

Virtual reality instruction in automotive technology education at Renton Technical College

by

Douglas Hugh Redman

A.A., Fullerton College, 1994

B.A., California State University Fullerton, 1998

M.S., California State University Fullerton, 2006

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Department of Educational Leadership
College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

The purpose of this mixed methods study is to determine if virtual reality (VR) instruction may support learning in community college automotive technical education by measuring learners' levels of presence and faculty perceptions of learning when using VR instruction. Presence is "the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)" (Knerr et al., 1998, p. 32). If learner levels of presence are high and faculty perceive learning is occurring, it may indicate VR offers educators a valuable tool that can be used to move learners toward success. Two research questions guided this study. The first was: What are the learners' levels of presence when using VR in automotive technology instruction? To address this question, learners in an automotive technology program at Renton Technical College taking courses incorporating VR instruction were administered the Witmer et al. (2005) Presence Questionnaire. The second research question was: What are faculty perceptions of learning when using VR in automotive technology instruction? To address this question, faculty were interviewed to capture their perceptions of the learning occurring during VR instruction.

This study employed a mixed methods approach. The quantitative portion of this study was non-experimental and descriptive, in which learners enrolled in a community college automotive technology course utilizing VR instruction were surveyed. Additionally, the qualitative portion of the study was comprised of interviews with faculty teaching courses using VR to assess their perceptions of the learning occurring during instruction. Finally, the mixed methods analysis employed a convergent parallel design (Creswell & Plano Clark, 2010). The quantitative and qualitative results were provided in a joint display comparison noting the convergent and divergent findings.

Keywords: Adaptation/immersion, andragogy, automotive technology, career and technical education, community college, interface quality, involvement, learning, presence, sensory fidelity, virtual reality.

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Approved by:

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Dedication

This dissertation study is dedicated to my wife and children. My wife, Lynn, is an exemplary mother of our children and has supported my endeavors putting up with my many flaws along our life journey. And my favorite children, Gregory and Allyson, who are a continuous inspiration.

Chapter 1 - Introduction

Virtual reality (VR) is a technology being used more often each day in business and education. VR is not new. One of its early manifestations was in the 1930s with the introduction of the *View-Master* (Stone, 2017), a device allowing children of all ages to enter the world of dinosaurs, the grandeur of the National Parks, or to learn about vintage automobiles. In the 1950s, Morton Heilig started his work on the *Sensorama* (Boas, 2012), a mechanical device that included a stereoscopic color display, odor emitters, a motion chair, a stereo-sound system, and fans. The idea was to provide an *experience theater* where one could experience the noise, smell, sight, and wind of a bus going by as well as many other elements of what one senses in daily life. Today, the latest evolution of VR includes the *Oculus Quest* and *Rift* series headsets. These offer the user an immersive environment with high fidelity. The video gaming industry is successfully leveraging the latest technology and spends millions of dollars each year to develop games set in virtual environments. In 2020 alone, the Call of Duty franchise had sales of over three billion dollars (Bankhurst, 2020).

VR is a computer simulated environment where the user experiences, controls, and interacts with the environment. VR technology is being used more often in education, not for entertainment but for instruction and to facilitate learning (Babich, 2019). Yet, the question remains whether VR instruction facilitates learning. To help answer this question, this study explored the use of VR in community college automotive instruction from the learner and faculty perspectives. More specifically, this study measured learners' level of presence. Presence is a relatively new construct, defined as "the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)" (Knerr et al., 1998, p. 32). The importance of measuring

presence is because studies showed a relationship between presence, task performance, and learning (Witmer & Singer, 1994). This study measured learners' level of presence by employing a presence questionnaire (Appendix E).

In addition to examining learner level of presence, this study also examined the perceptions of faculty related to learning that occurs when using VR instruction. To understand their perceptions of learning, faculty interviews were conducted. If the learners' level of presence is high and faculty perceive learning is taking place, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

Statement of the Problem

A significant gap exists between the skills required by technical careers and the skills possessed by those entering this workforce. Approximately 40% of employers in the United States struggle to find qualified people to hire, even for entry-level positions (Laboissiere, 2017). One point of focus for community colleges is to provide the necessary training to equip students with the comprehensive skill sets needed to succeed in today's job market (California Community Colleges, n.d.). Those who attend community college as a pathway to a fulfilling career must learn the requisite knowledge and skills to succeed. The problem this study addressed was in the domain of learning and VR technology in automotive instruction. The study explored whether VR instruction had a positive effect on learning in a community college automotive technology course. Little research exists on VR instruction, presence, and the learning that takes place in community colleges in general, with no studies in the discipline of automotive technology.

The use of VR in education is not a new concept. One example is the use of VR flight simulators. Flight simulators are used for training pilots and for entertainment. They are VR

environments where the user can interact, manipulate, and experience a level of presence through the physical controls that interface with a computer-generated environment. The first digital flight simulators were developed in the 1960s (Page, 2004). Technology has greatly improved since the 1960s and so have the levels of fidelity, involvement, and immersion. Once VR was primarily a tool of the gaming industry, but now it is being used more often for instruction by the military, industry, and higher education. The current generation of learners, Generation Z, is familiar with highly interactive, immersive VR in gaming with the growth of the Oculus headsets, Google Glass, and cell phone technology, but it is unknown if VR instruction facilitates learning or if there is a connection between instruction in a virtual environment and performance. More research is needed to know if incorporating VR instruction benefits the learner.

This study focused on learners' levels of presence, interaction, immersion, and focus when using the technology-mediated modality of VR instruction. To experience presence, a learner must have some levels of involvement, immersion, attention shift from the real to the virtual, and focus. A valid and reliable instrument to measure the level of the factors comprising presence is Witmer and Singer's Presence Questionnaire (PQ). This 29-item instrument was originally developed by Witmer and Singer in 1994 and was revised in 1998 and again by Witmer et al. in 2005, referred to as PQ 3.0 (Appendix E). PQ 3.0 measures four factors: involvement, sensory fidelity, adaptation/immersion, and interface quality.

A high level of presence has a positive relationship to performance. Witmer and Singer (1994) found, "Approximately 89% of the correlations between presence and task performance for these data were in the predicted direction." Task performance is an important aspect of learning, especially in automotive technology. By measuring the learners' presence through the PQ 3.0 and understanding the learning taking place from the faculty interviews, this study

addressed the problem of whether VR instruction contributed to learning in community college automotive technology instruction.

Background of the Problem

Community colleges have many expectations placed on them, including imparting knowledge, developing skills, stimulating creativity, and developing critical thinking in the learner. To meet these expectations, community colleges should understand the learner and employ the latest technology to enhance learning. Community colleges offer several pathways for learners, such as gaining knowledge and skills, earning a certificate, obtaining an associate degree, or earning a transfer degree. One of the key objectives of career and technical curricula is to provide learners with requisite skills for employment in their chosen field. This is important because industry is looking to hire those with the skills for the job. To continue to offer a high level of instruction, it would benefit community colleges to continue to evolve as technology and learners change.

Technology has advanced. On the cutting edge of technology, the world has artificial intelligence (AI), quantum computers, and neural interfaces between machines and the human brain. Technology revolutionized many areas of life such as self-driving cars, military jets controlled by AI that can outperform a human pilot, cell phones a million times more powerful than the Apollo 11 guidance computers, and computer games that mirror reality (Puiu, 2020; Tucker, 2020).

This research focused on VR technology. VR has been used in education for years, but the levels of interaction, immersion, and fidelity have grown in the past few years (Carruth, 2017). VR is more interactive, immersive, and has better fidelity with the delivery medium as computers and internet connectivity speeds have improved. In addition, the cost efficiency of

development and deployment has improved, making it available to more individuals and institutions (Carruth, 2017). Yet, it is unknown if VR is a viable and effective method of instruction.

The learner has changed. What engaged the Baby Boomers (born between 1946-1964), Generation X (born between 1965-1980), and Millennials (born between 1981-1996) may not be what engages the Generation Z learner (born after 1996). Generation Z comprises the majority of today's community college learners (Parker & Igielnik, 2020). This generation, as with each generation, is different than the previous. Pearson (2018) conducted a survey of 2,588 people in the United States aged 14-40 comparing Generation Z with Millennials. Pearson discovered Generation Z is less likely to see technology as transformational to education but as part of their daily life. Although members of Generation Z are digital natives, meaning they are familiar with computers, the internet, and other digital technology from a young age, they still see teachers as important to learning. According to Pearson (2018), 32% of Generation Z preferred online courses with video lecture as compared to 44% of Millennials. The importance of YouTube as a learning method was preferred by 59% of Generation Z. Textbooks were preferred by less than half of Generation Z, 46%. Generation Z is sometimes referred to as the app generation; 47% of them like interactive apps and learning through games. Fong et al. (2019) summed up learning for Generation Z by saying, "Passive learning is out, engagement is in" (p. 120). More specifically, standard curriculum for everyone with limited access to teaching materials and resources was out whereas blending in videos, online media, discussions and activities, individualized curriculum, and unlimited access to teaching materials and resources was in. Generation Z learners work well independently and with cohorts. Generation Z has grown up

with YouTube, mobile phone apps, video games that mirror reality, Google, Wikipedia, and Facebook. Higher education needs to be ready for the Generation Z learner.

Purpose of the Study

The purpose of this mixed methods study was to determine if VR instruction may support learning by measuring learners' levels of presence and faculty perceptions of learning when using VR instruction in community college automotive technology education. If learner levels of presence are high and faculty perceive learning is occurring, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

To successfully complete an automotive course, each learner must have a cognitive understanding of the material and be able to perform the required psychomotor tasks. VR instruction offers a bridge where learners can take their cognitive knowledge and develop their psychomotor skills in a safe and forgiving environment without the need for actual physical equipment such as tools and vehicles. VR instruction offers an environment where mistakes, which are part of the learning process, neither harm the learner nor are costly to the college because of damage to expensive vehicles and equipment.

Primary Research Questions

This study was guided by two research questions:

Research Question One: What are the learners' levels of presence when using VR in automotive technology instruction?

Research Question Two: What are faculty perceptions of learning when using VR in automotive technology instruction?

Research question one focuses on the learners. Using the Witmer and Singer PQ 3.0, the learners were surveyed to determine their levels of presence when using VR during automotive

instruction. Research question one determines if learners using VR feel like they are working on the automobile as measured with the PQ 3.0. It is an important question because Witmer and Singer (1994) found some studies showed a relationship between presence and task performance whereas others did not.

Research question two focuses on the faculty perceptions of learning through VR instruction. If faculty believe VR instruction results in learning, this may indicate VR instruction can effectively be incorporated into automotive technology curriculum to teach necessary skills.

Using the existing PQ 3.0 instrument provided the learners' levels of presence. Interviewing faculty provided an understanding, from the faculty perspective, of the learning occurring with VR instruction. High levels of presence among learners and positive faculty about learning may indicate VR can effectively be used in automotive technology community college classrooms as a method of instruction.

Theoretical Framework

The theoretical framework for this study is andragogy – the art and science of helping adults learn. Andragogy was chosen as the framework for this study because the population of learners in this study were adults. The term andragogy was first used by German educator Alexander Kapp in 1883, then introduced in the United States by educator Eduard C. Lindeman in his book *The Meaning of Adult Education*, which was first published in 1926. The framework of andragogy was popularized in the United States by Malcolm S. Knowles (1913-1997). Knowles did extensive work developing andragogy into a theoretical framework in the 1960s and continued building on the framework throughout his life. This framework was introduced in his book, *The Modern Practice of Adult Education: Andragogy versus Pedagogy* (Knowles, 1970).

The andragogy framework is based on several assumptions and principles about adult learners. The three foundational principles of adult learning are that adults can learn, learning is an internal process, and there are superior conditions of learning and principles of teaching referred to as process elements (Knowles, 1980). Knowles proposed five assumptions of adult learners. The first was self-concept, meaning adults have a need to be self-directed. Adults should be involved in and take responsibility for their learning by setting their learning climate, diagnosing their needs, being involved in the planning process, and conducting the learning. The second is learner experience, in which adult learners have a reservoir of prior experiences from which to draw upon as a source of learning. Adult learners have a vast array of experiences brought with them when learning. They can draw from good and bad experiences of their past and apply them to the learning of today. The third assumption is readiness to learn, meaning adults want to and are ready to learn based on requirements of their social roles within society. The fourth is orientation to learning, meaning adult learners are performance-centered and education develops competencies in areas of relevant application. The fifth assumption is motivation to learn, meaning adults are internally motivated to improve themselves. Figure 1.1 presents a comparison of the assumptions of andragogy versus pedagogy developed by Knowles in 1980.

Figure 1.1. Comparison of Andragogy to Pedagogy

ASSUMPTIONS			PROCESS ELEMENTS		
About:	Pedagogical	Andragogical	Elements	Pedagogical	Andragogical
Concept of the learner	Dependent personality	Increasingly self-directing	Climate	Tense, low trust Formal, cold, aloof Authority-oriented Competitive, judgmental	Relaxed, trusting Mutually respectful Informal, warm Collaborative, supportive
Role of learner's experience	To be built on more than used as a resource	A rich resource for learning by self and others			
Readiness to learn	Uniform by age-level & curriculum	Develops from life tasks & problems	Planning	Primarily by teacher	Mutually by learners and facilitator
Orientation to learning	Subject-centered	Task- or problem-centered	Diagnosis of needs	Primarily by teacher	By mutual assessment
Motivation	By external rewards and punishments	By internal incentives, curiosity	Setting of objectives	Primarily by teacher	By mutual negotiation
The body of theory and practice on which teacher-directed learning is based is often given the label “pedagogy,” from the Greek words <i>paid</i> (meaning child) and <i>agogus</i> (meaning guide or leader)—thus being defined as the art and science of teaching children. The body of theory and practice on which self-directed learning is based is coming to be labeled “andragogy,” from the Greek word <i>aner</i> (meaning adult)—thus being defined as the art and science of helping adults (or, even better, maturing human beings) learn.			Designing learning plans	Teachers’ content plans Course syllabus Logical sequence	Learning contracts Learning projects Sequenced by readiness
			Learning activities	Transmittal techniques Assigned readings	Inquiry projects Independent study Experiential techniques
			Evaluation	By teacher Norm-referenced (on a curve) With grades	By learner-collected evidence validated by peers, facilitators, experts Criterion-referenced

Note. Source: Knowles (1980, Exhibit K-14).

