real and virtual, promote well-being by reducing sensory monotony and feelings of isolation and confinement (Kanas & Manzey, 2008). Anecdotal reports from astronauts and cosmonauts reported appreciating the ability to look outside a spacecraft since the first flights into orbit (Kanas & Manzey, 2008). During his 211 day Salyut-6 mission, Russian cosmonaut Valentin Lebedev described the relaxing feeling of being able to view Earth through the space station portholes (Lebedev, 1988). With communication delays expected as astronauts venture deeper into space, advances in the ability to remain connected with families and loved ones such as email and privatized audio/video transmissions could help combat feelings of isolation. Other countermeasures include advances in lighting and noise, such as improved LED lighting and acoustic blankets, aimed at improving the quality of sleep.

As NASA prepares for future long-duration missions, it is clear significant challenges and obstacles lie ahead. Crewmembers may be exposed to a variety of extreme physiological altering conditions, such as low gravitational fields, high levels of radiation, and extreme climates. Beyond the physiological challenges, a major obstacle to successful long-duration spaceflight are the psycho-social challenges. Environmental factors such as zero-gravity and confinement may induce stress responses altering behaviour. In addition, altered sleep cycles, sensory monotony, and isolation may factor into abnormal behavioral patterns, such as mood change. Prolonged conditions of isolation and confinement will also challenge a variety of interpersonal issues. Crew cohesion, the degree to which individuals in a crew are committed to each other and to the goals of the mission (Vakoch, & United States, 2011), remains one of the important social behavioral gaps currently under investigation. Weak crew cohesion may lead to interpersonal tension, conflicts, and ultimately hinder mission success.

Rise of Online Learning

Online learning is defined as an educational environment where, most if not all, content is delivered online with typically no face-to-face contact between instructor and student (Allen & Seaman, 2013). Allen & Seaman's (2013) *Changing Course: Ten Years of Tracking Online Education in the United States* suggests courses are considered to be "online" when at least 80% or more of the course content is delivered online. An alternative method of online delivery includes blended or hybrid educational environments where delivery of education includes both online and face-to-face (Allen & Seaman, 2013). A substantial amount of content is delivered online through discussion boards and forums. However, students also meet with instructors for face-to-face meetings and presentations. A third educational environment includes the traditional face-to-face instruction where no online technology is applied. Content is delivered in writing or orally. Today, the traditional face-to-face classroom mode of learning, a staple of the educational system across the world, is being challenged with the rapid rise in online educational programs being offered by accredited institutions of higher learning. This paradigm shift from traditional face-to-face delivery to online and blended education environments is fuelled by major technological advances in the twenty-first century

(Mitchell et al., 2015). Perhaps most prominent is the internet; now almost universally accessible, even in the most remote and rural locations. The internet has redefined education, removing spatial and temporal boundaries, making it available anytime and anywhere. According to Allen & Seaman's (2007) study *Online Nation: Five Years of Growth in Online Learning*, online education enrollment is now growing at a higher rate than overall higher education institutional enrollment, with more than two thirds of all higher education institutions providing some form of online learning. In addition, Allen & Seaman's (2013) study *Changing Course: Ten Years of Tracking Online Education in the United States* reports: the proportion of all students taking at least one online course is at an all-time high of 32%. Online learning promotes schedule flexibility allowing students to learn from anywhere and at their own desired pace. Online learning also eliminates both spatial and temporal restrictions. In addition, online learning increases the ease of accessibility to course material and facilitates student-to-instructor and student-to-student interaction. Students are provided with access to a broad spectrum of relevant course content, including lecture notes and supplemental readings available online. In addition, unique online software such as Blackboard facilitate online communities. Along with these benefits, learning outcomes in online education are also favourable. Within ten years of tracking the learning outcomes of online education, the percent of academic leaders rating the outcome of online education as equal or superior to face-to-face has risen from 57% to 77% (Allen & Seaman, 2013). At the same time, a report from Allen & Seaman's (2013) *Changing Course: Ten Years of Tracking Online Education in the United States* indicates, contrary to some expectations, teaching an online course requires more faculty time and effort than teaching a face-to-face class. In addition, academic leaders continue to express concerns about the need for more discipline on the part of students enrolled in online classes and lower retention rates. An online learning environment allows for full autonomy, yet requires self-discipline, ultimately influencing the outcome of learning.

First developed in 2008 by educators Stephen Downes and George Siemens, the Massive Open Online Course (MOOC) is a free online class aimed at large scale interactive participation (Finkle & Masters, 2014). Typical features of MOOCs include 10 to 20 minute lectures consisting of a diverse variety of delivery methods, built in quizzes, weekly auto-graded assignments, and instructor moderated discussion boards. MOOCs also provide interactive user forums creating a community between instructors and students (Finkle & Masters, 2014). The first MOOC began at Stanford University as *An introduction to Artificial Intelligence* course taught to nearly 160,000 students. The success of this MOOC lead a number of educators and business personnel to create their own MOOC startup provider, prompting the New York Times to declare 2012 as “The year of the MOOC” (Chauhan, 2014, p. 8). The three major competitors within the MOOC industry include: Coursera, Udacity, and EdX. Coursera is a for-profit organization and as of March 2014, has hosted nearly 108 educational institutions in 19 different countries and offered more than 600 free courses all over the world (Finkle & Masters, 2014). Udacity is another for-profit organization wherein over 1.6 million students have taken courses, while EdX is a non-profit organization. As of January 2014, EdX has frequented over 30 different institutions (Finkle & Masters, 2014). Dr. Charles Layne at the University of Houston created the first MOOC on the history of spaceflight. This MOOC is offered through providers such as Coursera and Class central with enrollment including participation from over 90 different countries. The course provides a brief history on manned spaceflight beginning with early fascinations of spaceflight through to current space stations. Features of this MOOC include video lectures, unit reviews, and weekly quizzes.

With MOOCs widening in participation and expanding globally, one of its biggest strengths is international collaboration. In addition, since MOOCs do not require pre-requisites, typical obstacles preventing students from enrolling in programs or courses are eliminated. Finally, the accessibility of MOOCs makes it easier to reach out to wider audiences of any socio-economic distinction, such as disadvantaged groups (Finkle & Masters, 2014). However, certain critics of the MOOC believe the latter serves as a disadvantage to its effectiveness. Students at the bottom of the economic tier may be those who require the most one-on-one interaction, something difficult to obtain through MOOCs (Finkle & Masters, 2014). Critics of the MOOC also point to the high enrollment but low completion rates. According to a report from Zhenghao et al. (2015) *Who's benefitting from MOOCs, and Why*, over 25 million people around the world have enrolled in MOOCs offered by Coursera, EdX and other platforms. However, only a small percentage of these millions completed the courses. Other discrepancies include testing, cheating, and perhaps most importantly the ability to measure its effectiveness (Finkle & Masters, 2014). Though MOOCs are still relatively new to the field of education, the ups and downs experienced within the last five years have created an uncertain future. As more and more higher education institutions create their own MOOCs, the means by which learning is measured and evaluated will continue to remain a controversial topic in higher education.

Advancements in technology such as the World Wide Web have led to a rapid rise in online educational programs being offered by a variety of accredited institutions of higher learning. The traditional face-to-face classroom mode of learning, a staple of the educational system, is now being challenged by online and hybrid classrooms promoting flexibility and global access. Online classrooms incorporate unique software such as blackboard, offering a variety of dynamic learning content, online communities, and the integration of social media. Despite early criticism and low retention rates, the use of Massive Open Online Courses (MOOCs) continue to grow, offering courses in a variety of different subjects and serving a number of different countries around the globe. MOOCs cater to all individuals, incorporating a variety of delivery methods such as text, images, videos, and animations.

Cognitive Styles

With highly diversified methods of educational delivery such as those provided by the MOOC, students realize they have a choice in deciding how to pursue their education. Giving students the option of selecting their preferred mode of learning is founded on the principles of cognitive style. The cognitive style of an individual refers to a psychological dimension describing the distinctive and observable ways in which individuals organize, process, and store information (Messick, 1984). This is not to be confused with cognitive ability, referring to an individual's general and specific intellectual capabilities (Kollöffel, 2012). Though there are a multitude of cognitive style dimensions to explore, the preferred perceptual mode of visualizer versus verbalizer is of most significance when attempting to connect method of material delivery and an individual's cognitive style (Klein, 2003). Allan Paivio (1971) first proposed the dual-coding theory in which the cognitive system consists of two distinct components: a verbal system and a visual system where perceived information is processed differently along distinct channels in the human mind. An example of dual coding theory can be best demonstrated when an individual is asked to remember a specific object. The individual may store the object as an image or the word and when asked to recall the object, may retrieve the image, word, or both, making use of both systems. Following the work of Paivio, Richardson (1977) proposed the theory of the visualizer-verbalizer dimension of cognitive style and described it as an individual preference for attending to and processing visual versus verbal information (Jonassen & Grabowski, 1993). Individuals who are visualizers rely primarily on imagery processes when performing cognitive tasks, while verbalizers prefer to process information through verbal means such as text. Current literature suggests, within the population, the proportion of visual versus verbal learners is approximately: 60% visual versus 30% verbal with another 10% being kinesthetic learners (Gangwer, 2009; Russell, 2005)