Andragogy and pedagogy are often seen as opposites, with andragogy for adults and pedagogy for children. As Knowles refined his theory, he saw pedagogy and andragogy a bit differently, as two ends of a spectrum. Knowles (1980) explained,

These two models do not represent bad/good or child/adult dichotomies, but rather a continuum of assumptions to be checked out in terms of their rightness for particular learners in particular situations. If a pedagogical assumption is realistic for a particular situation, then pedagogical strategies are appropriate. For example, if a learner is entering into a totally strange content area, he or she will be dependent on a teacher until enough content has been acquired to enable self-directed inquiry to begin. (p. 391)

Viewing andragogy and pedagogy as two ends of a spectrum recognizes that in some cases, depending on the individual and learning need, andragogy can be applied to the child and pedagogy to the adult (Knowles, 1980). But these cases are not typical nor the norm. Instruction in community colleges lends itself primarily to the andragogy end of the spectrum because the learners are adults.

Methodology

This study employed a mixed methods approach. Creswell and Plano Clark (2010) defined mixed methods as an approach that collects, analyzes, and integrates both quantitative and qualitative data. Quantitative data focused on numbers and analysis via statistical procedures. In contrast, qualitative data are more narrative in nature and focus on people's perceptions. The quantitative portion of this study was non-experimental and descriptive, in which learners enrolled in a community college automotive technology course utilizing VR instruction were surveyed. The qualitative portion of the study was comprised of interviews with faculty teaching courses using VR to assess their perceptions of learning occurring during instruction. Additionally, the mixed methods analysis employed a convergent parallel design (Creswell & Plano Clark, 2010). The quantitative and qualitative results were provided in a joint display comparison noting the convergent and divergent findings.

The study employed a quantitative approach to explore learners' presence during VR instruction through a survey, the PQ 3.0 developed by Witmer et al. (2005). The PQ 3.0 is comprised of 29 questions and was designed to measure learner levels of presence in a VR setting (see Appendix E). The questions drill into four groups (i.e., factors) contributing to presence, involvement, sensory fidelity, adaptation/immersion, and interface quality. Involvement is the ability of the user to control VR events and how VR responds to user actions. Sensory fidelity is the quality of the sensory interactions and appearance within the VR environment. Adaptation/immersion is related to the proficiency of the VR interaction and how quickly a user can adjust to the environment. Interface quality is whether the control devices and display contribute to or distract from the ability to concentrate and perform a given task in the VR environment. Witmer and Singer (1998) performed reliability and validity analyses. Their

findings supported the questionnaire's reliability and validity. The questionnaire was given to the learners using both SurveyMonkey and paper copies to measure total presence, presence level for each item, and level of presence for each factor during VR instruction for automotive technology. The requirements for participants being surveyed were:

- Must be currently enrolled at Renton Technical College (RTC)
- Must be currently taking, or took during the previous quarter, a credit-bearing automotive technology course
- The course incorporated VR instruction
- Voluntarily willing to complete the survey

The qualitative methodology explored the perceptions of faculty regarding the learning occurring from VR instruction. This was done through faculty interviews. The researcher conducted Zoom interviews, approximately 30 minutes in length, consisting of 14 questions. Four RTC faculty were interviewed. The faculty interviewed were those assigned to teach automotive technology courses requiring the use of VR. The researcher developed, tested, and administered the interview questions.

Delimitations and Assumptions

This study was delimited to automotive learners at RTC building their skills, seeking a certificate, or working toward a degree. The PQ 3.0 was given to a sample of learners participating in VR instruction at RTC, located in Renton, Washington. The instructors were interviewed to understand faculty perceptions of the learning. All generations of learners enrolled in these courses were eligible to participate in the study.

It was assumed study participants were open and honest when responding to the survey or interview. It was assumed the survey was distributed and collected by a representative from RTC

where the participants were enrolled. This should have netted a higher response rate from participants.

RTC was selected for this study for several reasons. First, RTC was already using VR for automotive instruction and the faculty were willing to participate in the study. Second, the college had the state's highest completion rate and an 85% job placement rate within nine months of graduating across its 52 career programs. Lastly, in 2019 the Aspen Institute named RTC one of the top 150 community colleges in the country for the third straight year.

Significance of the Study

This study was significant because it examined if VR instruction may be a useful methodology for automotive technology education in the community college. A positive link between presence and learning could serve as an example of how VR can be used in automotive technology instruction to facilitate learning. Without such a link, then those tasked with curricula development and instruction could look elsewhere for technology that will better aid the learning process in automotive technology education. If the learners' levels of presence are high and the perceptions of faculty are that learning is occurring, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

Definition of Terms

The definitions of the following terms were employed for this study:

Adaptation/Immersion: The perceived proficiency of interacting with and operating in the virtual environment (VE) and how quickly the user adjusted to the VE experience (Witmer et al., 2005).

Andragogy: The methods or techniques used to teach adults.

Career and technical education (CTE): Instructional programs offering a series of courses in which learners gain knowledge and skills toward a specific profession; CTE programs are offered in fields often requiring a certificate to work or advance in the field, such as allied health, cosmetology, dental hygiene, automotive technology, and culinary arts.

Digital native: A person born in a time where they are exposed to technology from an early age, making them familiar with and comfortable working with technology (Merriam-Webster, n.d.).

Generation Z: A generation of people born in the late 1990s and early 2000s (Merriam-Webster, n.d.). Generally, members of Generation Z are tech-savvy, pragmatic, open-minded, individualistic, and socially responsible (Premack, 2018).

Interface quality: Perceived quality of the VE interface and the extent to which it does not interfere with activities in the VE (Witmer et al., 2005).

Involvement: An interface natural to the user immediately facilitates the user's ability to control activities in the environment, increasing their involvement (Witmer et al., 2005).

Learning: The process by which someone gains new knowledge or skills through instruction or study (Merriam-Webster, n.d.).

Presence: "Presence is defined as the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)" (Knerr et al., 1998, p. 32).

Sensory fidelity: The degree to which the VE configuration permits active search or survey of and/or examination of the objects in the VE (Witmer et al., 2005).

Skill builders: Learners who completed at least one course but less than one year's worth of courses in a CTE program (Smith, 2016).

Virtual reality (VR): Three-dimensional computer simulations that mimic reality offering users a realistic yet computer-generated experience (Merriam-Webster, n.d.).

Chapter 1 Summary

This chapter introduced the study, *Virtual Reality Instruction in Automotive Technology Education at Renton Technical College*. The problem and background were described. The problem was the gap between knowledge and skills learners enter an automotive technology education with, and the knowledge and skills needed to succeed in a career in the automotive industry. The background of the problem was defined. Many expectations are placed on community colleges, including imparting knowledge, developing skills, stimulating creativity, and developing critical thinking in the learner.

This introductory chapter also examined the changes in technology and learners affecting the problem. The concept of presence was explained. The purpose of this mixed methods study was then established, which was to determine if VR instruction may support learning by measuring learner levels of presence and faculty perceptions of learning when using VR instruction in automotive technology education. The two research questions were presented. Research question one was: What are learners' levels of presence when using VR in automotive technology instruction? Research question two was: What are faculty perceptions of learning when using VR in automotive technology instruction? The theoretical framework of andragogy was introduced, followed by the methodology – mixed methods, non-experimental, descriptive study. This was followed by the delimitations and assumptions of the study.

Most importantly, the significance of the study was explained. This study was significant because it examined VR instruction and determined learners' levels of presence and faculty perceptions of learning when used in automotive technology education. If learner levels of

presence were high and faculty perceived learning as occurring, it may indicate VR offers educators a valuable tool that can be used for learner success. Lastly, definitions of terms were provided.

Organization of the Study

This dissertation is comprised of five chapters. Chapter 1 introduced the framework for the study. Chapter 2 is the literature review where research related to the topic is explored, focusing on the theoretical framework of andragogy and studies on presence, performance, and learning. This enriched the study by assuring it brought new, valuable work to the field of higher education. Chapter 3 presents the research design and methodology, which covers the design and methodological approach for the study. Chapter 4 includes findings and analysis in which the research was presented and critically analyzed. Chapter 5 includes the summary, discussion, and recommendations. In this final chapter, conclusions from the research are drawn and recommendations for future research are provided.

Chapter 2 - Literature Review

Chapter 2 reviewed and analyzed relevant, primary source literature pertaining to presence and learning when incorporating virtual reality (VR) instruction in automotive technology education in the community college system. This chapter begins with a review of relevant literature on andragogy, which is the theoretical framework for this study. Next, the composition and characteristics of community college learners is reviewed. This is followed by a review of literature related to VR instruction and literature related to presence and learning. Last, this chapter identifies the gaps in the literature pertaining to presence and learning when employing VR instruction in automotive technology education at the community college level.

Andragogy - Theoretical Framework

The theoretical framework for this study was andragogy, the methods and practice of teaching adult learners. The roots of andragogy can be traced back to German educator Alexander Kapp in 1883. The development of this theoretical framework continued in the United States through the work of Eduard C. Lindeman in his book, *The Meaning of Adult Education*, published in 1926. Malcolm S. Knowles popularized andragogy and conducted extensive work developing it into a theoretical framework in the 1960s and throughout the remainder of his life. His work on andragogy was introduced in one of his early books, *The Modern Practice of Adult Education: Andragogy versus Pedagogy* (Knowles, 1970).

The History of Andragogy

The roots of andragogy grew from the long-established educational methods and practices of teaching children, known as pedagogy. Since the beginning of recorded history, cultures in one form or another educated their children. Formal pedagogical theories date back to the time of Socrates (469-399 BCE). In 1548, Jesuit Priests who believed a quality education was

the best way to achieve a meaningful life started their first school. The Jesuits, practicing their pedagogical methods, became known as the schoolmasters of Europe (*Pedagogy - New World Encyclopedia*, n.d.).

Many scholars observed the differences between child and adult learners over the years. One significant scholar who chose to delve into the differences was Cyril O. Houle (1913-1998). In his 1961 work *The Inquiring Mind: A Study of the Adult who Continues to Learn*, Houle talked about studying why adults participate in continuing education. He fit the 21 adult subjects from his study into three categories: goal-oriented learners, activity-oriented learners, and those who were simply learning-oriented for its own sake. Community college learners fit into these categories as determined in a study by the Education Advisory Board (EAB; 2019), which described why adult learners enter higher education. Some adults entered college to change their career options (goal-oriented), some to stay competitive in their field (activity-oriented), and some to keep learning (learning-oriented).

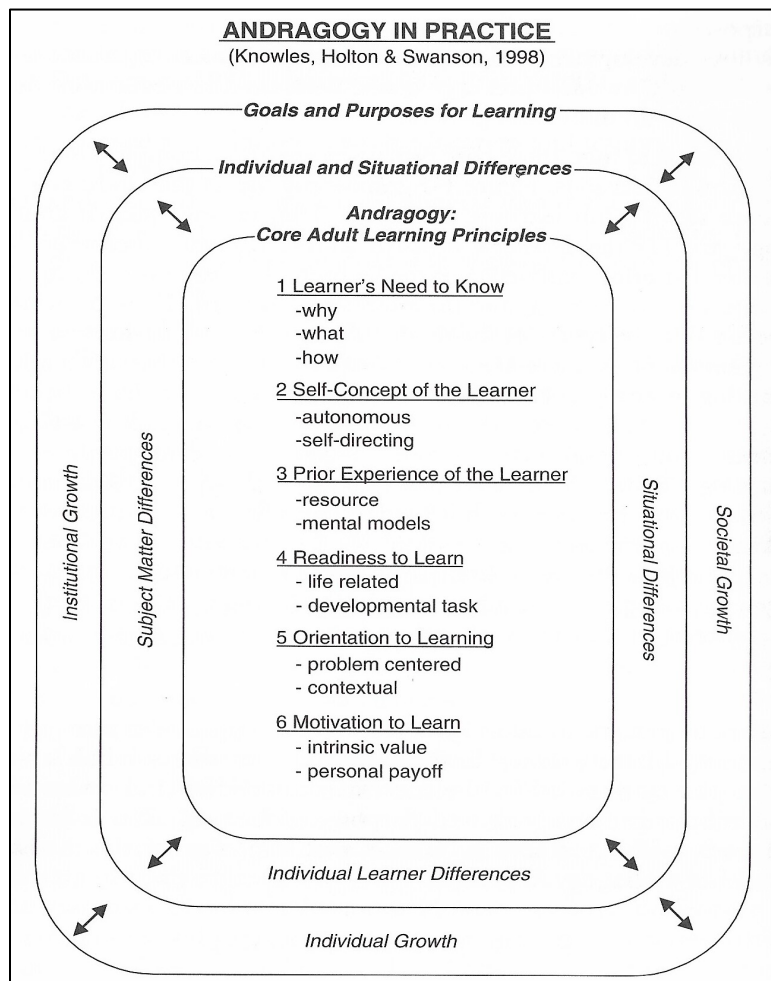
Knowles Contributions to Andragogy

Knowles integrated the work of previous scholars, like Houle, with his own studies and codified the framework of andragogy. Knowles (1970) proposed five key assumptions of andragogy differing from pedagogy. First, in andragogy the learner is increasingly independent and self-directed whereas in pedagogy the learner is dependent on the teacher who is expected to direct the subject and methods of instruction. Second, adult learners have a mature and growing pool of experiences from which to pull from when learning whereas children have few personal experiences to facilitate learning, relying on teacher experiences to add richness to learning. Third, andragogy explains readiness to learn comes from recognizing a real-life task or problem that must be addressed whereas in pedagogy learner readiness is determined by society. Fourth,

adult learners tend to be performance driven and education is seen as a way to achieve their full potential whereas children see education as a prescribed process yielding knowledge and skills for the future. Fifth, the adult learner is motivated by internal rewards and a sense of accomplishment whereas children are often motivated by external rewards and consequences.

In the book *The Adult Learner*, Knowles et al. (2005) elaborated and built on Knowles' previous work (Figure 2.1). Specifically, a sixth learning principle was added, the need to know. "Adults need to know why they need to learn something before they learn it" (Knowles et al., 2005, p. 159).

Figure 2.1 Andragogy in Practice



Note. Source: Knowles et al. (2005).

Andragogy and the Community College Learner

The framework of andragogy aligns with this study because the population of community college learners are adults. The average age of a community college learner is 28 with the median age of 24 (American Association of Community Colleges, 2020). The automotive technology learner is a sub-group of the community college population.

Automotive technology adult learners fit the model developed by Knowles et al. (2005). First, those enrolled in a community college automotive course have a need to know. They want to know why, what, and how they will learn. Second, they have an adult self-concept and understand they are responsible for their education and training. Third, they have the prior experiences of an adult. Life experiences of the last 20 plus years can be pulled upon to enhance their education. Fourth, they exhibit an adult-level readiness to learn. They know they need to cope with real-life situations and see the value in education to handle those situations. If their chosen career is in the automotive industry, the knowledge and skills learned will help them cope with real-life situations in that industry. Fifth, they have an adult orientation to learning. They are motivated to learn because it will help them with life issues related to a career, independence, and if they choose, raising a family. They are not enrolled in courses because they are required, but rather they choose to enroll because the learning will help them in life. Sixth, they fit the adult learner model because of their motivation to learn. They are internally motivated and gain a sense of accomplishment and pride when they master the required knowledge and skills.

The theoretical framework of andragogy applies to this study because the community college, automotive technology learner is an adult. It is important to have this understanding and foundation when designing and delivering instruction. The next section takes a closer look at the community college adult learners.

Community College Learners

This section of the literature review focuses on the community college learner. It is important to know the learner to design effective instruction. Learners at community colleges are comprised of the following generations: Baby Boomers aged 55-73, Generation X aged 39-54, Millennials aged 23-38, and Generation Z aged 9-24. According to the American Association of Community Colleges (2020), 54% of learners are under 22 years old and therefore Generation Z learners, whereas 38% are Millennials and only 9% of learners are older than 40. Generation Z will comprise most community college learners over the next 10 years.

Today's Generations of Learners

Today's learners are different than previous generations. Generation Z has grown up with YouTube, mobile phone apps, video games that mirror reality, Google, Wikipedia, and social media. The following quote best sums up the literature on the largest group of community college learners, Millennials and Generation Z:

Tech-savvy millennials and Gen Zers, who grew up playing games on their cell phones, laptops and other devices. And while games are popular among both generations, there's some evidence to support that Gen Z responds particularly well to the technique.

Gamification has caught on in workplace training too, with nearly half of Gen Z members surveyed in a recent report saying they prefer to learn through gameful approaches. Responding to those preferences can be key for colleges and universities, as members of Gen Z — who were born since 1997 — make up the new college-age crowd. (Schwartz, 2019, para. 4-5).

Most community college learners today are tech savvy and engaged by game-based learning (GBL). The authors of an article “Engaging Perioperative Learners Using Online Game-Based Education,” discussed how GBL is becoming more popular in medical education and learners reported GBL offered positive ways to learn (Crowley-Barnett et al., 2020). The article looked at learner responses to GBL used for teaching and testing the medical instrument

sterilization process. The learners were able to interact with GBL and were immersed in the environment. It was a small sample size and the authors recognized additional research would be needed, but the feedback from learners and faculty from their evaluation of using GBL was positive.

Learners and Virtual Reality

A study by Baxter and Hailey (2019) looked at what learners think of VR instruction. In this study, a group of 100 undergraduate students enrolled in the creative computing program at the University of the West of Scotland were given a questionnaire to determine their views of VR. “The overall findings of the research were predominantly positive with students indicating that there are beneficial pedagogical uses of VR to be had in an educational context” (Baxter & Hailey, 2019, p. 12). One of the questions asked learners what they saw as a potential use for VR technology. Education as a potential area for VR use ranked third with 83% of the participants noting this as a use for VR (Figure 2.2).

Figure 2.2 Areas for Potential use of Virtual Reality Technology

Potential area	Ranking	Percentage
Gaming	1st	99
Entertainment	2nd	84
Education	3rd	83
Science	4th	81
Military	5th	76
Training	6th	75
Space	7th	65
Tourism	8th	62
Healthcare	9th	60
Advertising	10th	40

Note. Source: Baxter & Hailey (2019, p. 10)

Today’s college learners, the majority of whom are Millennials and Generation Z, grew up with technology as part of their social and entertainment life and expect VR to be part of their

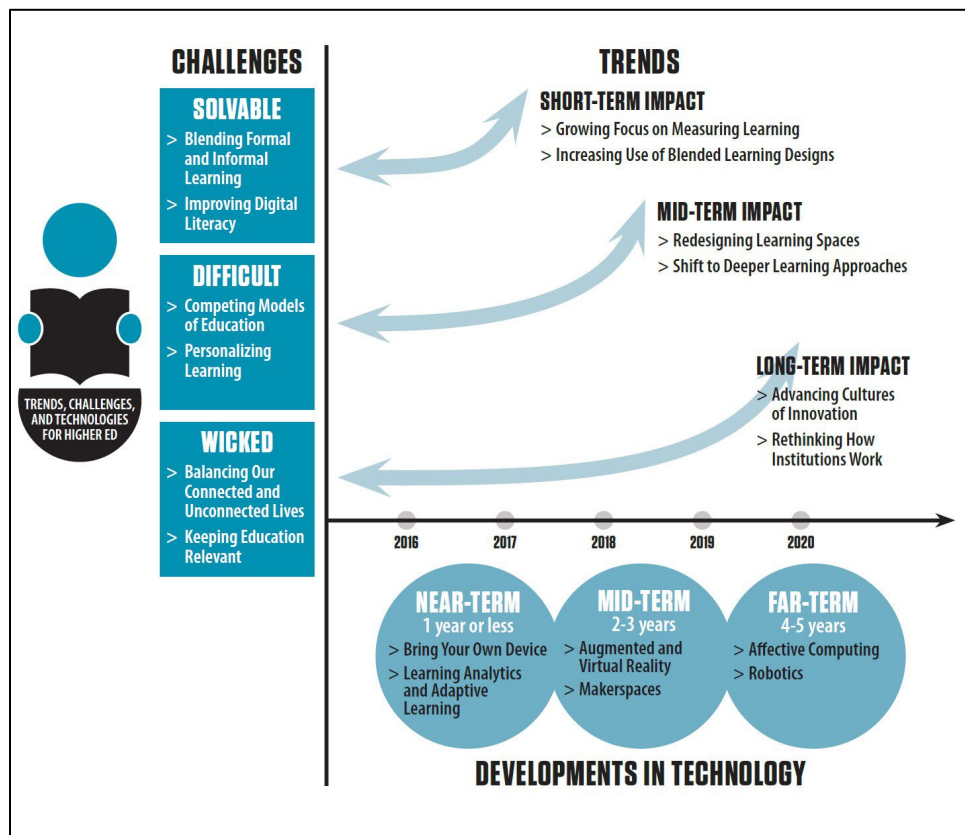
education. An immersive VR environment that allows for interaction is likely to appeal to these younger community college learners.

Virtual Reality Instruction

VR instruction is not new. A specific example of VR instruction is flight simulators, which are used for training pilots and for entertainment. Flight simulators are VR environments where users can interact, manipulate, and experience a level of presence through the physical controls that interface with the computer-generated environment. The first digital flight simulators were developed in the 1960s (Page, 2004).

For a number of years, it was expected VR instruction would be one of the hottest methods in higher education (Johnson et al., 2016). Over the past 15 years, New Media Consortium (NMC) and Educause (Educause acquired NMC in 2018) published the annual *Horizon Report*, which identifies trends, emerging technologies, and practices projected to shape the future of higher education. In the 2016 report, Johnson et al. identified trends emerging in VR instruction (Figure 2.3). The 2017 report noted VR would be prevalent in two to three years. VR in higher education is growing, but not as widespread as anticipated.

Figure 2.3 Topics from the 2016 NMC Horizon Report



Note. Source: Johnson et al. (2016, p. 2).

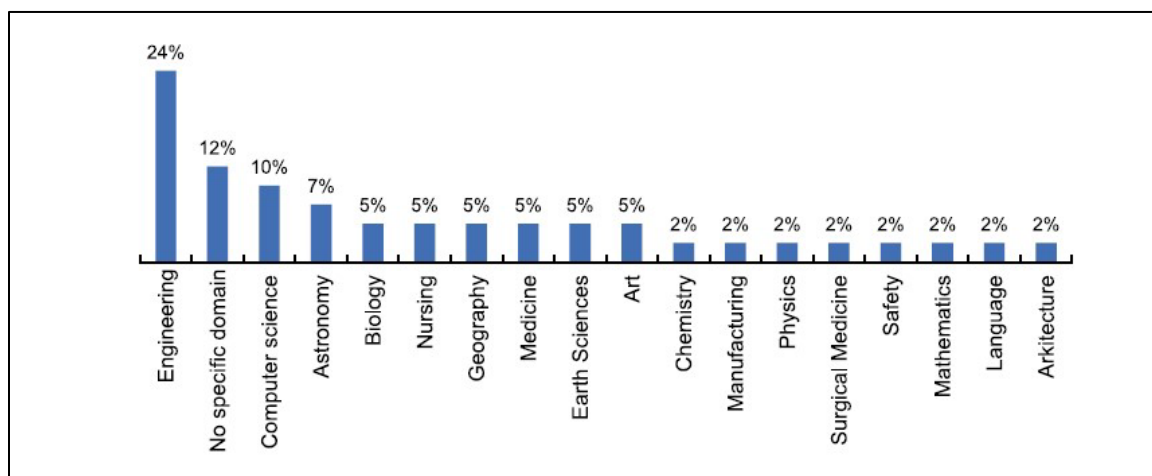
Uses in Higher Education

A literature review by Radianti et al. (2020) made some key points regarding the adoption of VR in higher education. First, from 1997-2006 computer networking was a focus of information technology departments in institutions of higher education. The growth and advancements of the internet, hardware, and software enabled a highly connected and powerful technology grid available for use in all facets of higher education. These networks and technology factors paved the way for increasingly interactive and immersive VR technologies. Second, from 2007-2016, higher education was using this new technological bandwidth to grow online learning. During this period, the number of online course offerings grew substantially. VR was tried during this time period with various success, but the realism, interaction, immersion,

and costs were limiting. In regard to VR instruction in higher education, the authors pointed out, “VR technologies are actively being incorporated into education, teaching, and training in various application domains” (Radianti et al., 2020, p. 2).

Radianti et al. (2020) reviewed studies where VR was used in higher education. They asked nine research questions, one of which looked at the use of immersive VR applications in various higher education disciplines. They identified 18 disciplines across the articles reviewed. Figure 2.4 shows engineering adopted VR the most, found in 24% of the articles reviewed.

Figure 2.4 Virtual Reality across Higher Education Disciplines



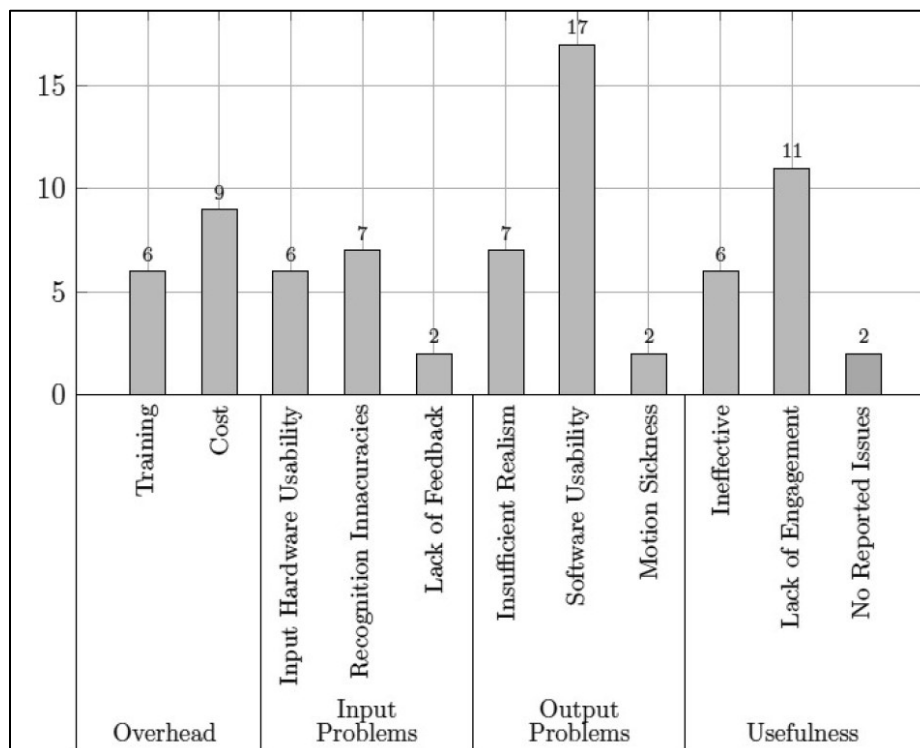
Note. Source: Radianti et al. (2020)

This breakdown allows various institutions of higher education to analyze the data in different ways. For example, when considering which disciplines should adopt a VR instructional platform, the institution can consider what would be most cost effective based on disciplines the institution offers. If a community college is considering using VR instruction in some of their disciplines, they could group certain categories together such as nursing, medicine, parts of biology, and surgical medicine when doing a cost analysis of the VR technology platform.

Despite improved access to technology, VR instruction has not been adopted as expected. The question remains, why not? A literature review conducted by Kavanagh et al. (2017)

addressed this issue. The study reviewed 99 papers relevant to VR in education and listed the most common issues and limitations of the use of VR in education. Although most of the papers discussed higher education, a small percentage discussed primary, secondary, private sector, military, and other educational institutions. Thirty-five papers presented issues and limitations, broken down into four main themes: overhead, input problems, output problems, and usefulness. Next, 11 common codes were established: training, cost, input hardware usability, recognition inaccuracies, lack of feedback, insufficient realism, software usability, motion sickness, ineffective, lack of engagement, and no reported issues. The data related to each theme and code are presented in Figure 2.5. The three limitations occurring most often were software usability, lack of engagement, and cost. Education uses VR instruction but issues remain.

Figure 2.5 Issues and Limitations of Virtual Reality in Education



Note. Source: Kavanagh et al. (2017).

The prior sections offered a foundational understanding of the general use of VR in higher education, including where it is being used, why it is not as widely adopted as some

expected, and some issues and limitations. The next section looks at where it is being used in career and technical education (CTE) and specifically automotive education. Both disciplines are combined as few studies focused on automotive education and because some of the principles in CTE are transferable to automotive technology education.

Virtual Reality in Career Technical Education

A paper titled *Virtual Reality System for Training in Automotive Mechanics* proposed a VR training system be established to train various positions within the automotive industry (Quevedo et al., 2017). The paper identified the benefits of using graphics created when a vehicle, its systems, and components were designed and manufactured, and using them to create VR training for vehicle service and repair technicians. Vehicle manufacturers would incorporate VR in their service information to assist the repair technicians in resolving vehicle malfunctions. This paper illustrated the direction automotive manufactures may go in the future, but this idea has not yet been developed. Quevedo et al. (2017) illustrated the potential for VR and spoke to the need for additional studies on VR instruction in automotive technology.

Another study was a dissertation titled *The Impact of Virtual Reality Programs in Career and Technical Education* (Catterson, 2013). This study looked at CTE students taking online classes through Second Life, a virtual world where learners can travel to other places and live an entire second life through the creation of their avatar, called a Sim. The avatar can socialize, role play, and interact with other people's avatars and even go to school. Second Life has an educational branch of their VR. If an institution of higher education elects to purchase Second Life, it may be used by learners enrolled in the institution and the staff. Faculty can set up a VR classroom and offer VR office hours. Although it is primarily a VR environment, instructional pieces can be integrated. The research questions for the study focused on student engagement,

academic success, and satisfaction. End-of-course interviews were conducted on two groups of students taking an introduction to computing course. The students in the first group took the class in the traditional online environment and the second group took the online class in the Second Life environment. The results showed:

The qualitative data that emerged from this research indicates that the impact of virtual reality programs in career and technical education is worthy of consideration. Students enrolled on the Second Life...course indicated a higher level engagement, motivation to achieve academic success, and a higher level of satisfaction compared to students enrolled in the traditional online learning environment. (Catterson, 2013, p. 62)

Although this is promising, Catterson's (2013) study was more focused on the learning management system end of the VR spectrum than the instructional content of VR.