An important step in research concerning the individual differences in learning is establishing an economical way of measuring them (Mayer & Massa, 2003). Paivio was the first to introduce the Individual Differences Questionnaire (IDQ) used to determine each individual's primary style for cognitive processing. Following up on Paivio's work, Alan Richardson (1977) devised the Visualizer-Verbalizer Questionnaire (VVQ) in order to differentiate between individual preferences for visual or verbal modalities. The VVQ consists of a subset of 15 statements extrapolated from Paivio's IDQ where subjects answer true, "This statement is true for me", or false, "This statement is false for me". For example, statements about visual thinking may include "I enjoy using maps" or "I cannot create a mental image of my dog's face". For verbal thinking, statements may include "I enjoy doing work that requires the use of words" or "I am a very slow reader" (Leutner & Plass, 1998). Antonietti & Giorgetti (1998) have suggested the VVQ, according to Richardson, is based on the assumption of unidimensionality, wherein verbalizers and visualizers exist on opposite ends of a bipolar spectrum. However, critics question the assumption of a distinct fine line between verbalizers and visualizers. For example, one critic argues the opposite of a visualizer may not necessarily mean a verbalizer. An individual who does not use mental images in thinking may be using abstract thoughts not verbal in nature, or perhaps may be using a mixture of all (Zenhausern, 1978). In Kirby, Moore, and Schofield's (1988) *Verbal and Visual Learning Styles*, the unidimensionallity of the VVQ is called into question, suggesting at least some subjects would score equally in either domain or neither. It's also argued of the 15 items on the VVQ, none actually contrasts a verbal approach with a visual one. There appears to be some ambiguity regarding whether a negative response to any verbal statement implies a visual preference or vice versa. It's also suggested the nature of the visualizer-verbalizer preference deserves further investigation. For example, of the eight visual statements, only three relate specifically to the formation of mental images, with the remainder concerning either dreams or imagination. The authors argue it is unclear whether imagery in dreams is related to the conscious formation of images and whether it would be related to learning (Kirby, Moore, & Schofield, 1988). Finally, critics suggest the VVQ lacks construct validity (Edwards & Wilkins, 1981) and high levels of internal consistency (Boswell & Pickett, 1991).

Mayer and Massa (2003) developed the Santa Barbara Learning Style Questionnaire (SBLSQ), which is intended to tap the same factors as Richardson's VVQ but with fewer questions. In addition, the SBLSQ statements are more explicit in asking about cognitive styles. The SBLSQ consists of six statements on a seven point liker scale with the total score equalling the sum of pro-visual ratings minus the sum of pro-verbal ratings. Participants with a positive total score ranging from +9 to +18 classify as visualizers, while those with a negative total score ranging from −9 to –18 classify as verbalizers. The SBLSQ was calculated to have an acceptable level of internal consistency with a Cronbach's alpha coefficient of .76 (reliability coefficients of .70 or higher are considered acceptable) (Mayer & Massa, 2003). Finally, a 2006 study by Massa and Mayer was conducted to determine the validity of a number of self-reported measure instruments (including the SBLSQ) of the visualizer-verbalizer cognitive style model. There was a consistent relationship between both cognitive style and processing measures and learning preference and processing measures. In other words, individuals who reported themselves as a specific type of learner or having a specific learning preference, tended to rely on the same type of cognitive style or learning preference to complete tasks (Massa & Mayer, 2006). These findings provide validation of the SBLSQ as a self-report instrument for measuring the visualizer-verbalizer cognitive style model and learning preference.

Once individuals are classified as either visualizers or verbalizers, the underlying assumption is students will gain an increased level of understanding when educational material is delivered in a way suiting their cognitive preference. Verbalizers will learn better when material is delivered in the traditional form of text, while visualizers will learn better when material is delivered dynamically in the form of images, videos, and animations (Kollöffel, 2012). This assumption of matching method of material delivery to an individual's cognitive style for the purpose of improving learning has long been under heavy debate. A literature review on previous studies has revealed some ambiguity regarding the validity of this assumption.

Matching Instructional Mode and Cognitive Style Review

A study conducted by Riding and Staley (1998) attempted to address whether a student is more likely to succeed when enrolled in a course either predominantly visual or verbal in nature. Students were divided into visualizers and verbalizers based on scores on a variety of measuring tools such as the VVQ. Results indicated verbalizers outperformed visualizers in a business management course which was predominantly verbal in nature, while visualizers outperformed verbalizers in an information technology course that was predominantly visual in nature. In addition, Riding and Staley discovered when method of delivery was matched with cognitive style, students underestimated their performance, whereas when method of delivery did not match cognitive style, they overestimated their performance. Not only did this study support the assumption a student's performance is affected by the extent to which the method of material delivery matches their cognitive style, it also suggests students are not consciously aware of the matching or mismatching that is occurring (Riding & Staley, 1998). Another study by Riding and Watts (1997) involved having secondary school students study one of three information sheets. All sheets contained identical information but were purposely created in three different formats: an unstructured verbal version, a structured verbal version, and a structured pictorial version. After having identified and separated visualizers and verbalizers, students were asked to come up one at a time and select any version. The results indicated the majority of verbalizers selected the structured verbal version, the majority of visualizers selected the structured pictorial version, and no students selected the unstructured verbal version. Riding and Watts interpreted these findings as support for matching the method of delivery to a student's cognitive style. Students obviously preferred and were drawn to the version of material suiting their personal style of learning (Riding & Watts, 1997). More support for cognitive style comes from a study conducted by Plass, Chun, Mayer, and Leutner (1998). English speaking students enrolled in a German course were classified as either visualizers or verbalizers. They were required to read a German language story with the ability to translate key words into English verbal annotations or view visual annotations in the form of pictures and video clips. Results indicated students were able to better comprehend the story when they selected their preferred method of annotation. In other words, visualizers were more likely to produce the correct translation when a visual retrieval cue was presented, while verbalizers were more likely to produce the correct translation when presented with a verbal retrieval cue. These studies all emphasize individual differences in learning and support Paivio's visualizer-verbalizer duel-coding theory.

Other studies have found no significant relationship between the visualizer-verbalizer cognitive styles and methods of material delivery. For example, Kollöffel (2012) attempted to address whether students completing a mathematical learning task, in which the learning materials were either diagram-based or mainly text-based, would create differences among visualizers and verbalizers when matched with their preferred method of delivery. Results indicated cognitive style and learning outcomes were not related. For example, individuals with a preference for visual material did not necessarily perform better when presented with visual material. In contrast to previous studies supporting the matching of method of delivery and cognitive style, this study differed by suggesting within the visualizer domain, there are two distinct types of visualizers: spatial visualizers who excel in schematic or spatial imagery and object visualizers who excel in pictorial imagery. Additionally, a modified version of Richardson's VVQ was used, in which three factors were measured: verbal preference, dream vividness, and mental imagery. Kollöffel (2012) argues cognitive ability may in fact be the independent factor influencing learning outcomes and warns providing students with the option of choosing their most desired format of material delivery may lead to the selection of a format least effective for learning. Similar results were obtained by Massa and Mayer (2006) in their attempt to determine whether multimedia instruction should accommodate the visualizer-verbalizer cognitive styles. Certain critics argue mismatching cognitive style with method of material delivery may be more beneficial to the learning process than matching. For example, Hayes and Allison (1996) propose learning situations that are unsuited to a student's cognitive style may be beneficial in the long term in strengthening areas of weakness and promoting versatility.

One of the key aspects of online and blended classrooms is their ability to create a virtual environment catering to all different types of learners. The cognitive style of an individual is defined as the distinctive and observable ways in which individuals organize, process, and store information. When attempting to connect method of material delivery and cognitive style, the dual-coding theory proposed by Paivio (1971) suggests individuals are classified into two distinct groups: one, visualizers relying primarily on imagery processes when performing cognitive tasks and second, verbalizers preferring processing information through verbal means. Richardson's (1977) Visualizer-Verbalizer (VVQ) and Mayer and Massa's (2003) Santa Barbara Learning Style Questionnaire (SBLSQ) are examples of self-measure tools used to differentiate between visualizers and verbalizers. Literature attempting to address the advantage of matching material delivery methods with a student's cognitive style remains somewhat ambiguous. Certain studies show distinct advantages of matching an individual's cognitive style with a preferred delivery method while others deduce no distinct advantage. By building two psycho-social issues of spaceflight modules with distinct methods of content delivery, this thesis attempted to challenge the ambiguity centered on the matching of method of material delivery along the visualizer-verbalizer cognitive dimension. Information gained from this project may be used to guide future educators in their delivery of space life sciences educational materials.

CHAPTER THREE

METHODOLOGY

The purpose of this study was to explore the relationship between cognitive styles and delivery methods of educational material focusing on psycho-social issues associated with human space exploration. This chapter will outline the methodology utilized to firstly, build a spaceflight psycho-social issues module. Secondly, for recruiting and screening participants. And thirdly, the intervention, collection of data, and statistical analysis.

Building Spaceflight Psycho-Social Issues Module

During the process of building a module on the psycho-social issues of spaceflight, it was necessary to identify key topics and develop an outline. Selection of key topics were based on a review of literature including Kanas and Manzey's (2008) *Space Psychology and Psychiatry* as well as Connors, Harrison, and Atkin's (1985) *Living Aloft: Human Requirements for Extended Spaceflight.* Key topics selected included: the environment and conditions of spaceflight, individual issues, interpersonal issues, spaceflight analogs, and countermeasures (see figure 1). The outline and sequence of selected topics were inspired by the reviewed literature as well as Dr. Gary Kitmatcher's *Space Habitats* course (this course was offered within the Master's and Doctoral curriculum at the University of Houston's Space Exploration Sciences program). Content and material such as text, images, and videos were predominantly obtained from the reviewed literature. Additional content was extrapolated from a variety of online resources. In order to explore the relationship between cognitive style and different methods of material delivery, two distinct modules were built using the selected material. Though both modules contained all the same content required for learning, they differed in how material was delivered. One module consisted purely of text, while the second module included the addition of images and videos to support the text.

Spaceflight Environment and Environmentally Induced Issues

Isolation

Confinement

Sleep disruption

Sensory deprivation

Individual Issues

Changes in mental health

Examples in spaceflight

Interpersonal Issues

Crew cohesion

Organizational structure

Spaceflight Analogs and Countermeasures

Introduction to spaceflight analogs (e.g., Antarctica)

Screening and selection

Team training

Habitat design and other countermeasures

Figure 1. General outline of content

The psycho-social issues of spaceflight modules presented topics in this order.

Recruitment and Screening

Following the development of two distinct modules, participants were recruited for the experimental portion of the study. Recruitment was accomplished via flyers distributed around the University of Houston's Health and Human Performance department and face-to-face contact with undergraduate students. Further recruiting of participants occurred through the University Of Houston Department Of Psychology's Research Management System (SONA Systems). Forty participants were engaged in the experimental portion of the study. Of the forty, 20 would constitute visualizers and the remaining 20, would constitute verbalizers. As previously outlined, current literature suggests approximately 60% of the population are visual learners, 30% are verbal, and 10% are kinesthetic learners. As a result, in order to meet the requirement for visualizers and verbalizers, over 200 undergraduate students were screened. Recruited participants had to meet two separate screening criteria in order to be eligible to complete the study. First, they were administered the SBLSQ in order to determine cognitive style (see appendix). The SBLSQ was initially intended to be implemented once, however, for reliability purposes it was later decided participants would complete it twice. Participants had up to five minutes to rate their agreement on six statements regarding preference for visual and verbal thinking on a seven point liker scale. Total score equalled the sum of pro-visual ratings subtracted from the sum of pro-verbal ratings. Participants with a positive total score ranging from +9 to +18 classified as visualizers, while those with a negative total score ranging from −9 to −18 classified as verbalizers. Only those participants scoring in the ranges necessary to be identified as visualizers or verbalizers met the first screening criteria. Unfortunately, of the 200 or more participants screened, no students met the criteria to be classified as verbalizers. Consequently, it was decided to replace verbalizers with 20 neutral learners. Neutral learners were defined as those participants who scored in the middle range, between both extremes. In order to classify as a neutral learner, participants had to score between (and including) +5 to −5. To maximize time efficiency, participants were screened individually. The SBLSQ was first administered either in person or online, while the second SBLSQ was administered in person following a minimum period of four days, and a maximum period of 30 days. This was to allow sufficient time to pass between attempts at the SBLSQ. Only participants who scored in the same range on both attempts were able to proceed to the next screening criteria. For example, if a participant initially scored as a visualizer (+9 to +18) and then proceeded to score below a +9 on their second attempt, they were immediately discontinued from the study.

The second screening criteria required participants classified as visualizers and neutral learners to take an identical pretest on the psycho-social issues of spaceflight. The pretest was administered individually to participants immediately following the 2^{nd} SBLSQ. In other words, the 2^{nd} SBLSQ and pretest were administered on the same day. The pretest was designed to test for pre-existing knowledge of the content. Students who scored a 40% or lower met the second screening criteria and were eligible to move on to the intervention portion of the study. Participants had a maximum of 30 minutes to complete the assessment, consisting of a mix of multiple choice, true/false, and short answer questions based off the spaceflight psycho-social issues modules. An Item analysis was conducted prior to the study to evaluate the difficulty of multiple choice and true false questions (see table 4). Questions were administered to a separate sample of 20 individuals, including an eclectic mix of undergrad students, graduate students, and professors with non-space life sciences educational backgrounds. Any item above a 75% correct score rate was omitted from the final version of the test. The majority of questions selected for the final version of the test ended up within a 30%-60% correct score rate. Following the item analysis, the final version of the test was administered to a second separate sample population of individuals to determine an appropriate time limit. The second sample consisted of 10 individuals between the ages of 18 and 28 with non-space life sciences educational backgrounds. The majority of individuals completed the assessment in under 30 minutes, which lead to a proposed allotted time of 30 minutes. A feedback survey was designed and administered following the completion of the study in order to determine the effectiveness of the assessment as well as the learning material (see appendix). In the context of the assessment, effectiveness was measured as how satisfied subjects were with the overall makeup of the test. This included the type and number of questions, as well as, whether the questions reflected the material. In the context of the learning material, effectiveness was measured by how the content was arranged and presented, the length of the content, and whether it was easy to understand.

Table 4. Pre-study item analysis for final version of assessment

Assessment item mc = multiple choice tf = true/false	Percent correct score Sample size N = 20		
1 mc	33.3%	9 mc	53.8%
2 mc	38.5%	10 mc	58.3%
3 mc	53.8%	11 mc	58.3%
4 mc	50%	12 tf	30.8%
5 mc	23.1%	13 tf	53.8%
6 mc	75%	14 tf	30.8%
7 mc	53.8%	15 tf	53.8%
8 mc	61.5 %		

Intervention, Data Collection, and Statistical Analysis

The experimental stage of the study was designed to take place exactly one day following the 2nd SBLSQ and pretest for each of the 40 participants. Participants from each cognitive style were randomly assigned into one of two learning groups differing in how content was delivered. A coin toss determined whether a participant would learn visual material or verbal material. Ten neutral learners were randomly assigned to exclusively verbal content delivery, while the other 10 neutral learners were randomly assigned to visual content delivery. Similarly, 10 visualizers were randomly assigned to exclusively verbal content, while the other 10 were randomly assigned to visual content delivery. It was originally estimated all 40 participants would be allotted 45 minutes to study any spaceflight psycho-social issues module they were assigned to. To test the adequacy of this estimate, both modules were administered to the same sample group of individuals previously used for determining the assessment time. The majority of individuals assigned to verbal content found the estimated time of 45 minutes to be adequate. Since the visual content included up to 10 minutes of video clips to go along with images and text, most individuals who were administered the visual content surpassed the 45 minute period. As a result, it was concluded participants administered visual content would receive an additional 10 minutes (if necessary), raising the maximum allotted time to 55 minutes. Participants were also required to complete post-tests. The first post-test was administered immediately following the learning period, while the second post-test was administered one week later to determine retention rates. The pretest and both post-tests were identical. Participants were given 30 minutes to complete each post-test.

Each participant qualifying as either a visualizer or neutral learner was assigned a numeric subject code to be used for the remainder of the study. Any participant failing to meet the cut off requirement of 40% or lower for the pretest, or failing to attend all sessions, had their subject code removed from the experiment. Each subject code along with the associated age and gender were entered into an excel file. Each subject code was subsequently matched with a subject number, cognitive style, method of material delivery, and test scores for the three different time points, respectively. The final spreadsheet completed with all 40 subjects was then transferred to IBM SPSS software to explore descriptive statistics of the sample such as age, gender, along with test scores and to perform further statistical analysis. Statistical analysis of test scores between groups and within the subjects was accomplished through a 2X2X3 mixed factorial repeated measures ANOVA. The two between-group independent variables represented type of learner (neutral or visualizer) and method of material delivery (visual or text-only). The within-subject repeated measure independent variable represented three different testing time points: pretest, post-test one, and post-test two.

Post-test scores were compared to pretest scores to explore learning outcomes and efficacy of the learning material. Further analysis of post-test scores between the four groups was conducted to determine whether matching a participants' cognitive style with a method of educational material delivery improved learning outcomes (see figure 2). It was expected there would be no differences based on cognitive style on the pretest scores. It was also expected all participants would score higher on post-tests compared to the pretest following a period of learning. Finally, it was expected all participants learning material through a method of delivery matching their cognitive style would outperform the rest of the participants. Meanwhile, participants mismatched with a method of content of delivery would perform the worst. Visualizers learning visual material would outperform visualizers learning verbal material. Likewise, visualizers learning visual material would outperform neutral learners receiving visual material. Finally, neutral learners receiving verbal material would outperform visualizers receiving verbal material.