Some literature pointed to VR as a tool for assessment and placement of learners. Byrd et al. (2015) focused on virtual welding simulators used as assessment tools for existing welders. A slight difference was seen between experienced welders and trained novice welders, but the difference was more pronounced when the quality of the welds was evaluated. This spoke to the point that VR could be a valid tool to assess psychomotor skill attainment.

In a different study but still focused on welding simulators, Whitney and Stephens (2014) found VR instruction was not at the point of replacing face-to-face laboratory tasks but was an effective supplement to the laboratory tasks. The study found blending traditional hands-on instruction with VR simulations was effective for beginning welders and saved costs and time compared to traditional hands-on training. In fact, beginning welders who received a 50/50 mix of live and simulation-based training performed better than beginning welders who received 100% live training. The study did not show evidence that VR simulations would replace instructors. Instructor feedback and modeling in a face-to-face setting were important for beginning welders and especially for advanced welders. It was found high fidelity was not

necessarily required to train basic welding skills. However, the study did not provide evidence that VR simulations were effective in training experienced welders.

Presence and Learning

This section begins by reviewing the definitions of presence and learning. Knerr et al. (1998) defined presence as “the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)” (p. 32). Merriam-Webster (n.d.) offered three definitions of learning, focused on the act of gaining new knowledge and skills or modifying behavior based on experience. With these definitions, the question was whether presence indicated learning occurred from VR instruction. In some studies, a relationship existed between presence and learning whereas other studies were inconclusive. This indicated the need for more research. This study added to the body of knowledge relating to presence and learning by measuring learner levels of presence through a survey and then understanding if learning was taking place through faculty interviews. This section considers literature relevant to the construct of presence and the works related to presence and learning.

The History of Presence

In 1992, Massachusetts Institute of Technology (MIT) began publishing a journal called *PRESENCE: Virtual and Augmented Reality* (Ch’ng & Rizzo, 1992). The MIT journal offers articles and research related to human-computer interactions including robotics, simulations, VR and augmented reality environments, autonomous vehicles, and presence. The concept of presence is broad and scholars studied the topic from various angles.

One example is an article by Sheridan (1992), which presented an almost philosophical approach. He built a definition of presence and explained the experience of the human user

interfacing with and performing operations in a virtual environment (VE). Through this, he posed the need for an operational measure of presence. Sheridan explained:

“Presence” is a subjective sensation, much like “mental workload” and mental model—it is a mental manifestation, not so amenable to objective physiological definition and measurement. Therefore, as with mental workload and mental models, subjective report is the essential basic measurement. (p. 123)

Sheridan (1992) proposed three main determinants of presence: the extent of sensory information, the control and relation of sensors to the environment, and the ability to modify the physical environment with motor controls. His focus in this article was general and touched on training and performance but indicated more work was needed in this area. He concluded,

What are the relative effects of efferent or afferent distortions on sense of presence, training efficiency, and performance? I submit that we have very poor experimental answers to this question, for other than relatively trivial distortions such as pure time delay. (p. 123)

In a follow up paper, Sheridan (1996) built on what he hypothesized and added three practical psychophysical approaches to measuring presence. The first measurement of presence is reflective responses. For example, if an object is moving toward a person’s head, instinct is to move out of the way. The second measurement of presence is subjective scaling. Sheridan proposed a three-attribute scale for measuring subjective scaling of presence, one to measure fidelity of the VE, one to measure user viewpoint or position when in the VE, and a third to measure the ability of the user to change the configuration of the VE. The third measurement of presence is the ability to discriminate between a virtual and real environment. Moreover, to manipulate the subject’s perception of the virtual verses the real environment by the introduction of *noise* and then measuring presence according to the amount of noise.

Held and Durlach (1992) approached presence from a different perspective based on the work of Akin et al. from 1983. In a work setting, automation, robotics, and machine intelligence systems provide “the dexterity to allow the operator to perform normal human functions. At the

control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the worksite” (Held & Durlach, 1992, p. 109). They were primarily concerned with how one could create a robot able to emulate the movements of a human or provide a life-like experience or telepresence. This robot or VE could be used to explore the depths of the ocean or to train pilots with minimal risk to the scientist or learner. Held and Durlach (1992), like Sheridan, went on to say there was a lack of a well-defined measurement tool. Their ideal instrument would be a subjective scale with both psychological and physiological tests.

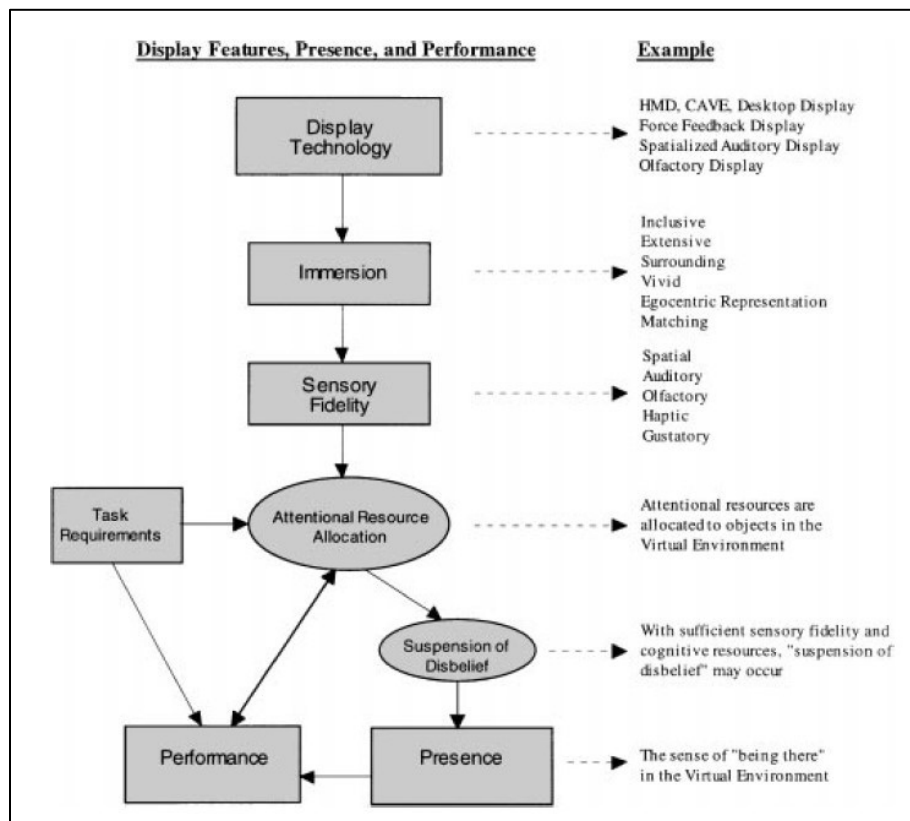
In an article titled *A Conceptual Model of the Sense of Presence in Virtual Environments*, Bystrom et al. (1999) presented a model of three interdependent elements: immersion, presence, and performance. Immersion, in relationship to VR, is the ability of the computer display to provide a vivid reflection of the real world to the user. Immersion involves the physical characteristics of the VE and the user’s interaction within it. This concept is objectively quantifiable and dependent on the available technology and quality of the hardware and software used to create and navigate the VE. The second concept is presence, which they defined as, “the degree to which the participants feel that they are somewhere other than where they physically are when experiencing the effects of the computer-generated simulation” (p. 241). Presence is subjective, qualitative, and a state where the consciousness of the user is involved. The third concept is performance, which is based on task and will vary depending on the subject and goals of the VE. For example, in automotive technology the task may be to properly order steps in a linear diagnostic process, disassemble an engine, or interact with a customer bringing their vehicle in for service.

Conceptual Model of Presence and Learning

Presence in a VE is experiencing the environment created by the computer versus the physical environment where one is located. The idea of presence was presented in an article titled “A Conceptual Model of the Sense of Presence in Virtual Environments” (Bystrom et al., 1999). Figure 2.6 shows the links between immersion, presence, and performance. The model is divided into two parts. The first three blocks comprise the contribution of the computer display, software, and user interface, and the remainder of the blocks and ovals comprise the interaction of the user within the VE represented as a feedback loop. For the participant to experience presence, there must be a certain amount of attentional resource allocation. This is partially dependent on the level of immersion and task requirements. If the display technology is poor and sensory fidelity is low, the user is less likely to allocate their attention to the task, but if the task is not engaging or seen as irrelevant, the user is less likely to pass the point of suspension of disbelief, which is a requirement for presence. The user must believe the VE is real and suspend their disbelief of the VE for presence to occur.

The second half of the diagram, which is the interaction of the user in the VE, is where presence and learning occur. Learning is the task performance designed into the VE and presence is a necessary condition for the learning or performance to occur. The model postulated, “The nature of the task, the level of attention the user gives to the task, and the sense of presence may all affect the quality of performance on the task” (Bystrom et al., 1999, p. 243).

Figure 2.6 Conceptual Model of Immersion, Presence, and Performance



Note. Source: Bystrom et al. (1999, p. 243).

Witmer and Singer's Presence Questionnaire

As scholars were understanding, defining, and clarifying the construct of presence, two researchers conducted studies for the U.S. Army Research Institute. Witmer and Singer were developing two instruments for measuring presence as part of their studies. They developed an immersive tendencies questionnaire (ITQ) and a presence questionnaire (PQ). Witmer and Singer presented their findings in a technical report in October of 1994.

The technical report provided information related to the effectiveness of learning and skill acquisition of VR training and rehearsals. They sought to understand if there was a relationship between presence and learning/performance, so they developed the ITQ and PQ. The ITQ was administered to participants before they took part in the VR instruction to measure their

abilities and tendencies to immerse themselves in the VE. The PQ was administered to the participants after partaking in the VR instruction to measure presence. The original PQ instrument was developed in 1992 and consisted of 32 questions where the participants answered each question using a Likert-type scale from one to seven. The questions could be further broken down to analyze the four factors hypothesized to contribute to presence: control, sensory, distraction, and realism (Figure 2.7).

Figure 2.7 Factors that Contribute to Presence

Control Factors	Sensory Factors	Distraction Factors	Realism Factors
Degree of control	Sensory modality	Isolation	Scene realism
Immediacy of control	Environmental richness	Selective attention	Information consistent with objective world
Anticipation of events	Multimodal presentation	Interface awareness	Meaningfulness of experience
Mode of control	Consistency of multimodal information		Separation anxiety/ disorientation
Physical environment modifiability	Degree of movement perception Active search		

Note. Source: Witmer & Singer (1998, p. 229).

In their conclusion, Witmer and Singer (1994) acknowledged this was their first attempt at an instrument to measure presence and it was promising. Their study showed about 89% of the correlations between presence and task performance were in the predictive direction. They admitted it was just a start and the results need to be replicated in larger samples before more could be said about the instrument.

Their PQ went through three revisions. In 2005, Witmer et al. published a paper with version 3.0 of the PQ (Appendix E), which clarified the factors influencing presence. The revisions included changing the number of items from 32 to 29 and revising factors to involvement, sensory fidelity, adaptation/immersion, and interface quality. The PQ is not the only instrument to measure presence, but it is the most cited in the field. A paper on

administering PQs within the VE and separate from the VE made the following point: “While multiple physiological measures have been proposed [18], validated questionnaires are still the most common method for measuring this construct [10]” (Schwind et al., 2019, p. 360). In their study, Schwind et al. reported the Witmer and Singer PQ was the most cited in Google Scholar in 2018 (Figure 2.8); therefore, it was the questionnaire used in this study.

Figure 2.8 Citations of Published Presence Questionnaires

Authors	Year	Citations*	Items	Usage
Banos et al. [2]	1998	146	77	VE
Barfield & Hendrix [3]	1995	186	5+1	VE
Cho et al. [4]	2003	34	4	VE
Dinh et al. [6]	1999	365	13+1	VE
Gerhard et al. [9]	2001	57	19+4	SVE
Kim & Biocca [12]	1997	664	8	VE
Krauss et al. [13]	2001	8	42	VE
Lombard & Ditton [16]	2000	205	103	NA
Lombard & Weinstein (TPI) [17]	2009	120	4-8	CM
Lessiter et al. (ITC-SOPI)[14]	2001	861	44	CM
Nichols et al. [20]	2000	158	9	VE
Nowak & Frank [21]	2003	569	9	SVE
Schubert et al. [23, 27, 28] (IPQ)	2001	758	14	VE
Usuh/Slater et al. [36, 39] (SUS)	1994/2000	853/466	3/6	VE
Witmer & Singer [43] (WS)	1998	3569	32	VE
VE = Virtual Environment, CM = Cross-Media, SVE = Shared Virtual Environment, NA = items not listed * determined using Google Scholar, Sept 2018				

Note. Source: Schwind et al. (2019, p. 361).

Criticism of the Witmer and Singer Questionnaire

The Witmer and Singer (1998) PQ is a valid and reliable instrument, yet some literature criticizes it. Slater authored two papers disagreeing with Witmer and Singer’s approach to measuring presence. In his 1999 paper, Slater’s paramount issue was the PQ did not necessarily show presence was related to task performance. A participant in a VRE who does not perform well when it comes to required tasks within the environment may rate the same level of presence as the participant who performs well in the environment.

Slater (2004) argued against using questionnaires to measure presence, but not because they lacked value. He understood the many ways to measure presence, including interviews, eye movements, physiological responses, and questionnaires. He questioned why questionnaires were the default instrument, noting the benefits of critically analyzing how the concept was best defined and measured. Despite the opportunity to better define and measure this relatively new construct, the questionnaire remains the best instrument to date. Slater (1999) said,

At the end of the day, I use questionnaires because, for the time being, I do not know what else to do, and, in order to construct predictive equations, concerned with how presence varies with other factors in groups of people, some method of quantification is necessary. (p. 564)

Singer and Witmer (1999) responded to one of Slater's critiques in their paper titled, *On Selecting the Right Yardstick*. They argued their instrument considered the conceptual aspects of presence, which was the domain Slater was arguing from, but partnered the practical aspects of measuring presence. Slater (1999) described presence as requiring immersion, but Singer and Witmer (1999) insisted involvement and immersion were necessary for experiencing presence, saying, "We believe that presence is a much richer concept than Dr. Slater acknowledges, and hence requires comprehensive coverage of its various aspects to include elements of both involvement and immersion as we have defined them" (p. 573). Witmer et al. (2005) acknowledged presence and how to measure it needs more research, which is why the released version 3.0 of the PQ and progressed in their clarity and definition of the contributing factors.