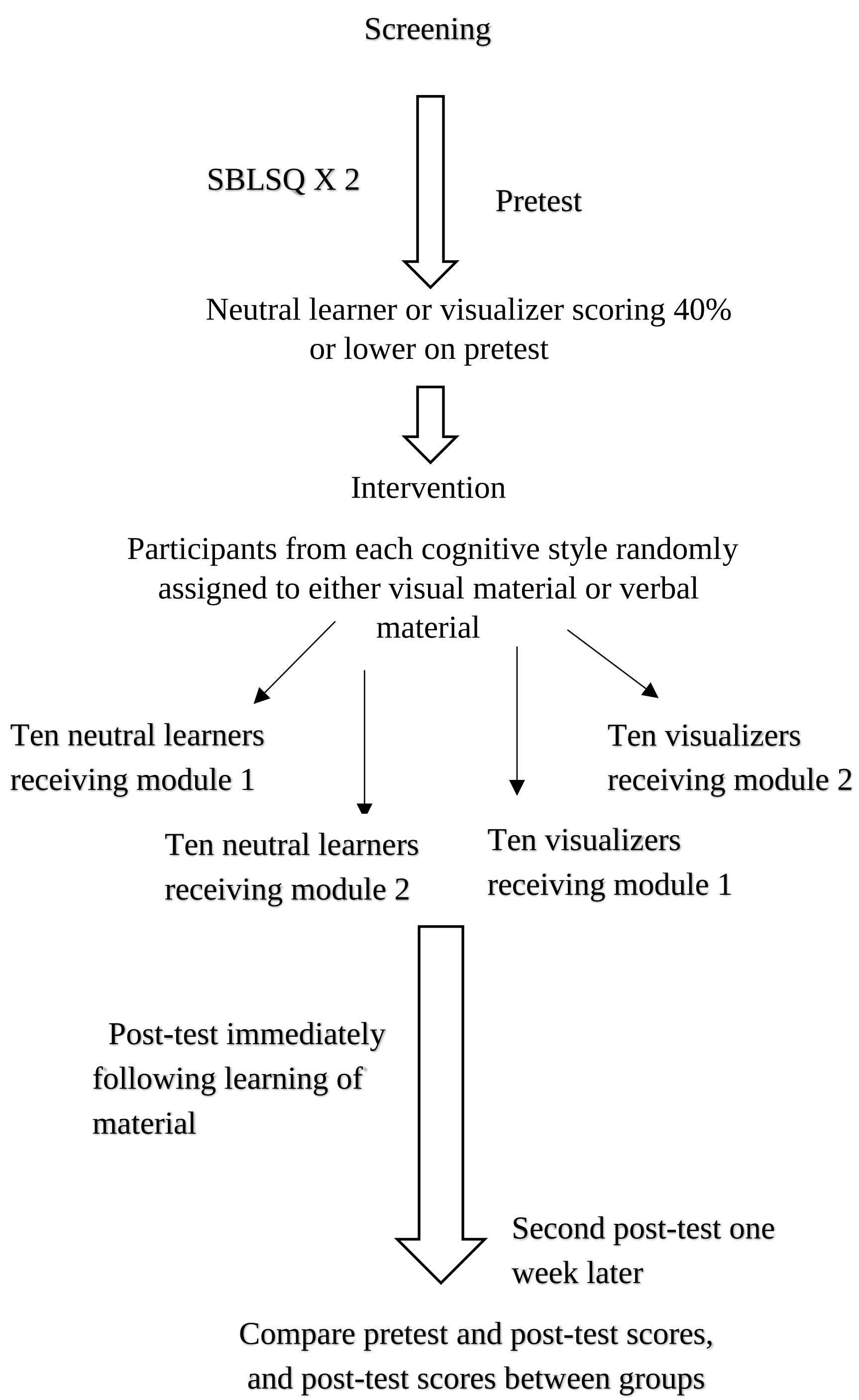

Figure 2. Proposed methodology flowchart. Module one (M1) consisted exclusively of text material. Module two (M2) included more visually stimulating material such as images and videos to support the text.

CHAPTER FOUR

RESULTS

Over 200 individuals were screened with the SBLSQ from June 1st, 2016 to September 9th, 2016. First time submissions were completed in person and online, while second attempts were completed exclusively in person. For first time submissions, a total of 148 were completed online through either SONA or Survey Monkey. The majority of all submissions fell in the ranges between −2 and +9. No submissions met the criteria in order to be classified as verbalizers. Of those identified as either visualizers or neutral learners, a total of 52 agreed to participate in the study. Of those beginning the study, one subject was dropped as a result of inconsistency in their SBLSQ score. In other words, 51 out of 52 subjects scored in a consistent range on both attempts on the SBLSQ. These results indicated the SBLSQ was a reliable self-assessment tool for determining cognitive style in this study. Three more subjects were dropped from the study as a result of failing to meet the screening criteria for the pretest, with another eight subjects dropped due to either absences or not following correct protocol. In the end, a total of 40 subjects completed all three phases of the study. Their gender, age, cognitive style, method of material delivery, and test scores were collected and recorded both on paper and on a computer spreadsheet. All data from the spreadsheet was later copied into IBM SPSS to be used for subsequent data analyses.

The results of this study are presented in the following order: (1) descriptive statistics of the sample population, (2) descriptive statistics of the test scores, (3) results from the analysis of variance, and (4) results from the feedback survey.

Descriptive Statistics of the Sample Population

Of the 40 subjects, 75% were female and 25% were male. This resulted in an uneven distribution of females to males per group (see table 6). Over two thirds of the subjects were between 20 and 23-years of age (M = 21.85, SD = 3.21). The oldest subject in the study was 34, while the youngest was 17 years of age (see table 5).

Table 5. Age and gender statistics

Variable	N	Minimum	Maximum	Mean	Std. deviation
Age	40	17	34	21.85	3.21
Female	30				
Male	10				

Table 6. Gender distribution among groups

Cognitive style + method of material delivery	Gender ratio F:M
Visualizer + visual material	7:3
Visualizer + verbal material	4:1
Neutral learner + visual material	7:3
Neutral learner + verbal material	4:1

Descriptive Statistics of the Test Scores

Among all three testing points, the average of the pretest scores for all subjects was the lowest at 30%. Post-test one, which was administered immediately following the learning period, had the highest average test score at 67%. Post-test two, which was administered a week later, had an average test score of 65% (see figure 3). An item analysis was conducted for both pretest and post-test one to analyse assessment items before and after the learning period (see table 7) for all subjects. Among the cognitive styles, it was discovered neutral learners outperformed visualizers at all three testing points (see figure 4). Finally, the average test score on the post-tests for individuals receiving verbal material was consistently higher than the average test score for individuals receiving visual material (see figure 5).

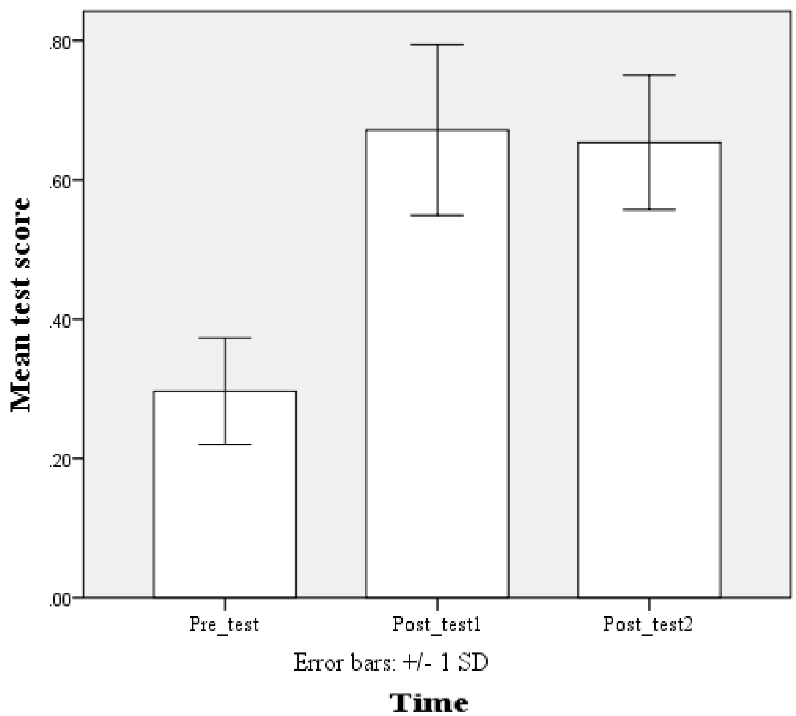

Figure 3. Mean test scores for all subjects
This figure shows the effect of time.

Table 7 Post-study item analysis

Assessment item mc = multiple choice tf = true/false	Percent correct score Sample size N = 40				
	Pretest	Post-test one			
1 mc	5%	27.5%	9 mc	57.5%	95%
2 mc	5%	57.5%	10 mc	30%	59%
3 mc	50%	62.5%	11 mc	57.5%	67.5%
4 mc	32.5%	67.5%	12 tf	77.5%	97.5%
5 mc	17.5%	87.5%	13 tf	57.5%	90%
6 mc	47.5%	97.5%	14 tf	40%	75%
7 mc	85%	90%	15 tf	77.5%	95%
8 mc	40%	87.5%			

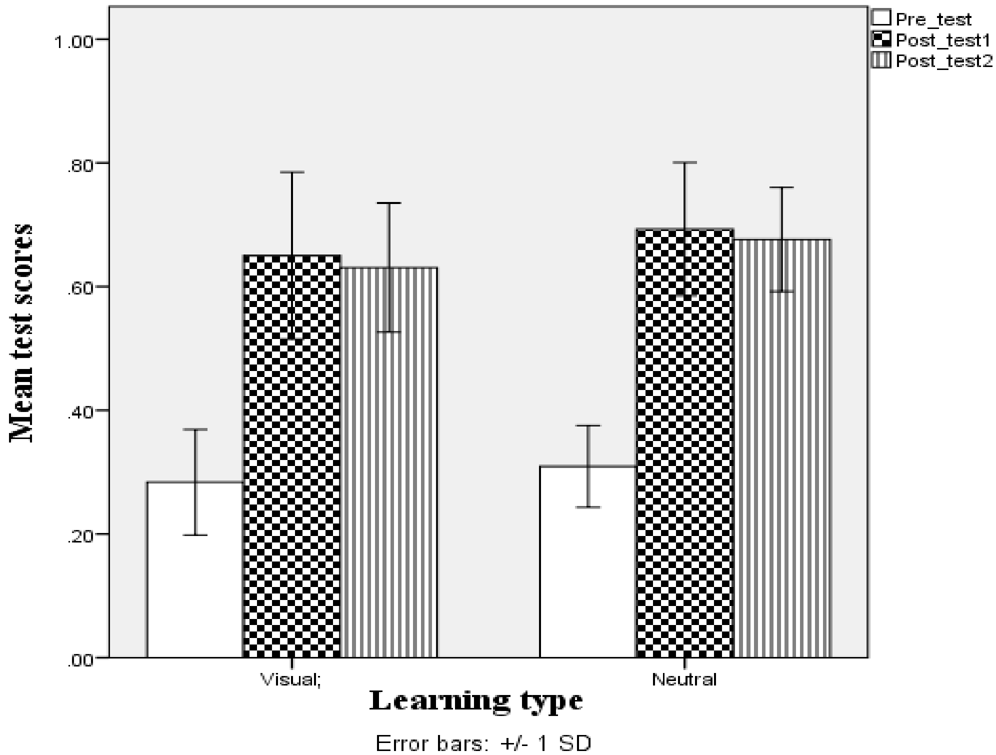

Figure 4. Mean test scores by cognitive style (learning type)
Note there was no significant main effect of cognitive style on test scores.

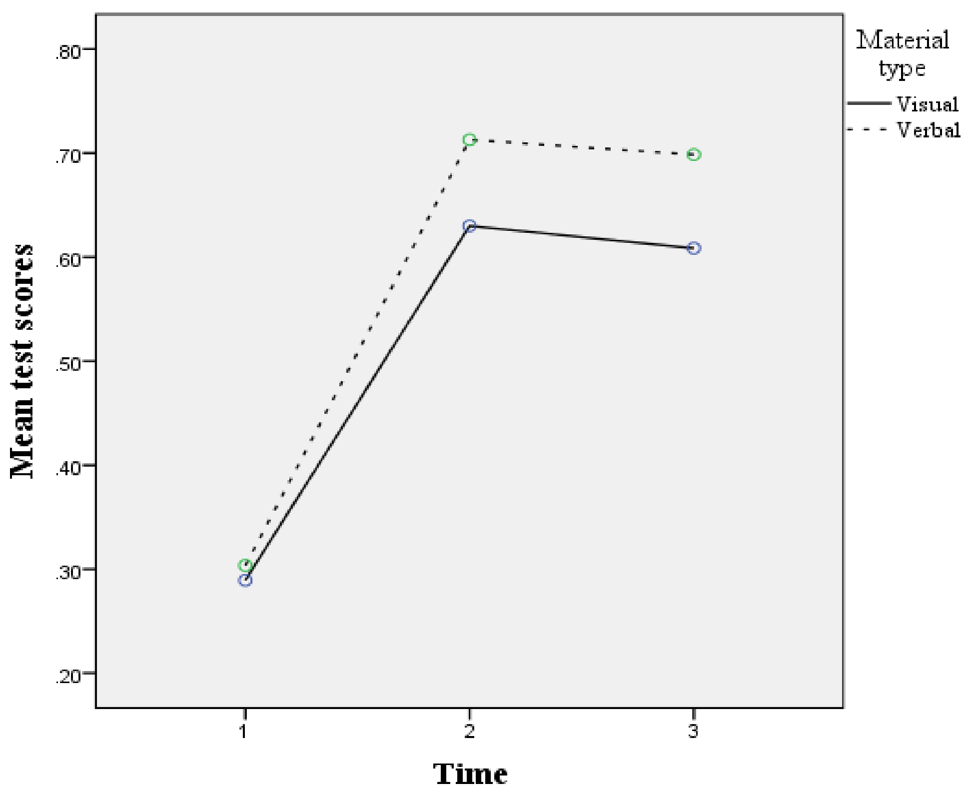

Figure 5. The effect of method of material delivery (material type)

Analysis of Variances

A 2X2X3 mixed factorial repeated measures ANOVA was performed to evaluate the effects of cognitive style, method of material delivery, and time on test scores. Participants were divided into four groups based on cognitive style and method of material delivery. The Huynh-Feldt correction was utilized in interpreting the ANOVA results due to a significant Mauchly's test of sphericity. For the data, the corresponding corrective coefficient was $\varepsilon = .96$. The assumptions of homogeneity of variance and normality were met by using a p value of $p < .01$ as the criteria for the Levene's and Shapiro-Wilk test, respectively. There was a statistically significant main effect of time on test scores $F(1.93, 69.41) = 525.87$, $p < .001$. Post-Hoc tests using the Bonferroni correction indicated the mean score for post-test one was significantly greater than the mean score for the pretest $M = .38$, Std. Error $=.02$, 95% CI = (.34, .41), $p < .001$. It was also revealed the mean score for post-test two was significantly greater than the mean score for the pretest $M = .36$, Std. Error $= .01$, 95% CI = (.33, .39), $p < .001$. Post Hoc revealed post-test one and post-test two were not significantly different. The interaction effect between time and method of material delivery was statistically significant for post-test one $F(1, 36) = 5.05$, $p < .05$ and post-test two $F(1, 36) = 11.16$, $p < .05$. The interaction effect between cognitive style, method of material delivery, and test scores was not statistically significant. The analysis of variance determined there was no significant main effect of cognitive style in this study.

Feedback Survey Results

Of those completing the feedback survey (33 of 40 subjects), 51.5% rated the effectiveness of the learning material as very effective, while 90.9% felt the learning material adequately covered all aspects of the assessment tests, giving it the highest rating possible. In rating the effectiveness of the assessment tests, 42.4% rated it as very effective, with 54.6% giving it a moderately effective score. Finally, 45.5% rated the difficulty of the assessment tests as moderately difficult. See appendix for additional tables.

CHAPTER FIVE

DISCUSSION

General Discussion

The learning benefits of matching an individual's cognitive style with a method of material delivery remains a somewhat ambiguous topic. Current literature provides evidence of studies where learning outcomes were improved with this type of intervention, while other studies have been inconclusive. The main purpose of this study was to empirically test this relationship in order to examine the question of whether matching an individual's cognitive style with a method of material delivery improves learning outcomes. In order to satisfy a secondary purpose of this study, educational content centered on the psycho-social issues of spaceflight was created and implemented for both the learning and testing phase of this study. It was hoped this content would both address the need for more accessible educational content in this field, as well as introduce and educate students in a field possibly unknown to them.

The analysis of variance revealed there was a significant main effect of time on test scores. Specifically, all participants significantly improved their knowledge as a result of exposure to the modules. This was evidenced by the higher scores on post-test one and post-test two in comparison to the pretest (which may be further analysed by comparing the percent correct score rate of assessment items before and after the learning period). There was also a strong level of retention of information evidenced by comparing post-test two scores to post-test one scores. These results indicate both modules were effective in promoting learning in an academic area known to be lacking in educational materials and would support their use as learning material in educational settings. The analysis of variance further revealed cognitive style had no significant main effect in this study. In other words, there were no differences based on cognitive style on the pre-test scores, nor did there appear to be any benefit or disadvantage to matching or mismatching a subject's cognitive style with a method of material delivery. As stated in the literature review, an equal number of studies have found both significant and non-significant effects pertaining to the matching of cognitive styles with method of material delivery on learning outcomes. Kollöffel's (2012) study, where learning materials for a mathematical learning task were either diagram-based or mainly text-based, found no relationship between cognitive style and learning outcomes among verbalizers or visualizers when matched with their preferred method of delivery. Similar results were obtained by Massa and Mayer (2006) in their attempt to determine whether multimedia instruction should accommodate the visualizer-verbalizer cognitive style model. Woolner's (2006) study of teaching mathematical concepts to secondary school students also found no interactions between teaching style and a learner's cognitive style. These studies suggested test scores were influenced by other factors and circumstances beyond the participant's cognitive style. Studies conducted by Riding and Pearson (1994), and Peterson, Deary, and Austin (2003), have demonstrated that though cognitive style and cognitive ability both affect performance on a learning task, they appear to be independent of one another. As stated in the literature review, cognitive ability refers to an individual's general and specific intellectual capabilities, such as memory (Kollöffel, 2012). These measures can be distinguished by the fact that performance will generally improve as cognitive ability improves, while with cognitive style, performance will depend on the nature of the task at hand (Wang, 2007). Therefore, it can be speculated the performance of some subjects in this study may have been influenced by their cognitive ability, regardless of their cognitive style. For example, a visualizer receiving verbal material may have outperformed a visualizer receiving visual material due to differences in intellectual capabilities. Different innate attributes and factors among individuals within and between the groups, such as age and test taking skills, may have led to these differences.

Comparing visualizers to neutral learners may explain the lack of a significant main effect for cognitive style. The original objective was to explore Paivio's dual coding theory of the visualizer-verbalizer dimension in order to determine if matching cognitive style with a method of material delivery would improve learning outcomes. However, due to the inability to identify any verbalizers, it was decided by the principal investigator to compare visualizers to a newly formed group of individuals who scored in between both ends of the spectrum and were referred to as neutral learners. The newly formed hypothesis proposed visualizers receiving visual material would outperform neutral learners receiving visual material. This was established on the concept that although neutral learners may fall in a positive range and have a slight preference or propensity for visual material, it would not be as substantial as visualizers. However, it was believed this comparison would not display the magnitude of differences that would have been expected, had visualizers learning visual material been compared to verbalizers learning visual material. Likewise, it was proposed neutral learners receiving verbal material would outperform visualizers receiving verbal material. This proposition was built on the concept that although neutral learners may fall in both ends of the spectrum, they would still have more predisposition or preference for learning verbal material over a visualizer. Again, this discrepancy could have been much more substantial comparing verbalizers learning verbal material to visualizers learning verbal material.

Further analysis also revealed a significant interaction effect between method of material delivery and time on post-test scores. Regardless of cognitive style, one would have expected most, if not all subjects receiving visual material to outperform subjects receiving verbal material (text-only content). This is predicated by a review of educational literature which suggests around 65% of the population of students prefer learning with visuals such as videos, images, and animations rather than the traditional style of plain text (Gangwer, 2009; Russell, 2005). A large number of educational studies centered on instruction and learning have also validated the use of visuals for supporting learning in educational settings (Lewalter, 2003). From a biological perspective, text requires active processing and the creation of mental thoughts to decipher meaning, while learning from images and videos is a more passive, cognitive process (Glenberg & Robertson, 1999). Nevertheless, when further analysing the effect of time on post-test scores, it was discovered subjects receiving verbal material outperformed subjects receiving visual material (see figure 5). It's unclear whether this was due to the weakness of the visual material or the strength of the verbal material, however, it is believed a combination of both, along with other confounding factors, might be the most plausible explanation for this finding.