Allowing researchers to focus on different aspects of the construct brought richness to the concept of presence. The criticism raised by Slater and responded to by Witmer and Singer was a matter of focus, being immersion or involvement and immersion. As researchers conduct more studies, presence and instruments to measure it will become more refined and useful. Such debate is why new research is important to the field.

Studies on Presence and Learning

Few studies considered the learner level of presence in VR instruction and the learning taking place. In studies referenced below, presence was measured by a presence questionnaire given to participants and learning was determined by a task performance measurement from within the VE. Some studies found statistically significant correlations between presence in VR instruction and task performance, but others found no significant correlations (Witmer & Singer, 1998). This pointed to the need for further studies and supported the importance of this study.

In November 1998, another U.S. Army Research Institute technical report (1089) was released to “summarize the current state of knowledge of the use of VE for dismounted soldier training” (Knerr et al., 1998, p. 2). The report listed various recommendations for interface design, tasks suitable for training in VR, improvements for training and training transfer, and reductions in simulator sickness. Regarding presence, the report recommended, “Presence is weakly but positively related to performance. To maximize performance in a VE, first design the VE and tasks in conformance with good training principles. Then increase the factors that contribute to experiencing more presence” (Knerr et al., 1998, p. 54). This report supported the relationship between presence and performance or learning.

More studies looked at learning or performance when using VR instruction. However, they were missing one or more key elements of this study. They were either not conducted at a community college, did not look at presence, or were not automotive related. The studies included:

- VR training for operating room fire scenarios (Sankaranarayanan et al., 2018)
- VR training for vehicle service procedures (Borsci et al., 2016)

- The effects of VR instruction on performance, emotion, and engagement (Allcoat & Mühlenen, 2018)
- First responder VR training for hydrogen safety (Tretsiakova-McNally et al., 2017)
- VR simulators to develop welding skills (Yunus et al., 2011)

A literature review conducted by Jensen and Konradsen (2018) analyzed 21 studies related to the use of head-mounted displays (HMDs) in VR education and training. Their findings were mixed. It was noted learners liked using the HMD. In some studies, learning occurred from the VR instruction and it allowed learners to make mistakes in a safe atmosphere at a reduced cost compared to face-to-face instruction. In other studies, there were no advantages or negatives like simulator sickness and high costs without learning. As in almost all the literature reviewed in this section, Jensen and Konradsen (2018) concluded the need for further research. Gaps exist in the research related to presence and learning. Use of PQ 3.0 to measure presence and the faculty interviews to better understand perceptions of learning while using VR instruction in automotive technical education helped fill the gap in this field.

Gaps in the Literature

Few studies reviewed related specifically to community college instruction. A gap in the literature exists specific to VR instruction for community college automotive technology education. However, the following two studies most closely aligned with the research being conducted in this study.

The first was a study of 171 two-year technical college aviation and automotive learners (Madathil et al., 2017). The study looked at the use of VR instruction in one portion of an existing manufacturing safety course required for both programs, not the entire course. Three conditions were created for delivering the safety information. The first delivery method was

online only where the learners were trained in manufacturing safety using video lectures, an eBook, and web instruction. The second delivery method was online plus VR simulations. The third method was online with photo-based case studies. The learners were given a pre-post survey after each group completed the course. The study showed no distinction between what was learned in any of the conditions, but,

The findings revealed that while there were no significant differences in actual learning gains between the control, VR, and photo-based case study conditions, they did show that the control and VR integrated conditions actually enhanced the student's experience and perception of learning more than the photo-based case study condition. (Madathil et al., 2017, p. 7)

Although this study was valuable to the field, it did not measure presence using a robust instrument nor offered insights about the learning that may have taken place from the faculty perspective. Additionally, only a small number of safety tasks were used in the study and some of those were unique to a vehicle manufacturing facility.

The second was a study conducted with 60 volunteers consisting of Jaguar/Land Rover professionals (Borsci et al., 2016). The participants comprised of novice, intermediate, and advanced technicians, machinery service technicians and trainers, managers, designers, and others. They were divided into three groups, two of which were trained in a specific skill using VR whereas the control group was trained through a video. The results showed VR training was more effective than video training. This was an important study linked to VR automotive training, but it did not examine learner levels of presence or faculty perceptions of learning. Presence was not measured and the participants were employees of Jaguar/Land Rover and not community college learners. As employees, they had specialized knowledge and experience working on one specific manufacture's brand of vehicles.

This literature review found related papers containing elements of this study but there remains a clear gap. The gap in the literature is that no studies have measure presence and

learning when using VR instruction in automotive technology in the community college setting. This study helped to address this gap.

Chapter Two Summary

This chapter provided an overview of the theoretical framework for the methods and techniques used in adult learning. Community college learners and their characteristics and attributes were described in addition to providing a brief description of the diversity of goals these learners have when attending institutions of higher education. The history of using VR as a means of instruction and the evolution of using VR instruction in the community college classroom was reviewed. An introduction to presence and its connection to learning was outlined and a review of studies resulting in positive relationships between presence and learning was provided. Finally, gaps in the literature were discussed. This study attempted to determine whether VR would be a viable means of instruction in an automotive technology community college classroom that results in presence and most importantly, learning.

Chapter 3 - Methodology

This chapter presents the methodology used for this study. It begins with reiterating the study purpose – to determine if virtual reality (VR) instruction leads to learning in automotive technology education by measuring learner levels of presence and faculty perceptions of learning. This is followed by restating the research questions and theoretical lens of andragogy (how adults learn) based on research by Malcolm S. Knowles. Next, the research design is presented, along with information about the study participants and instrumentation. The data collection process and data sources are explained, detailing the qualitative and quantitative data, as well as issues of validity and reliability. The chapter concludes with ethical considerations, limitations, and a summary of key points.

Purpose of the Study

The purpose of this mixed methods study was to determine if VR instruction may support learning by measuring learner levels of presence and faculty perceptions of learning when using VR instruction in a community college, automotive technology program. If learner levels of presence are high and faculty perceive students are learning, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

To successfully complete an automotive course, each learner must have a cognitive understanding of the material and be able to perform the required psychomotor tasks. VR instruction offers a bridge where learners can gain cognitive knowledge and develop psychomotor skills in a safe and forgiving environment without the need for actual physical equipment such as tools and vehicles. VR instruction offers an environment where mistakes, which are part of the learning process, neither harm the learner nor cost the college because of damage to expensive vehicles and equipment.

Research Questions

Two research questions guided this study:

Research Question One: What are learners' levels of presence when using VR in automotive technology instruction?

Research Question Two: What are faculty perceptions of learning when using VR in automotive technology instruction?

Research question one focused on the learners. The Witmer and Singer Presence Questionnaire (PQ) was used to determine learners perceived levels of presence when using VR during automotive instruction. Research question one examined if learners using VR felt like they were working on the automobile as measured with the PQ. This was an important question because Witmer and Singer (1994) found some studies showed a relationship between presence and task performance whereas others did not.

Research question two focused on faculty perceptions of learning occurring through VR instruction. If faculty believe VR instruction results in learning, this may indicate VR instruction can effectively be incorporated into automotive technology curriculum to teach necessary skills.

Research Design

This study employed a mixed methods approach. Creswell and Plano Clark (2010) defined mixed methods as a study collecting, analyzing, and integrating both quantitative and qualitative data. Quantitative data focus on numbers and analyses are conducted using statistical procedures. In contrast, qualitative data are more narrative in nature and focus on people's perceptions. The quantitative portion of this study was non-experimental and descriptive, where learners enrolled in a community college automotive technology course utilizing VR instruction were surveyed. The qualitative portion of the study was comprised of interviews with faculty

teaching courses using VR to assess their perceptions of the learning occurring during instruction. A mixed methods design was selected because the quantitative data measured the learner levels of presence in the VR instruction and the qualitative data aided in understanding faculty perceptions of learning occurring through VR instruction.

The learner survey was administered via SurveyMonkey, which is a web-based platform for administering surveys. SurveyMonkey was founded in 1999 and is online, cloud-based software used by individuals and organizations to deliver, collect, and analyze data from customized surveys. SurveyMonkey is commonly used across many companies and has partnered with the U.S. Department of Education and Harvard Graduate School of Education to create educational survey templates (*Education Surveys for Schools, Teachers & Students*, n.d.).

Learners completed the PQ 3.0. The PQ was originally developed by Witmer and Singer (1994), revised by them in 1998, and Witmer et al. released version 3.0 in 2005. PQ 3.0 is comprised of 29 questions and was designed to measure levels of presence in a VR environment. The instrument was tested by the developers and found to be both valid and reliable. In addition to the PQ 3.0, learners were asked to complete a few demographic questions (see Appendix E).

The study was qualitative in that faculty teaching automotive technology courses with VR were interviewed. The faculty interviews were conducted over Zoom. Zoom was founded by Eric Yuan in 2011 and is focused on accessible, easy videoconferencing (Trueman, 2020). The interview consisted of 14 questions related to faculty perceptions of the learning (see Appendix F). The interviews were approximately 30 minutes in length.

Study Setting

This study took place with learners and faculty from Renton Technical College (RTC) in Renton, Washington. The VR environment used in this study was the zSpace hardware and

software automotive package. Because of the distance between the researcher and the participants, SurveyMonkey and Zoom were utilized to gather the data.

Renton Technical College

Renton Technical College (RTC) was established in 1941 as a war production school providing employment preparation training and career retraining (RTC, n.d.). In 1965, the state-funded technical school moved to its current location in Renton, Washington. The College's mission is to engage "a diverse student population through educational opportunities for career readiness and advancement, serving the needs of individuals, the community, businesses, and industry" (RTC, n.d.). In the 2018-19 academic year, RTC served 9,651 learners, equating to a little over 4,000 full-time equivalent learners. RTC offers 52 career programs with the state's highest completion rate and an 85% job placement rate within nine months of graduating. The Aspen Institute named RTC one of the top 150 community colleges in the country for the third straight year in 2019. RTC is on a quarter system offering fall, winter, and spring quarters, and a lighter summer session.

The automotive program at RTC offers two certificates and a two-year associate of applied science degree. Automotive technology courses vary from 1-10 credits. The maximum class size in the automotive technology program is 22. RTC offers 14 courses in the automotive program. Four courses are lecture only, with one being a work experience course. These four courses are not part of the current VR instruction at RTC. Of the remaining 10 courses, five incorporate VR into the course: AUTC 112- Maintenance and Light Repair, AUTC 117 – Electrical Systems, AUTC 118 – Brakes, AUTC 124 – Heating and Air Conditioning, and AUTC 132 – Steering and Suspension. RTC was chosen for this study because:

- The automotive program has a high completion rate
- The automotive program is utilizing VR instruction (zSpace)
- The automotive faculty at RTC were willing to participate in the study

zSpace

The VR learning platform for this study was zSpace. zSpace was founded in 2007 as Infinite Z and changed its name to zSpace in 2013. zSpace provides VR instruction through immersion in a 3D environment that allows objects to be pulled and manipulated through natural movements, allowing essential automotive tasks to be practiced in a safe, engaging environment. To use zSpace, learners need access to the zSpace proprietary software, a laptop, 3D glasses, and an interactive pen. The platform allows reporting on learner activity within zSpace through an Internet portal accessible by college faculty and staff.

Study Participants

Two groups participated in this mixed methods study. The first group comprised of learners enrolled in an automotive technology course at RTC. They were surveyed to determine their levels of presence during VR instruction. The second group consisted of the automotive faculty utilizing VR instruction. Faculty were interviewed to understand their perceptions of the learning taking place.

Quantitative – Learner Participants

The first group of participants for this study comprised of learners from RTC enrolled in automotive technology courses incorporating VR instruction along with lecture and laboratory training. The survey focused on learner levels of presence during VR instruction. All learners taking an automotive course incorporating VR instruction were asked to participate in the survey. By selecting all eligible learners, the potential for selection bias was eliminated.

The number of eligible learners varied from quarter to quarter, from approximately 66 to 132. The goal was to survey 60 to 90 participants from this group utilizing four to six courses between summer 2021 and fall 2022 quarters. This sample size was selected because of its potential to allow for generalization to the population of community college automotive learners. The criteria for the participants in this first group were:

- Learners enrolled in an automotive technology course at RTC where VR instruction was used
- Learners must be enrolled in credit-bearing courses leading to an automotive technology degree, certificate, or new employment skills in the automotive industry
- Learners must be enrolled between the quarters of summer 2021 and fall 2022

Qualitative – Faculty Participants

The second group of participants for this study comprised of all faculty teaching automotive courses incorporating VR instruction at RTC. The faculty were interviewed with the focus on their perceptions of the learning occurring from the VR instruction. The criteria for the participants in the second group were:

- Instructor of record for one or more of the eligible automotive courses at RTC
- Instructor teaching at least one quarter between summer 2021 and fall 2022

Four faculty members participated in the study. The minimum qualifications to teach automotive technology at RTC are a two-year degree, five years of experience in the field, and current Automotive Service Excellence (ASE) Automotive Master Technician Certification. By interviewing all eligible faculty, the potential for selection bias was eliminated.

Instrumentation

This study gathered data using two instruments, one quantitative and the other qualitative. The first instrument was the PQ 3.0 created by Witmer et al. (2005), which was administered to RTC automotive learners. The second instrument was a set of faculty interview questions created by the researcher, based on the automotive program and course learning outcomes.

Quantitative Instrumentation

The quantitative instrument for this study was the PQ 3.0, which measures presence. It was developed to understand if there was a relationship between VR training used by the military, presence, and learning or task performance (Witmer & Singer, 1998). The study used version 3.0 of the PQ (Witmer et al., 2005), which is a 29-question survey where each question is answered on a seven-point scale for which one is the most negative and seven is the most positive (see Appendix E).

Presence is a concept particularly useful when looking at user experience in a VR environment (VRE). Presence was defined as “the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)” (Knerr et al., 1998, p. 32). The more learners feel part of the VRE, the greater their level of presence. The PQ 3.0 quantifies degree of presence following a VR experience. Witmer and Singer (1994) found, “Approximately 89% of the correlations between presence and task performance for these data were in the predicted direction” (p. 30). A positive relationship between presence and task performance demonstrated learning, which contributed to learner success.

Research conducted by Witmer and Singer (1994) led them to understand two necessary conditions for presence are involvement, a focus of one’s energies and attention, and immersion,

the inclusion and interaction within a VRE. To measure presence, they defined factors contributing to involvement and immersion. Witmer and Singer's original four factors were: (1) control factors such as degree, immediacy, anticipation of events, mode, and physical environment modifiability; (2) sensory factors such as modality, environmental richness, multimodal presentation, consistency of multimodal information, degree of movement perception, and active search; (3) distraction factors such as isolation, selective attention, and interface awareness; and (4) realism factors such as scene realism, information consistent with objective world, meaningfulness of experience, and separation anxiety/distortion. Next, they developed items to measure learner perceptions of those necessary factors within a VRE. The greater the perceived involvement and immersion, determined by scoring the items related to the four factors, the greater level of presence.