Certain studies have found media features such as images, graphics, videos, or a combination thereof may not affect learning outcomes significantly (Means, Toyama, Murphy, Bakia, & Jones, 2009). For example, Schnitman (2007) attempted to determine whether enhancing text-based instruction with more visually stimulating material such as graphics and color would affect learning outcomes. He found no significant difference in learning outcomes between those receiving text-based instruction and those receiving text-based supported with visual instruction. Similar results were obtained by Maag (2004), Schroeder (2006), Schutt (2007), as well as by Zhang, Zhou, Briggs, and Nunamaker (2006). The majority of these studies concluded additional multimedia types are simply carriers of content and it is how they are used which is of significance (Means et al., 2009). For example, Zhang et al. (2006) found the effects of videos on learning depends on the individual's ability to control it and subsequently, interactive videos have shown to be more effective in learning settings than non-interactive videos. In the context of this study, replacing non-interactive videos and images with interactive control-friendly videos and animations, may have strengthened the visual material and improved learning outcomes.

Another possible explanation could be taken from Chandler and Sweller's (1991) cognitive load theory. The central assumption in this theory states only a limited amount of cognitive processing can take place in the verbal and visual channels at any one time. Cognitive overload occurs when the demands of a learning task exceed the processing capacity of the cognitive system (Mayer & Moreno, 2003). If an online interface (e.g., PowerPoint presentation) has too many features to be remembered, it can create a barrier to the learning process: the more items to learn, the harder the task may become (Schnitman, 2007). For example, in a series of studies conducted by Mayer, Heiser, and Lonn (2001), college students viewing an animation and listening to concurrent narration explaining the formation of lightning performed worse on retention tests when receiving concurrent on-screen text compared to subjects not receiving the text. The addition of on-screen text overloaded the visual system causing students to split their visual attention between both sources (Mayer et al., 2001). In the context of this study, subjects who received visual content were tasked with learning from slides presenting either both text and image or text and video. Therefore, it is possible subjects receiving visual content in this study may have suffered cognitive overload of the visual channel and thus retained less information. Following on this assumption, Mayer and Moreno (2003) have described a method of off-loading that may have prevented cognitive overload. It is suggested presenting text as a narration rather than on screen, may have diverted at least some of the learning information away from the eyes, which would already be tasked with taking in the visual information (Mayer & Moreno, 2003). This would thereby reduce the processing demands on the visual channel by diverting some information to the verbal channel. This method of off-loading the cognitive system was tested and supported by a series of studies conducted by Mayer and Moreno (1998). Students receiving animation and narration performed better on problem-solving tests compared those receiving animation and on-screen text. Similar results supporting the idea of off-loading were obtained by Mousavi, Low, and Sweller (1995).

Another explanation for the deviation in test scores between those receiving visual and verbal material may be explained by the form of material itself. Hooijdonk & Krahmer (2008) propose information modalities such as text, images, and videos bear different cognitive loading potentials which may influence learning. They suggest among the three modalities, plain text may impose the highest load on the cognitive system. In other words, it takes more mental effort to learn from text versus images or videos.

According to Glenberg's Indexical hypothesis (1999), reading text is a constantly active process initiating the formation of thoughts, thus activating mental structures in the brain in order to actively process what we read. In this context, one might assume watching a video or viewing an image is a more passive and less demanding process requiring less effort from the beholder. As it relates to this study, subjects receiving visual material were presented with slides consisting of two different information modalities. As a result, they may have preferred to ignore the text, and engage in videos and images only, thus adopting a more passive and easy to process approach to learning. Meanwhile, subjects receiving verbal material were presented with text-only content and may have had to apply a more focussed and active approach.

Limitations

One of the most significant limitations in this study was establishing the range and cut-off for neutral learners. Although the cut offs for visualizers and verbalizers had already been established and tested by Mayer and Massa (2003), the neutral range was a best guess approximation made by the principle investigator. This approximation implied, although an individual scoring a +5 and an individual scoring a −5 may be predisposed to opposite ends of the spectrum, they would still be classified in the same group. It's possible a sample group consisting of individuals scoring exclusively at the zero mark on the SBLSQ may have been a better representation of neutral learners. The absence of educational literature exploring research into the identification and classification of non-verbalizers and non-visualizers further compounds this issue. The assessment test used in this study presented another key limitation. The questions were self-created, not analyzed for bias or across various groups in the population, and finally were not measured for test-retest reliability. One could argue the level of retention between post-test two and post-test one would provide some justification for the existence of test-retest reliability. Additionally, the number of subjects in each group may have also played a part in the results among some of the variables tested. For example, it was revealed in the interaction between time and method of material delivery, data was not normally distributed at a Shapiro-Wilk p value of .05 at all three test points. With only a maximum of 10 subjects per group, it was difficult to access normality. Further analysis of quantile-quantile (q-q) plots and a Shapiro-Wilk p value of .01 were necessary to certify the data was normally distributed. This may or may not have been avoided with larger group sizes. Finally, gender differences were not taken into consideration in this study. Although there were both females and males, gender was not distributed equally across the four groups. Of the 40 subjects, 75% were female and only 25% were male. It should be noted, however, there is no current literature suggesting there are gender differences associated with cognitive styles.

Conclusion

The aim of this study was to explore the relationship between cognitive styles and method of material delivery while addressing the need for more accessible content on the psycho-social issues of spaceflight. The results of this study revealed the cognitive style of an individual did not have a significant main effect on learning outcomes. There was no significant main effect of matching an individual's cognitive style with a method of material delivery. This would not provide a credible justification for the customization of different on-line instruction methods for individuals with different cognitive styles. With that being said, this conclusion should acknowledge the study was slightly modified from the original proposal (based on a single lesson with multiple identical assessments and presented with several limitations). The failure to obtain evidence in favor of matching cognitive styles with a method of material delivery should not be interpreted in a way to suggest educational instruction should never accommodate individual cognitive differences. Rather, the results obtained from this study are simply questioning the effectiveness of modifying educational instruction methods to accommodate individual differences as it pertains to cognitive styles.

The improvement in test scores following the learning period would suggest both modules were effective in promoting learning in an academic field, lacking in educational materials, and it is believed they could be adopted in a variety of educational settings associated with learning about human spaceflight. A feedback survey administered following the completion of the study revealed subjects were satisfied with the material presented to them. Though they were initially unfamiliar with the content, they found it to be engaging and interesting. The majority of subjects also subscribed to the idea of enrolling in a hypothetical undergraduate course centered on the psycho-social issues of human spaceflight.

APPENDIX

Mayer and Massa's (2003) Santa Barbara Learning Style Questionnaire (SBLSQ)

Please place a check mark indicating your level of agreement or disagreement.

I prefer to learn visually

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

I prefer to learn verbally

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

I am a visual learner

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

I am a verbal learner

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

I am good at learning from labeled pictures, illustrations, graphs maps and animations

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

I am good at learning from printed text

3	2	1	0	-1	-2	-3
Strongly agree	*Moderately agree*	*Slightly agree*	*Neither agree or disagree*	*Slightly disagree*	*Moderately disagree*	*Strongly disagree*

Psycho-Social Issues of Spaceflight Test

SECTION ONE MULTIPLE CHOICE (1 mark per correct answer)

PLEASE SELECT ONE ANSWER ONLY

1) Which of the following is not a condition in spaceflight?

A) Changing perceptual field

B) Limited habitability

C) Weightlessness

D) Limited supplies

E) All are conditions in spaceflight

2) Which of the following is an accurate statement regarding isolation for a future Mars mission?

A) Crewmembers will begin to experience the most amount of discomfort and stress from isolation at the point of having completed 75% of the mission

B) The mission could expect up to 20 minutes in communication delays with Earth

C) Crews will have to become increasingly independent over time, which may serve to combat the sense of isolation

D) Crewmembers will begin to experience the most amount of discomfort and stress from isolation at the point of having completed 25% of the mission

3) Which of the following is not an accurate reflection of confinement in spaceflight?

A) Defined as a restriction within a highly limited and sharply demarcated physical and social environment

B) Cramped conditions may amplify sensory deprivation

C) Confinement in a spacecraft may actually serve as a countermeasure for improving levels of privacy under otherwise cramped conditions

D) Prolonged group confinement may lead to status leveling conditions

4) Which of the following scenarios poses the least threat to crew cohesion on a Mars mission?

A) A crew of three men and two women under a flat hierarchical management structure whose commander possesses a flexible leadership style

B) All male crew under a rigid military/maritime management structure whose commander possesses a flexible leadership style

C) All male crew under a flat military/maritime management structure whose commander possesses a fixed and rigid leadership style

D) All scenarios pose equal threat to crew cohesion

5) The amount and quality of sleep experienced on the ISS is affected by all of the following parameters except:

A) Musculoskeletal deconditioning

B) Weightlessness

C) Variable light/dark cycles

D) Poor illumination during daytime hours

6) According to Palinkas (2001) individuals characterized as having the “right stuff” exhibit:

A) High levels of extrovertism and low levels of introvertism

B) Positive expressivity

C) High levels of positive instrumentality

D) B and C only

E) All of the above

7) Group/organizational structure:

A) Is necessary for the maintenance of social order

B) Remains relatively consistent through prolonged conditions of isolation and confinement

C) Has little effect on crew cohesion

D) All of the above statements are true

8) Leadership in long-duration spaceflight:

A) Is important in regards to total group unity

B) Is situational and can change throughout a mission

C) Can be determined by studying isolated crews stationed in Antarctica

D) All of the above

9) Which of the following is incorrect regarding mixed gender crews?