In 2005, Witmer et al. further defined and revised the factors related to involvement and immersion and revised the PQ to version 3.0 in a paper titled, *The Factor Structure of the Presence Questionnaire*. The four factors were revised to: (1) involvement, the ability of the learner to control VRE events and how the VRE responds to actions; (2) sensory fidelity, the quality of the sensory interactions and appearance within the VRE; (3) adaptation/immersion, the proficiency of the VRE interaction and how quickly a learner can adjust to the environment; and (4) interface quality, whether the control devices and display contribute to or distract from the ability to concentrate and perform a given task in the VRE. The number of items on the PQ was revised from 32 to 29. Cronbach's Alpha on version 3.0 is 0.91. Cronbach's alpha is a measure used to assess the reliability, or internal consistency, of a set of scale or test items. In other words, the reliability of any given measurement refers to the extent to which it is a consistent

measure of a concept, and Cronbach's alpha is one way of measuring the strength of that consistency.

Scoring the PQ. Scoring the PQ is rather straight forward. The researcher scored the survey following the directions of Witmer et al. (2005). Scoring involved adjusting the response values of some of the questions by reversing their scores. This was a necessary step because the way these questions were worded, the positive presence indication was reversed from the other questions. To reverse the value of these questions, the researcher subtracted the original score from eight. The total presence score for each participant was the sum of the scale scores for all questions. Further, descriptive analysis was conducted on the data, including the level of presence for each individual item and on the four factors of presence. Specifically, the mean and standard deviation for the overall instrument, the four scales, and each of the 29 items were calculated. The researcher used Excel to record the PQ data from the participants and perform the descriptive analysis.

Quantitative instrument reliability and validity. Instrument validity refers to how well it measures what it is supposed to measure. The reliability of the data refers to the consistency with which results occur. Witmer et al. (2005) found the PQ 3.0 was reliable with a Cronbach's alpha of 0.91. The instrument has content validity because it was based on factors found in their review of the presence literature and touches on both involvement and immersion, which are necessary for presence. The construct validity was determined through task performance and statistical analysis, in which Witmer and Singer (1998) found:

Our preliminary results suggest that presence, as measured by the PQ, is a valid construct. Supporting evidence includes consistent positive correlations between the degree of presence and VE task performance. Also, variables that might be expected to be significantly related to presence (e.g., ITQ scores, SSQ scores) were related, while variables that might be expected to be unrelated to presence (Spatial Ability Test scores, number of collisions in VE) were not. The significant

correlation of the items derived from the original factors with the PQ total and with the subscales identified through the cluster analysis also attests to the construct validity of the PQ. (p. 238).

In summary, the PQ 3.0 used in this study was determined to be a valid and reliable instrument.

Qualitative Instrumentation

The qualitative instrument for this study focused on faculty perceptions of learning when using VR in automotive technology instruction. The qualitative instrument was developed by the researcher based primarily on the automotive program and course learning outcomes. Additional questions were developed allowing the faculty to elaborate on specific aspects of learning that occurred when using VR instruction. The interview questions were developed and refined with the assistance of established guidelines (Pew Research Center, n.d.) and reviewed by educational experts. The questions were derived from the automotive program, related to the course learning outcomes, and aligned with Research Question Two. The interview instrument had 14 questions focusing on faculty perceptions of learning with VR instruction (Appendix F). Each interview lasted approximately 30 minutes.

Qualitative instrument validity. The validity of a qualitative research instrument is concerned with its ability to measure the desired variable. For this study, the variable was faculty perceptions of learning from the automotive VR instruction. To validate the instrument, the researcher used an expert panel. This increased the validity of the instrument and reduced the potential for researcher bias. The expert panel was comprised of an automotive content expert, a VR expert, and a research expert. The experts each had a minimum of five years of experience in their respective field and were not members of the RTC staff. The panel determined if the instrument measured what it was intended to measure. The panel reviewed the instrument and

provided feedback to the researcher. The researcher revised the instrument as recommended to ensure it was designed in a way to obtain valid results. The researcher sent a copy of the instrument to each reviewer at the same time, collected their feedback, and incorporated the feedback, repeating these steps until an agreed upon version of the interview was established.

Once an agreed upon version was developed, cognitive interviewing was conducted to pilot test the instrument and ensure validity. Cognitive interviewing is a method allowing a researcher to analyze how those being interviewed understand each question and the process in which the participants go about answering each question (Ryan et al., 2012). This also helped to verify the time necessary for the interview. The faculty participating in the cognitive interviews met the participant qualifications but were not from RTC. The cognitive interviews were recorded on Zoom and reviewed by an evaluator to provide feedback on the researcher's interview techniques.

Data Collection and Data Sources

This section of the study describes how the data were collected, what data were collected, and how they were stored. Approval from the Kansas State University (KSU) and RTC institutional review boards (IRBs) was obtained before gathering data. The quantitative data were collected from RTC automotive learners using a survey instrument, the PQ 3.0 developed by Witmer et al. (2005). The qualitative data were collected from RTC automotive faculty using interview questions developed by the researcher.

Quantitative Data Collection

The quantitative data for this study were collected using the PQ 3.0, which measures learner presence when using VR instruction. This survey was chosen because of its high reliability and validity. Additionally, it was the most commonly cited instrument for measuring

presence on Google Scholar (Schwind et al., 2019) at the time of the study. The survey was administered using both SurveyMonkey and paper copies.

Once IRB approval was received, the quantitative data collection process began. The researcher established a working relationship with the lead automotive faculty member at RTC for assistance with coordination and communication throughout the study. The RTC faculty coordinator sent an email to eligible learners introducing the researcher and study. At the same time, the researcher worked with the RTC faculty coordinator to establish a three-week timeframe for the learners to complete the survey during the selected instructional quarters, between summer 2021 and fall 2022. The participants were encouraged to take the survey within a short time after one of their VR instructional sessions, in the second half of the quarter, so their experience was fresh in their minds and they had an opportunity to become familiar with the VR. The researcher followed up with an email to the prospective participants to further explain the study and solicit participation (Appendix B). All eligible learners were sent an informational letter and consent form containing a link to the survey (Appendix C). After the survey was launched, the researcher followed up with email reminders to complete the survey after two, five, and 10 days.

Qualitative Data Collection

The qualitative data for this study were collected using semi-structured interviews to understand faculty perceptions of learning using VR automotive instruction. The semi-structured interview format was chosen because it allows the researcher to ask additional open-ended questions. In a semi-structured format, the questions serve to introduce topics and can be used to guide the participant into a deeper response (Lochmiller & Lester, 2016). The interviews were recorded, both video and audio, using Zoom. Once IRB approval was received, the researcher

established a working relationship with the lead automotive faculty member at RTC for assistance with coordination and communication throughout the study. The RTC faculty coordinator sent an email to eligible faculty participants introducing the researcher and study. The researcher then followed up with an email to the eligible participants to further explain the study and solicit participation. The faculty participating in the interviews were instructed to contact the researcher, upon which the researcher verified the eligibility of each participant. An informed consent form was sent electronically, which they had to sign and return (Appendix D). Next, a Zoom meeting was scheduled at a time and date convenient for the interviewee. The interviews were conducted toward the end of the quarter, giving faculty participants the maximum time possible to assess learning using VR instruction. Prior to the interview, each participant was sent a follow up email confirming the time and providing the link for the Zoom session. Then the Zoom interviews were conducted and recorded. After the interview, the researcher transcribed the interview using the Zoom transcription capability and verified the accuracy of the transcription, making corrections when necessary. Within 72 hours, the transcription was sent to the interviewee to check for accuracy. Upon conclusion of the interview and transcription verification, the researcher sent each participant an email thanking them for their time and participation in this study.

Data Security

All data collected from the survey were stored on a secured, password protected external drive. Once the study was completed, the Zoom recordings were permanently deleted. The survey data and transcribed interview data were kept at the researcher's residence on the password protected external drive store in a locked container. The names of participants were kept anonymous and the courses were described in general terms related to their level of

difficulty and subject matter, such as introduction to automotive, basic automotive electrical systems, or automotive engine operation.

Data Analysis

In this mixed methods study, the quantitative survey data were analyzed and used to answer Research Question One. The qualitative interview data were analyzed, interpreted, and used to answer Research Question Two. The results from the survey and interviews were analyzed and interpreted using the five steps outlined in *Designing and Conducting Mixed Methods Research* (Creswell & Plano Clark, 2010):

- Step 1: Prepare the data for analysis
- Step 2: Explore the data
- Step 3: Analyze the data
- Step 4: Represent and interpret the results/findings
- Step 5: Validate the data and results/findings

Quantitative Analysis

A quantitative analysis was conducted based on the scoring of the PQ 3.0. This analysis was conducted using descriptive statistics as there was no comparison to another group or between variables within the group. Once the data were scored, the mean and standard deviation were calculated for each of the 29 items of the PQ 3.0, the four scales, and the overall presence score. The standard deviation represents the variance in the scores and shows how homogeneous the group was in terms of their means. The standard deviation is a measure of disbursement, or the spread of the data from the mean in terms of statistical distance.

The scores from the PQ were analyzed for each individual participant and for the group. First, the PQ was scored for each individual participant, indicating the level of presence for each

item, for each of the four factors (involvement, sensory fidelity, adaptation/immersion, and interface quality), and the total level of presence. Second, using the data for the entire group, the mean, standard deviation, and the range were calculated to assess the level of presence for each item, the four factors, and the total level.

Qualitative Analysis

Qualitative data differ from quantitative data in that qualitative data are subjective. Researchers must quantify the subjective qualitative data to allow analysis and interpretation of the data. Once the faculty interviews were completed, the researcher coded and then interpreted the qualitative data. The researcher first transcribed the interviews and became familiar with the data by watching the recorded Zoom video interviews multiple times and reading over the transcriptions two to three times. Next, the researcher coded the data from the transcriptions, looking for units of text, themes, and closely related responses across interviews. The coding utilized the exact words of the participants to minimize researcher bias. Coding is defined as, “Dividing the text into small units (phrases, sentences, or paragraphs), assigning a label to each unit, and then grouping the codes into themes” (Creswell & Plano Clark, 2010, p. 208). The codes from each interview were categorized and a legend of the categories and codes were produced. The codes from each interview were tallied and a frequency table was created to identify themes emerging most often in the data. Lastly, the codes and themes were interpreted.

Qualitative validation: Member-checking. It is important to ensure data are valid. Validity is a measurement of the accuracy of data. To assure the accuracy of the data obtained through the interviews, the researcher member-checked the data. Upon the completion of each interview, a transcript was created within 72 hours. The researcher reviewed the transcript to ensure it was accurate and addressed any language issues. Next, the transcript was sent to the

participant who was asked to review the transcript for accuracy and make any additions. All participants were given one week to provide any updates or additions to their transcripts upon which time they were considered finalized and prepared for data analysis.

Qualitative reliability: Inter-rater reliability. Reliability of qualitative data is important. Inter-rater reliability, sometimes referred to as intercoder agreement, is the degree of agreement among coders or researchers given a set of qualitative data (Creswell & Plano Clark, 2010). This method was used to guard against researcher inaccuracies or bias. For this study, the researcher used a third-party statistician with over 20 years of experience in qualitative research and had her double-code a percentage of the data. To verify the researcher was coding correctly, the coding from the researcher and statistician were compared to check for inter-rater reliability.

Mixed Methods Analysis

The mixed methods analysis employed a convergent parallel design (Creswell & Plano Clark, 2010). The researcher collected the quantitative and qualitative data concurrently, analyzed both separately, interpreted both separately, then compared and related the results of both with an overall interpretation. The quantitative and qualitative results were provided in a joint display comparison noting the convergent and divergent findings.

Ethical Considerations

For this study to bring value to the field, it was conducted in an ethical manner. The researcher recognized possible ethical issues and addressed them prior to conducting the study. The ethical considerations for this study fell into two areas, researcher bias and data collection and storage.

Bias

The researcher currently holds a position at a California community college as an associate professor of automotive technology and has a master's degree in instructional design. There might be a tendency toward bias because of the researcher's background and the focus of this study. This background might also benefit the study when the data are analyzed. The researcher was careful to follow clearly defined protocols (AERA Code of Ethics, 2011; American Association for Public Opinion, n.d.) throughout the study, including data collection and analysis. Strict adherence to the highest level of ethics guards against researcher bias. Additionally, the researcher had the qualitative instrument reviewed by an expert panel and had a statistician review the validity of the coding to reduce the potential for bias.

Data Collection and Storage

Prior to collecting data, this study was reviewed by the KSU and RTC IRBs to ensure it was not deemed as high-risk. Prior to data collection, participants were informed about the intent of the study, risks, benefits, and confidentiality, and were given contact information of the researcher and KSU IRB. Participants were informed their participation was voluntary and there was no penalty for terminating their participation at any time (Appendices C, D).

Once data were collected, they were stored on a password protected device only accessible by the researcher. Once audio recordings were transcribed, the files were destroyed. All transcripts and other data related to the study were destroyed upon publication of this dissertation.

Limitations

Limitations are elements of a study, typically out of the researcher's control, which may influence the results of the study (Wordvice, n.d.). Two potential limitations were identified, one

related to response rate and one related to the timing of the study. Ultimately, the concern was either or both types of limitations could hinder the ability to generalize findings.

A methodological limitation was the low response rate. This might be due to the timing of when the surveys were distributed or limited communications with the learners within the automotive program. Additionally, due to the Covid-19 pandemic, fewer courses were being taught and disruptions within the quarters occurred because of quarantine and other safety precautions, which reduced the number of potential participants. Although data collection was originally intended to occur over a shorter period of time, it was necessary to extend the study to obtain additional data and increase the number of participants.

The timing of the surveys and interviews was between the summer 2021 and fall 2022 quarters at RTC, but the exact time was unknown due to unforeseen issues like the availability of learners due to holidays and the time instructors deemed appropriate. RTC had four faculty members utilizing VR instruction in automotive courses at the time of the study, although they hoped to expand that number in the future. This timing limited the number of faculty who were eligible to participate in the study. Although these were recognizable limitations, they were not insurmountable and do not invalidate study findings.

Chapter Three Summary

Chapter three detailed the methodology for this study. First, the purpose and research questions were reviewed. The purpose of this study was to determine if VR instruction supported learning by measuring learner levels of presence and faculty perceptions of learning when using VR instruction in automotive technology education. Next, the mixed methods research design was described. The quantitative portion of this study was non-experimental and descriptive, where learners enrolled in a community college automotive technology course utilizing VR

instruction were surveyed. Additionally, the qualitative portion of the study comprised of interviews with faculty teaching courses using VR to assess their perceptions of the learning occurring during instruction.

This chapter detailed the study setting of RTC in Renton, Washington, along with the two groups of study participants. The first group were learners enrolled in an automotive technology course at RTC and the second group consisted of the faculty of record for the courses utilizing VR instruction. Next, the study instruments were described. The study data collection processes and sources were then detailed, along with a description of the data analysis conducted. Finally, ethical considerations and limitations were identified. The next chapter presents the findings from this study.

Chapter 4 - Findings and Analysis

This chapter presents the quantitative and qualitative findings and analysis from this study. The purpose of the study is reviewed followed by the findings and analysis of the quantitative and qualitative data. The methodology and sample for both the quantitative and qualitative data are described. Next, the findings of the quantitative and qualitative data are presented, along with an integration of the two where the data are compared. The chapter concludes with a summary of the study findings.

Review of Purpose and Research Questions

The purpose of this mixed methods study was to determine if virtual reality (VR) instruction may support learning by measuring learner levels of presence and faculty perceptions of learning when using VR instruction in a community college, automotive technology program. If the learners' levels of presence were high and the perceptions of faculty were that learning was taking place, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

To successfully complete an automotive course, each learner must have a cognitive understanding of the material and be able to perform the required psychomotor tasks. VR instruction offers a bridge where learners can gain cognitive knowledge and develop psychomotor skills in a safe and forgiving environment without the need for actual physical equipment such as tools and vehicles. In addition, VR instruction offers an environment where mistakes, which are part of the learning process, neither harm the learner nor cost the college because of damage to expensive vehicles and equipment. Two research questions guided this study:

Research Question One: What are learners' levels of presence when using VR in automotive technology instruction?

Research Question Two: What are faculty perceptions of learning when using VR in automotive technology instruction?

Research Question One focused on the learners. The Witmer and Singer Presence Questionnaire (PQ) was used to determine learner levels of presence when using VR during automotive instruction. Research Question One determined if learners using VR felt like they were working on the automobile as measured with the PQ.

Research Question Two focused on faculty perceptions of learning occurring through VR instruction. If faculty believed VR instruction resulted in learning, this may indicate VR instruction can effectively be incorporated into automotive technology curriculum to teach necessary skills.

Review of Methodology

The quantitative data for this study were collected using the PQ 3.0, which measures learner presence when using VR. This survey was chosen because of its high reliability and validity. Additionally, it was the most cited instrument for measuring presence on Google Scholar (Schwind et al., 2019). The survey was delivered using both SurveyMonkey and paper copies.

A quantitative analysis was conducted based on the scoring of the PQ. This analysis was conducted using descriptive statistics as there was no comparison to another group or between variables within the group. Once the data were scored, the mean and standard deviation were calculated for each of the 29 items of the PQ, the four scales, and the overall presence score.

The scores from the PQ were analyzed for each individual participant and for the group. First, the PQ was scored for each individual participant, indicating the level of presence for each item, for each of the four factors (involvement, sensory fidelity, adaptation/immersion, and interface quality), and the total level of presence. Second, using the data for the entire group, the mean, standard deviation, and the range was calculated to assess the level of presence for each item, the four factors, and the total level for the group.

The qualitative data for this study were collected using semi-structured interviews to understand faculty perceptions of learning using VR in automotive instruction. The semi-structured interview format was chosen because it allowed the researcher to ask additional open-ended questions and probe to obtain a deeper response. The interviews were recorded using Zoom.

Qualitative data differ from quantitative data in that qualitative data are subjective. Researchers must quantify the subjective qualitative data to allow for analysis and interpretation of the data. Once the faculty interviews were complete, the researcher coded and then interpreted the qualitative data. The researcher transcribed the interviews then coded the transcriptions looking for units of text, themes, and closely related responses across interviews. The coding utilized the exact words of the participants to minimize researcher bias. The codes from each interview were categorized and a legend of categories and codes were produced. The codes from each interview were tallied and a frequency table was created to identify themes emerging most often in the data. Lastly, the codes and themes were interpreted.

The mixed methods analysis employed a convergent parallel design. The researcher collected the quantitative and qualitative data concurrently, analyzed both separately, interpreted both separately, then compared and related the results of both with an overall interpretation. The

quantitative and qualitative results were provided in a joint display comparison noting the convergent and divergent findings.

Description of the Sample - Learners

Renton Technical College (RTC) was chosen for this study. The automotive program at RTC offers two certificates and a two-year associate of applied science degree. Automotive technology courses vary from 1-10 credits. The maximum class size in the automotive technology program was 22. The automotive program at RTC offers 14 courses, of which four are only lecture. These four courses were not a fit for the current VR instruction at RTC. Of the remaining 10 courses, five incorporated VR into the course: AUTC 112- Maintenance and Light Repair, AUTC 117 – Electrical Systems, AUTC 118 – Brakes, AUTC 124 – Heating and Air Conditioning, and AUTC 132 – Steering and Suspension. RTC was chosen for this study because:

- The automotive program has a high completion rate
- The automotive program is utilizing VR instruction (zSpace)
- The automotive faculty at RTC were willing to participate in the study

The third version of the Presence Questionnaire (PQ 3.0; Witmer et al., 2005) was used to gather the quantitative data (Appendix E). Four groups of learners were surveyed, each comprised of learners from the courses utilizing zSpace. The first three groups were given a SurveyMonkey link and asked to complete the survey after using zSpace. Because the return rate was so low, the fourth group was given the option to use SurveyMonkey or complete a hard copy of the survey. In addition, the fourth group was incentivized to complete the survey. Learners were not allowed to take the survey more than once.

Several factors complicated the survey process. The main factor was the Covid-19 pandemic. Enrollment in the automotive program dropped because of the pandemic and there were internal infrastructure issues. For example, one quarter there was a mix-up between the automotive program and the technology department and the zSpace laptops were not accessible for instruction. During some courses, the use of zSpace was delayed, which made administering the survey difficult because the facilitators were scrambling to catch up and complete course learning outcomes.

Group one was surveyed in August 2021 via SurveyMonkey. Of 21 learners given the survey, eight completed it. Group two was surveyed December 2021 via SurveyMonkey. Three of 11 learners completed the survey. Group three was surveyed in April 2022 via SurveyMonkey. Ten of 21 learners completed the survey. Group four was surveyed December 2022 via a paper copy administered during class time. Twenty-three of 51 learners complete the survey. As shown in Table 4.1, 44 surveys were completed out of 104 given out for a response rate of 42%.

Table 4.1 Sample of Learners

	Group 1	Group 2	Group 3	Group 4	Total
Date	August 2021	December 2021	April 2022	December 2022	
Method	SurveyMonkey	SurveyMonkey	SurveyMonkey	Hard Copy	
Learners	21	11	21	51	104
Surveys Returned	8	3	10	23	44
Completion Rate	38%	27%	48%	45%	42%

Description of the Sample - Faculty

Four automotive faculty from RTC were interviewed for this study. Each was a full-time automotive faculty member. To maintain anonymity, they are referred to as *Interviewee A, B, C,* and *D* when necessary to distinguish between faculty. One of the interviewees had been teaching

at RTC for one semester, one for two years, one for four years, and one for over a decade. Of the four, one had extensive experience using zSpace, two had a moderate amount of experience with zSpace, and one had little experience with the VR tool. The first faculty member was interviewed in October of 2021 and the final interview took place in July of 2022.

Each interview lasted approximately 30 minutes. The interviews took place over Zoom and were recorded. A transcript of each interview was created and each interviewee was offered an opportunity to review and revise their particular transcript. No revisions were requested from their review.

Description of Sample – Mixed Methods

The mixed methods analysis employed a convergent parallel design. The researcher collected the quantitative and qualitative data concurrently, analyzed both separately, interpreted both separately, then compared and related the results with an overall interpretation. The sample for the mixed methods portion was comprised of 37 learners and the four faculty, each of whom were utilizing VR instruction, from the automotive program at RTC. The learners comprised the quantitative data and the faculty comprised the qualitative data for this study.

Learner Levels of Presence Findings and Analysis

The quantitative data were analyzed and findings presented to answer the first research question. Research Question One was: *What are learners' levels of presence when using VR in automotive technology instruction?* Research Question One focused on the learners. The PQ 3.0 was used to determine learners perceived levels of presence when using VR during automotive instruction. Research Question One examined if learners using VR felt like they were present, working on the automobile, as measured by the PQ.

Review of Quantitative Analysis Methodology

A quantitative analysis was conducted based on the scoring of the PQ. This analysis was conducted using descriptive statistics as there was no comparison to another group or between variables within the group. Once the data were scored, the mean and standard deviation were calculated for each of the 29 items of the PQ, the four scales, and the overall presence score. The standard deviation represents the variance in the scores and shows how homogeneous the group was in terms of their means. Standard deviation is a measure of disbursement, or the spread of the data from the mean in terms of statistical distance.

The Quantitative Instrument

The quantitative instrument for this study was the PQ 3.0, which measures presence and was developed to understand if there was a relationship between VR training used by the military, presence, and learning or task performance (Witmer & Singer, 1998). The PQ 3.0 is a 29-question survey where each question was answered on a seven-point scale for which 1 = *Not at All* and 7 = *Completely* (Appendix E).

Presence is a concept particularly useful when looking at user experience in a virtual reality environment (VRE). The more the learner feels part of the VRE, the greater their level of presence. The PQ 3.0 quantifies degree of presence following a VR experience. Witmer and Singer (1994) found a link between presence and task performance, which demonstrates learning.

Scoring the PQ. Scoring the PQ was rather straight forward and followed the directions of Witmer et al. (2005). This scoring involved adjusting the response values for three of the items by reversing their scores. This was a necessary step because of the way these three items were worded, a high score indicated a lack of presence. To reverse the value of these items, the

researcher subtracted the original score from eight. When the item scores were reversed, the mean scores could be compared to all other items in the PQ and a total PQ score could accurately be calculated. Once the values of the three items were reversed the total presence score for each participant was the sum of the scale scores for all items. Further, descriptive analysis was conducted on the data, including the level of presence for each individual item and on the four factors of presence. Specifically, the mean and standard deviation for the overall instrument, the four scales, and each of the 29 items were calculated. The researcher used Excel to record the PQ data from the participants and to analyze the data.

Learner Levels of Presence Findings

The scores from the PQ were gathered, organized, and cleaned. The scores from items 19, 22, and 23 were reversed coded. This was necessary because the way these questions were worded, the positive presence indication was reversed from the other the questions. To reverse the value of these questions, the researcher subtracted the original score from eight.

During the data cleaning process, seven of the surveys were excluded from the original 44, leaving a total of 37 valid surveys. The seven surveys were removed due to their suspicious nature. In two cases, the participants put all 1s or all 7s, even for the questions where the positive indication of the question was reversed, indicating these participants did not actually read the items. Five other surveys were also suspicious and their data removed. In each case, the participant selected 4 for every item after the first couple questions. It appeared they honestly started the survey but then, after answering 2-4 of the 29 questions, they decided the survey was too long and simply selected 4 for the remaining survey questions.

The PQ was scored for each individual item to include the mean, standard deviation, and range (Table 4.2). The findings were in the positive direction. The mean score for each item was

above the midpoint of 3.5. The mean had a range between 3.59 and 5.32 and the standard deviation had a range between 1.16 and 1.81.

Table 4.2 Descriptive Statistics by Survey Question

	Survey Question	Mean	Standard Deviation	Range
Item 1	How much were you able to control within zSpace?	4.92	1.23	1-7
Item 2	How responsive was zSpace to actions that you initiated?	4.76	1.16	1-7
Item 3	How natural did your interactions with zSpace seem?	4.22	1.60	1-7
Item 4	How much did the visual aspects of zSpace involve you?	4.95	1.31	1-7
Item 5	How much did the auditory aspects of zSpace involve you?	4.30	1.47	1-7
Item 6	How natural was the mechanism that controlled movement through zSpace?	4.03	1.69	1-7
Item 7	How compelling was your sense of objects moving through zSpace?	4.73	1.33	1-7
Item 8	How much did your experience in zSpace seem consistent with your real-world experience?	4.41	1.52	1-7
Item 9	Were you able to anticipate what would happen next in response to the actions that you performed?	4.95	1.54	1-7
Item 10	How completely were you able to actively survey or search zSpace using vision?	4.70	1.53	1-7
Item 11	How well could you identify sounds?	4.46	1.50	1-7
Item 12	How well could you localize sounds?	4.19	1.67	1-7
Item 13	How well could you actively survey or search within zSpace using touch?	4.35	1.49	1-7
Item 14	How compelling was your sense of moving around inside zSpace?	4.41	1.48	1-7
Item 15	How closely were you able to examine objects?	5.32	1.81	1-7
Item 16	How well could you examine objects from multiple viewpoints?	5.22	1.71	1-7
Item 17	How well could you move or manipulate objects in zSpace?	5.19	1.35	1-7
Item 18	How involved were you in the zSpace experience?	4.81	1.51	1-7
Item 19	How much delay did you experience between your actions and expected outcomes?	3.62	1.46	1-7

Item 20	How quickly did you adjust to the zSpace experience?	4.76	1.50	1-7
Item 21	How proficient in moving and interacting with zSpace did you feel at the end of the experience?	4.81	1.47	1-7
Item 22	How much did the visual display quality interfere or distract you from performing assigned tasks?	4.00	1.76	1-7
Item 23	How much did the control devices interfere with the performance of assigned tasks?	3.59	1.77	1-7
Item 24	How well could you concentrate on the assigned tasks rather than on the mechanisms used to perform those tasks?	4.51	1.30	1-7
Item 25	How completely were your senses engaged in zSpace?	4.62	1.28	1-7
Item 26	How easy was it to identify objects through physical interaction, like touching an object?	4.43	1.48	1-7
Item 27	Were there moments within zSpace when you felt completely focused on the task?	4.54	1.46	1-7
Item 28	How easily did you adjust to the control devices used to interact with zSpace?	4.62	1.50	1-7
Item 29	Was the information provided through different senses (e.g., vision, hearing, touch) in zSpace consistent?	4.62	1.50	1-7
Total	Overall Responses	4.55	1.50	1-7

Analysis of Learner Levels of Presence

The highest participant mean (and highest standard deviation) on the PQ was item 15 ($M = 5.32$, $SD = 1.81$), which related to the ability to closely examine objects. The lowest mean from the PQ was item 23 ($M = 3.59$, $SD = 1.77$), which referred to how much the control devices interfered with performing tasks. Both the highest and lowest means involved the use of a stylus and glasses allowing a three-dimensional (3D) view of objects on a laptop screen. This setup allowed participants to manipulate 3D objects in VR.