A) Mixed gender crews have flown in space for over two decades with woman performing on par with males

B) Proponents suggest each gender may provide separate attributes and qualities to the overall welfare of the crew

C) The incorporation of females in a crew may improve the overall welfare of the crew on an interpersonal level

D) All of the above statements are true

10) Which of the following statements is true?

A) A military/maritime structure would be most ideal for a crew of a future long-duration mission

B) An ideal commander will possess a consistent and rigid level of leadership throughout a mission

C) Introverted individuals are actually the most ideal candidates for long-duration missions

D) None of the above statements are true

11) Which of the following statements is true?

A) Sensory monotony leads to hallucinations

B) Confinement leads to sensory monotony

C) Confinement leads to increased privacy

D) A and B

E) All above statements are true

SECTION 2 TRUE OR FALSE (1 mark per correct answer)

12) Third quarter phenomenon seems to occur just past the halfway mark of a mission
T F

13) Mission specialists seek individuals who are either primarily introverted or exceedingly extroverted during the astronaut/crew selection process T F

14) Experiencing prolonged conditions of isolation and confinement may actually serve to strengthen the cohesion of a crew T F

15) Research on mixed gender crews suggest women may be more sensitive to interpersonal issues T F

SECTION 3 SHORT ANSWER

16) List two aspects of a future Mars mission that will compound the sense of isolation (2 marks)

17) Name two implications of prolonged confinement in spaceflight (2 marks)

18) What is a spaceflight analog? List two examples (3 marks)

19) Why are spaceflight analogs studied? (1 mark)

20) Many astronauts of past short-duration missions have commented on the existential and surreal phenomenon of viewing Earth from space. Members of future long-duration missions to distant planets may not be able to share this same experience. List two implications this may have for crewmembers of future long-duration missions (2 marks)

21) List at least four aspects of Antarctica winter-over missions that parallel long-duration spaceflight (2 marks)

22) Designers of a futuristic spacecraft are concerned about the quality of sleep of crewmembers. List two design considerations that may be applicable to help prevent sleep disturbances (2 marks)

23) List two factors affecting the group/organizational structure of a spaceflight crew (2 marks)

24) What kinds of leadership should a commander of a future mars mission possess? (2 marks)

25) Name two consequences of using sleeping pills to promote better sleep in space (2 marks)

/35

Post-Study Feedback Survey

1) How would you rate the effectiveness of the learning material (either visual or verbal)

Answer Choices–	Responses–
– Very effective	**51.52%** 17
– Moderately effective	**45.45%** 15
– Slightly effective	**3.03%** 1
– Not at all effective	**0.00%** 0
Total	**33**

2) Do you feel the learning material adequately covered all aspects of the assessment test?

Answer Choices–	Responses–
– Very much so	**90.91%** 30
– Somewhat	**9.09%** 3
– Did not	**0.00%** 0
Total	**33**

3) How would you rate the effectiveness of the assessment tests?

Answer Choices–	Responses–
– Very effective	**42.42%** 14
– Moderately effective	**54.55%** 18
– Slightly effective	**3.03%** 1
– Not at all effective	**0.00%** 0
Total	**33**

4) How would you rate the difficulty of the assessment tests?

Answer Choices–	Responses–
– Very difficult	**12.12%** 4
– Moderately difficult	**45.45%** 15
– Slightly difficult	**33.33%** 11
– Not at all difficult	**9.09%** 3
Total	33

REFERENCES

Allen, I. E., & Seaman, J. (2007). *Online nation: Five years of growth in online Learning*. Sloan Consortium. Retrieved from http://files.eric.ed.gov/fulltext/ED529699.pdf

Allen, I. E., & Seaman, J. (2010). *Class differences: Online education in the United States.* Sloan Consortium. Retrieved from http://files.eric.ed.gov/fulltext/ED529952.pdf

Allen, I. E., & Seaman, J. (2011). *Going the distance: Online education in the United States*. Sloan Consortium. Retrieved from http://files.eric.ed.gov/fulltext/ED529948.pdf

Allen, I. E. & Seaman, J. (2013). *Changing course: Ten years of tracking online education in the United States.* Sloan Consortium. Retrieved from http://files.eric.ed.gov/fulltext/ED541571.pdf

Antonietti, A., & Giorgetti, M. (1998). The Verbalizer-Visualizer Questionnaire: A review. *Perceptual and Motor Skills*, *86*(1), 227–239. https://doi.org/10.2466/pms.1998.86.1.227

Bachman, K. R. Ob., Otto, C., & Leveton, L. (2012). *Countermeasures to mitigate the negative impact of sensory deprivation and social isolation in long-duration space flight*. Retrieved from https://ntrs.nasa.gov/search.jsp?R=20120002722

Barger, L. K., Flynn-Evans, E. E., Kubey, A., Walsh, L., Ronda, J. M., Wang, W., … Czeisler, C. A. (2014). Prevalence of sleep deficiency and hypnotic use among astronauts before, during and after spaceflight: An observational study. *The Lancet Neurology*, *13*(9), 904–912. https://doi.org/10.1016/S1474-4422(14)70122-X

Basner, M., Dinges, D. F., Mollicone, D. J., Savelev, I., Ecker, A. J., Antonio, A. D., … Sutton, J. P. (2014). Psychological and behavioral changes during confinement in a 520-day simulated interplanetary mission to Mars. *PLOS ONE*, *9*(3), e93298. https://doi.org/10.1371/journal.pone.0093298

Bechtel, R. B., & Berning, A. (1991). *The third-quarter phenomenon: Do people experience discomfort after stress has passed?* Retrieved from: https://www.researchgate.net/publication/289822190_The_Third-Quarter_Phenomenon_Do_People_Experience_Discomfort_After_Stress_Has_Passed

Boswell, D. L., & Pickett, J. A. (1991). A study of the internal consistency and factor structure of the Verbalizer-Visualizer Questionnaire. *Journal of Mental Imagery*, *15*(3–4), 33–36.

Burrough, B. (1998). *Dragonfly: NASA and the crisis aboard Mir* (1st edition). New York, NY: HarperCollins.

Casey, M. B., Winner, E., Hurwitz, I., & DaSilva, D. (1991). Does processing style affect recall of the Rey-Osterrieth or Taylor complex figures? *Journal of Clinical and Experimental Neuropsychology*, *13*(4), 600–606. https://doi.org/10.1080/01688639108401074

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *ResearchGate*, *8*(4). https://doi.org/10.1207/s1532690xci0804_2

Chauhan, A. (2014). Massive Open Online Courses (MOOCS): Emerging trends in assessment and accreditation. *ResearchGate*, *25*(1), 7–18.

Connors, M. M., Harrison, A. A., & Akins, F. R. (1985). *Living aloft: Human requirements for extended spaceflight*. Retrieved from https://ntrs.nasa.gov/search.jsp?R=19850024459

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., … Pack, A. I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep*, *20*(4), 267–277.

Edwards, J. E., & Wilkins, W. (1981). Verbalizer-Visualizer Questionnaire: Relationship with imagery and verbal–visual ability. *Journal of Mental Imagery*, *5*(2), 137–142.

Evans, B. (2012). *Tragedy and triumph in orbit: The eighties and early nineties*. New York: Chichester, UK: Springer; Published in association with Praxis Pub.

Finkle, T. A., & Masters, E. (2014). Do MOOCs pose a threat to higher education? *Research in Higher Education Journal*, *26*. Retrieved from http://files.eric.ed.gov/fulltext/EJ1055324.pdf

Gangwer, T. (2009). *Visual impact, visual teaching: Using images to strengthen learning* (Second edition). Thousand Oaks, CA: Corwin Press.

Glenberg, A. M., & Robertson, D. A. (1999). Indexical understanding of instructions. *Discourse Processes*, *28*(1), 1–26. https://doi.org/10.1080/01638539909545067

Harrison, A. A. (2001). *Spacefaring: The human dimension*. Berkeley: University of California Press.

Harvey, B. (1996). *The new Russian space programme: From competition to collaboration*. Chichester; New York: Wiley.

Hayes, J., & Allinson, C. W. (1996). The Implications of learning styles for training and development: A discussion of the matching hypothesis. *ResearchGate*, *7*(1), 63–72. https://doi.org/10.1111/j.1467-8551.1996.tb00106.x

Hooijdonk, C. van, & Krahmer, E. (2008). Information modalities for procedural instructions: The influence of text, pictures, and film clips on learning and executing RSI exercises. *IEEE Transactions on Professional Communication*, *51*(1), 50–62. https://doi.org/10.1109/TPC.2007.2000054

Jonassen, D. H., & Grabowski, B. L. (1993). *Handbook of individual differences, learning, and instruction*. Hillsdale, N.J: Routledge.

Kanas, N., & Manzey, D. (2008). *Space psychology and psychiatry* (2nd edition). El Segundo, Cal: Dordrecht: Springer.

Kirby, J. R., Moore, P. J., & Schofield, N. J. (1988). Verbal and visual learning styles. *ResearchGate*, *13*(2), 169–184. https://doi.org/10.1016/0361-476X(88)90017-3

Klein, P. D. (2003). Rethinking the multiplicity of cognitive resources and curricular representations: Alternatives to “learning styles” and “multiple intelligences.” *ResearchGate*, *35*(1), 45–81. https://doi.org/10.1080/00220270210141891

Kollöffel, B. (2012). Exploring the relation between visualizer–verbalizer cognitive styles and performance with visual or verbal learning material. *Computers & Education*, *58*(2), 697–706. https://doi.org/10.1016/j.compedu.2011.09.016

Kubzansky, P. E. (1961). The effects of reduced environmental stimulation on human behavior: A review. In A.D. Biderman & H. Zimmer (Eds.), *The Manipulation of Human Behavior,* 51-95. Retrieved from http://www.frozenmeursault.com/wp-content/uploads/2015/03/Manipulation-of-Human-Behavior-1961.pdf#page=65

Lebedev, V. (1988). *Diary of a cosmonaut: 211 days in space* (1st edition). College Station, Tex: Phytoresource Research.

Leutner, D., & Plass, J. L. (1998). Measuring learning styles with questionnaires versus direct observation of preferential choice behavior in authentic learning situations: The Visualizer/verbalizer behavior observation scale (VV-BOS). *Computers in Human Behavior*, *14*(4), 543–57.

Lewalter, D. (2003). Cognitive strategies for learning from static and dynamic visuals. *Learning and Instruction*, *13*(2), 177–189. https://doi.org/10.1016/S0959-4752(02)00019-1

Maag, M. (2004). The effectiveness of an interactive multimedia learning tool on nursing students' math knowledge and self-efficacy. *Computers, Informatics, Nursing: CIN*, *22*(1), 26–33.

Macduff, I. (2012). Using blogs in teaching negotiation: A technical and intercultural postscript. *Negotiation Journal*, *28*(2), 201–215. https://doi.org/10.1111/j.1571-9979.2012.00335.x

Massa, L. J., & Mayer, R. E. (2006). Testing the ATI hypothesis: Should multimedia instruction accommodate verbalizer-visualizer cognitive style? *Learning and Individual Differences*, *16*(4), 321–335. https://doi.org/10.1016/j.lindif.2006.10.001

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

.

Mayer, R. E., & Massa, L. J. (2003). Three facets of visual and verbal learners: Cognitive ability, cognitive style, and learning preference. *Journal of Educational Psychology, 95*(4), 833–846. https://doi.org/10.1037/0022-0663.95.4.833

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *ResearchGate*, *90*(2), 312–320. https://doi.org/10.1037/0022-0663.90.2.312

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

McCormack, C., & Jones, D. (1998). *Building a Web-based education system*. New York: Wiley.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies*. US Department of Education. Retrieved from http://files.eric.ed.gov/fulltext/ED505824.pdf

Mendelson, A. L., & Thorson, E. (2004). How verbalizers and visualizers process the newspaper environment. *Journal of Communication*, *54*(3), 474–491. https://doi.org/10.1111/j.1460-2466.2004.tb02640.x

Merabet, L. B., Maguire, D., Warde, A., Alterescu, K., Stickgold, R., & Pascual-Leone, A. (2004). Visual hallucinations during prolonged blindfolding in sighted subjects. *ResearchGate, 24*(2), 109–13. https://doi.org/10.1097/00041327-200406000-00003

Messick, S. (1984). The nature of cognitive styles: Problems and promise in educational practice. *ResearchGate*, *19*(2), 59–74. https://doi.org/10.1080/00461528409529283

Mitchell, L. D., Parlamis, J. D., & Claiborne, S. A. (2015). Overcoming faculty avoidance of online education from resistance to support to active participation. *Journal of Management Education*, *39*(3), 350–371. https://doi.org/10.1177/1052562914547964

Mousavi, S. Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology*, *87*(2), 319–334. https://doi.org/10.1037/0022-0663.87.2.319

Paivio, A. (1971). Imagery and deep structure in the recall of English nominalizations. *Journal of Verbal Learning and Verbal Behavior*, *10*(1), 1–12. https://doi.org/10.1016/S0022-5371 (71)80086-5

Palinkas, L. (2001). Psychosocial issues in long-term space flight: Overview. *Gravitational and Space Biology Bulletin: Publication of the American Society for Gravitational and Space Biology*, *14*(2), 25-33. Retrieved from http://gravitationalandspacebiology.org/index.php/journal/article/view/264

Peterson, E. R., Deary, I. J., & Austin, E. J. (2003). The reliability of Riding's cognitive style analysis test. *ResearchGate*, *34*(5), 881–891. https://doi.org/10.1016/S0191-8869(02)00116-2

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology*, *90*(1), 25–36. https://doi.org/10.1037/0022-0663.90.1.25

Rasmussen, J. E. (Ed.). (2007). *Man in isolation and confinement*. New Brunswick, N.J: Aldine Transaction.

Richardson, A. (1977). Verbalizer-visualizer: A cognitive style dimension. *Journal of Mental Imagery*, *1*(1), 109–125.

Riding, R. J., Burton, D., Rees, G., & Sharratt, M. (1995). Cognitive style and personality in 12-year-old children. *British Journal of Educational Psychology*, *65*(1), 113–124. https://doi.org/10.1111/j.2044-8279.1995.tb01135.x

Riding, R. J., & Pearson, F. (1994). The relationship between cognitive style and intelligence. *Educational Psychology*, *14*(4), 413–425. https://doi.org/10.1080/0144341940140404

Riding, R. J., & Staley, A. (1998). Self-perception as learner, cognitive style and business studies students' course performance. *Assessment & Evaluation in Higher Education*, *23*(1), 43–58. https://doi.org/10.1080/0260293980230104

Riding, R. J., & Watts, M. (1997). The effect of cognitive style on the preferred format of instructional material. *Educational Psychology*, *17*(1–2), 179–183. https://doi.org/10.1080/0144341970170113

Russell, L. (2005). *Training triage: Performance-based solutions amid chaos, confusion, and change*. Alexandria, VA: Association for Talent Development

Santy, P. A. (1994). *Choosing the right stuff: The Psychological selection of astronauts and cosmonauts*. Westport, Conn: Praeger.

Schmidt, L., Keaton, K., Slack, K., Leveton, L., and Shea, C. (2008). Risk of performance errors due to poor team cohesion and performance, inadequate selection/team composition, inadequate training, and poor psychosocial adaptation. In McPhee, J. C., and Charles, J. B. (Eds.) *Human health and performance risks for space exploration missions* (45-84).

Schnitman, I. (2007). *The dynamics involved in web-based learning environment (Wle) interface design and human-computer interactions (Hci): Connections with learning performance*. West Virginia University, Morgantown, WV, USA

Schroeder, B. (2006). Multimedia-enhanced instruction in online learning environments. *Boise State University Theses and Dissertations*. Retrieved from http://scholarworks.boisestate.edu/td/386

Schutt, M. (2007). *The effects of instructor immediacy in online learning environments*. University of San Diego and San Diego State University.

Seedhouse, E. (2009). *Lunar outpost: The challenges of establishing a human settlements on the moon*. Berlin; New York: Chichester, UK: Springer; PraxisPub.

Simon, M., Whitmire, A., Otto, C., & Neubek, D. (2011). *Factors impacting habitable volume requirements: Results from the 2011 habitable volume workshop*. Retrieved from https://ntrs.nasa.gov/search.jsp?R=20110023287

Smith-Jentsch, K. A., Sierra, M. J., Weaver, S. J., Bedwell, W. L., Dietz, A. S., Carter-Berenson, D., …Salas, E. (2015). Training "The Right Stuff": An assessment of the team training needs for long-duration spaceflight crews -NASA/TM-2015-218589. Retrieved from https://ston.jsc.nasa.gov/collections/TRS/_techrep/TM-2015-218589.pdf

Stuster, J. (1996). *Bold endeavors: Lessons from polar and space exploration*. Annapolis, Md: Naval Institute Press.

Suedfeld, P., & Steel, G. D. (2000). The environmental psychology of capsule habitats. *Annual Review of Psychology*, *51*, 227–253. https://doi.org/10.1146/annurev.psych.51.1.227

Vakoch, D. A., & United States (Eds.). (2011). *Psychology of space exploration: Contemporary research in historical perspective*. Washington, DC: National Aeronautics and Space Administration, Office of Communications, History Program Office.

Wang, W. (2007). *Learning experiences in terms of verbalizer-visualizer cognitive style: Interviewing verbal and visual learners* (M.A.). State University of New York at Buffalo, United States -- New York. Retrieved from http://gradworks.umi.com/14/46/1446246.html

Woolner, P. (2006). Teaching and learning mathematics visually or verbally: A comparison of two teaching approaches and investigation of interactions with pupil cognitive style. *Journal of Cognitive Education and Psychology*, *5*(3), 288–309. https://doi.org/10.1891/194589506787382459

Zenhausern, R. (1978). Imagery, cerebral dominance, and style of thinking: A unified field model. *Bulletin of the Psychonomic Society*, *12*(5), 381–384. https://doi.org/10.3758/BF03329714

Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker Jr., J. F. (2006). Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. *Information & Management*, *43*(1), 15–27. https://doi.org/10.1016/j.im.2005.01.004

Zhenghao, C., Alcorn, B., Christensen, G., Eriksson, N., Koller, D., & Emanuel, E. J. (2015). *Who's benefiting from MOOCs, and why*, Harvard Business Review. Retrieved from https://hbr.org/2015/09/whos-benefiting-from-moocs-and-why

Zhu, A. (2012). Massive open online courses—A threat or opportunity to universities? Retrieved from http://www.forbes.com/sites/sap/2012/09/06/massive-open-online-course-a-threat-or-opportunity-to-universities/#6d86383137d2