A noticeable difference in the standard deviation between the items in the PQ was found. The lowest standard deviation was 1.16 for item 2 and the highest was 1.81 for item 15. The

differences in the standard deviations may have been due to a number of factors, including the environment around participants when using VR, familiarity with the zSpace tool, experience with VR, proficiency with technology, and the effort expended to focus when using VR. Other VR hardware incorporates the use of VR goggles like Oculus. This hardware may provide for a more uniform experience.

In summary, the mean for each item on the PQ was above the middle of the response scale, which was 3.5. These scores coupled with the fact that Witmer and Singer (1994) found a high correlation between presence and task performance is a strong indication that the students were present when using the VR and that learning was taking place.

Factors of the Presence Questionnaire

Presence can be defined as a psychological state of being in the moment. Presence “depends on the fidelity of its sensory components, the nature of the required interactions and tasks, the focus of the user’s attention/concentration, and the ease with which the user adapts to the demands of the environment” (Witmer et al., 2005, p. 289). To provide a robust measure of presence, Witmer et al., identified four factors related to measuring presence and refined their PQ instrument by focusing the items on these factors. Before the PQ 3.0, other factors were considered. In their paper titled, *The Factor Structure of the Presence Questionnaire*, the factors were revised to:

- **Involvement:** An interface facilitating control over the activities in the VRE
- **Sensory Fidelity:** A VRE configuration permitting users to closely exam objects
- **Adaptation/Immersion:** A VRE in which users are able to quickly adjust to and operate in the experience
- **Interface Quality:** Perceived quality of the VRE and interface

Relationship between the factors. Each of the four factors comprise the total level of presence. Witmer et al. (2005) determined a relationship exists between the factors affecting presence. The two primary factors of presence, involvement and adaptation/immersion, were highly correlated. When there was a positive or negative influence on one, the other followed in the same direction. Next, sensory fidelity affected both involvement and adaptation/immersion, with a greater impact on involvement. Last, interface quality was found to effect adaptation/immersion. It can be useful to understand the relationship between the factors. A VR developer could look at the scores for each of the factors to help determine how to improve the level of presence in a simulation. For example, if the involvement and adaptation/immersion were both low one could increase the sensory fidelity which would have a positive effect on both and increase the level of presence. The following sections provide the findings and analysis of the data related to the four factors.

Involvement findings. Involvement is based on having a natural interface that facilitates control of the VRE. It is the predominant factor in the PQ comprised of 12 items. The highest mean for the involvement factor was item 17 ($M = 5.19$, $SD = 1.35$), which was the ability to manipulate items in the VRE. The movement and manipulation of objects in the zSpace VR were facilitated by a stylus wired to the zSpace laptop and three-dimensional glasses. The participants believed this method allowed them to manipulate objects in VR. In contrast, the lowest mean from this factor was item 6 ($M = 4.03$, $SD = 1.69$), which related to the natural control of movements. Both the highest and lowest means involved the use of the stylus and three-dimensional glasses and even the lost mean was still above the midpoint of 3.5. The remaining items on the involvement scale ranged from a mean of 4.22 to 4.95, with standard deviations between 1.16 and 1.69 (Table 4.3).

Table 4.3 Descriptive Statistics for the Involvement Factor

	Survey Question	Mean	Standard Deviation	Range
Item 1	How much were you able to control within zSpace?	4.92	1.23	1-7
Item 2	How responsive was zSpace to actions that you initiated?	4.76	1.16	1-7
Item 3	How natural did your interactions with zSpace seem?	4.22	1.60	1-7
Item 4	How much did the visual aspects of zSpace involve you?	4.95	1.31	1-7
Item 6	How natural was the mechanism that controlled movement through zSpace?	4.03	1.69	1-7
Item 7	How compelling was your sense of objects moving through zSpace?	4.73	1.33	1-7
Item 8	How much did your experience in zSpace seem consistent with your real-world experience?	4.41	1.52	1-7
Item 10	How completely were you able to actively survey or search zSpace using vision?	4.70	1.53	1-7
Item 14	How compelling was your sense of moving around inside zSpace?	4.41	1.48	1-7
Item 17	How well could you move or manipulate objects in zSpace?	5.19	1.35	1-7
Item 18	How involved were you in the zSpace experience?	4.81	1.51	1-7
Item 26	How easy was it to identify objects through physical interaction, like touching an object?	4.43	1.48	1-7
Total	Involvement Factor	4.63	1.43	1-7

The involvement factor items related to how participants were focusing their mental energy and attention to the stimuli and how they were interacting with the VRE. This factor sought to determine if participants felt engaged in the VRE when performing activities. The greater the involvement, the greater the presence. Study participants scored above the midpoint with factor mean of 4.63 ($SD = 1.43$). This was a positive indication of presence and supported the idea that participants were learning.

Sensory fidelity findings. Sensory fidelity is the degree to which the VRE permits active and close examination of the objects. It is a contributing factor to presence and effects involvement and adaptation/immersion. The PQ has six items to measure sensory fidelity.

The highest mean for the sensory fidelity factor was item 15 ($M = 5.32$, $SD = 1.81$), indicating participants were able to examine objects closely. This was important when the VR tasks involved automotive objects like engines, brakes, and air conditioning systems. The lowest mean for this factor was item 12 ($M = 4.19$, $SD = 1.67$), which related to localizing sounds in the VRE. This was still above the midpoint of 3.5. The remaining items for sensory fidelity ranged from means of 4.30 to 5.22 and standard deviations between 1.47 and 1.81 (Table 4.4).

Table 4.4 Descriptive Statistics for Sensory Fidelity Factor

	Survey Question	Mean	Standard Deviation	Range
Item 5	How much did the auditory aspects of zSpace involve you?	4.30	1.47	1-7
Item 11	How well could you identify sounds?	4.46	1.50	1-7
Item 12	How well could you localize sounds?	4.19	1.67	1-7
Item 13	How well could you actively survey or search within zSpace using touch?	4.35	1.49	1-7
Item 15	How closely were you able to examine objects?	5.32	1.81	1-7
Item 16	How well could you examine objects from multiple viewpoints?	5.22	1.71	1-7
Total	Overall Sensory Fidelity Factor	4.64	1.61	1-7

Lack of sensory fidelity can distract the VR user and decrease the involvement and immersion, whereas high sensory fidelity can increase involvement, immersion, and thus presence. The participants in this study rated sensory fidelity above the midpoint with an average mean 4.64 ($SD = 1.61$). This was a positive indication of presence and supported the idea that participants were learning.

Adaptation/Immersion findings. Adaptation/immersion is the perceived proficiency of interacting with and operating within the VRE and how quickly users adjusted to the VRE. This

factor had the second most items on the PQ with eight. Adaptation/immersion had the highest overall mean of the four factors, indicating participants were able to quickly acclimate to the VRE. More specifically, the highest mean for the adaptation/immersion factor was item 9 ($M = 4.95$, $SD = 1.54$), which referred to anticipating responses in the VRE based on their actions. Anticipating responses in the VRE will help them understand what will happen when performing a similar task in a live auto shop. The lowest mean was item 24 ($M = 4.51$, $SD = 1.30$), which was still a full point above the 3/5 midpoint, indicating learners were able to focus on the VR task instead of the equipment used to do the task. The remaining items for adaptation/immersion ranged from a mean of 4.81 to 4.54 with standard deviations between 1.28 and 1.54 (Table 4.5).

Table 4.5 Descriptive Statistics for the Adaptation/Immersion Factor

	Survey Question	Mean	Standard Deviation	Range
Item 9	Were you able to anticipate what would happen next in response to the actions that you performed?	4.95	1.54	1-7
Item 20	How quickly did you adjust to the zSpace experience?	4.76	1.50	1-7
Item 21	How proficient in moving and interacting with zSpace did you feel at the end of the experience?	4.81	1.47	1-7
Item 24	How well could you concentrate on the assigned tasks rather than on the mechanisms used to perform those tasks?	4.51	1.30	1-7
Item 25	How completely were your senses engaged in zSpace?	4.62	1.28	1-7
Item 27	Were there moments within zSpace when you felt completely focused on the task?	4.54	1.46	1-7
Item 28	How easily did you adjust to the control devices used to interact with zSpace?	4.62	1.50	1-7
Item 29	Was the information provided through different senses (e.g., vision, hearing, touch) in zSpace consistent?	4.62	1.50	1-7
Total	Overall Adaptation/Immersion Factor	4.68	1.44	1-7

The adaptation/immersion factor is characterized by one's perception of being included in and interacting within VR. This is often the sensation one describes when enjoying a good

book. They are immersed in the story and along for the ride with the main characters. The higher the level of adaptation/immersion, the higher the level of presence. The participants in this study scored above the midpoint with a factor mean of 4.68 ($SD = 1.44$). This was a positive indication of presence and supported the idea that participants were learning.

Interface quality findings. Interface quality examines the extent to which technology enhances activities in the VRE, which contributes to presence. Three items on the PQ measure interface quality. These three items were negatively worded and thus needed to be reverse coded prior to scoring, which entailed subtracting participant responses from eight so they would be comparable to other items in the PQ and a total PQ score could accurately be calculated.

The highest mean for the interface quality factor was item 22 ($M = 4.00$, $SD = 1.76$) related to the visual display. The lowest mean was item 23 ($M = 3.59$, $SD = 1.77$) related to the control devices. This was only slightly above the midpoint of 3.5. The remaining items for interface quality ranged from a mean of 3.62 to 4.00 and a standard deviation of 1.47 to 1.76.

Table 4.6 Descriptive Statistics for the Interface Quality Factor

	Survey Question	Mean	Standard Deviation	Range
Item 19	How much delay did you experience between your actions and expected outcomes?	3.62	1.46	1-7
Item 22	How much did the visual display quality interfere or distract you from performing assigned tasks?	4.00	1.76	1-7
Item 23	How much did the control devices interfere with the performance of assigned tasks?	3.59	1.77	1-7
Total	Overall Interface Quality Factor	3.74	1.66	1-7

Interface quality had the lowest mean across the four factors, indicating participants experienced presence despite the mixed perceptions of quality of the interface. Some participants thought the quality of the VR control devices hindered their experience, which could have reduced their level of presence when using VR.

Interface quality can increase or decrease the time it takes to adapt to VR. The higher the interface quality, the more quickly users adapt to VR. The higher the level of interface quality, the higher the level of presence. Learners scored slightly above the midpoint with a mean of 3.74 ($SD = 1.66$). Although above the midpoint, it was the lowest of the four factors. Learning was taking place but improving the quality of the interface could raise the overall PQ scores and levels of presence. The next section covers findings by demographics.

Demographics

Three demographic questions were included at the end of the PQ survey. These demographic questions asked about gender, age group, and were comprised of questions about gender, age, and number of courses taken. Responses to the question on gender revealed that 89% of the participants were male, 5% were female, and 5% preferred not to answer. Of the 37 participants used for the data analysis, 33 were male with only two females and two who preferred not to answer. In terms of age, 25 participants were aged 18-24, six were aged 25-39, two were 40 or older, and four did not answer. In terms of the number of courses taken, 32 participants had previously taken 1-3 courses, one had taken 4-6 prior courses, one had taken more than 10 prior classes, and three did not answer (Table 4.7).

Table 4.7 Demographics

	n	%
Gender		
Male	33	89
Female	2	5
No Answer	2	5
Age Group		
18-24	25	68
25-39	6	16
40-45	2	5
No Answer	4	11
Number of Prior Courses		
1-3	32	86
4-6	1	3
7-10	0	0
10 +	1	3
No Answer	3	8

Demographic analysis. Gender was the least balanced of the three demographic groups with 89% male, 5% female, and 5% who preferred not to answer. The overall mean of the PQ was 4.55 ($SD = 1.50$). Males were just below the overall mean and standard deviation ($M = 4.49$, $SD = 1.51$) whereas the females were above the overall with a mean of 5.29 ($SD = 0.71$; Table 4.8). Although females had the highest ratings of any demographic group, they only comprised 5% of the population (2 of 37), so no conclusions can be drawn.

Table 4.8 Mean and Standard Deviation by Gender

Gender	<i>M</i>	<i>SD</i>
Male	4.49	1.51
Female	5.29	.71
Total	4.55	1.50

Age was the most balanced of the three demographics groupings included in the study, with 68% aged 18-24, 16% aged 25-39, and 5% aged 40-45 (11% did not answer). Due to the small number of participants, the analysis was conducted to compare two groups, those aged 18-24 and those older than 25 (Table 4.9). The overall mean was 4.55 with a standard deviation of

1.50. Those aged 18-24 were slightly below the overall mean and standard deviation ($M = 4.38$, $SD = 1.54$) whereas those 25 and older were slightly above ($M = 4.85$, $SD = 1.34$). The participants aged 25 and older reported a higher level of presence than those aged 18-24.

Table 4.9 Mean and Standard Deviation by Age

Age Group	<i>M</i>	<i>SD</i>
18-24	4.38	1.54
25+	4.85	1.34
Overall	4.55	1.50

The demographic of the number of courses taken was not balanced, with 86% of participants having taken 1-3 courses, 3% having taken 4-6 courses, 3% who took 10+ courses, and 8% who did not answer. Due to the small number of participants in each group, the number of courses taken was broken down into two groups for comparison: those who took 1-3 courses and those who took four or more courses (Table 4.10). The overall mean was 4.55 ($SD = 1.50$). Those who had taken 1-3 courses were equivalent to the overall mean and standard deviation with $M = 4.54$ and $SD = 1.53$. Those who had taken four or more courses were lower than the overall with a mean of 3.04 ($SD = 2.13$). Participants who had taken four or more courses reported a significantly lower level of presence than those who had taken 1-3 courses.

Table 4.10 Mean and Standard Deviation by Courses Taken

Number of Prior Courses	<i>M</i>	<i>SD</i>
1-3	4.54	1.53
4+	3.04	2.13
Overall	4.55	1.50

Demographics summary. The responses to the demographic questions revealed the vast majority of participants were males aged 18-24 who had taken 1-3 automotive courses, which is reflective of community college automotive learners. The number of participants was low and two of the demographic categories were overwhelmingly grouped, gender and number of courses

taken. Gender showed female ratings were higher than the overall mean for males, but females only represented 5% of the sample so it is difficult to know if this would hold true with a larger group of participants. The demographic of age showed those aged 25 and over had the highest overall mean, indicating higher levels of presence than those aged 18-24. Participants who had taken 1-3 courses had a higher overall mean compared to those who had taken more courses, indicating those newest to automotive instruction had higher levels of learning from VR.

Summary of Learner Levels of Presence

This section presents findings related to RQ1. After the data were cleaned, the mean, standard deviation, and range were calculated for each participant, each item, and each factor. Three demographic variables were collected (gender, age, and number of courses taken), but the sample size was too small to draw significance.

The mean scores for the overall PQ and four factors were each above the scale midpoint of 3.5 (Table 4.11). Regarding RQ1 (*What are learners' levels of presence when using VR in automotive technology instruction?*), these findings indicated learner level of presence was positive and learning was taking place.

Table 4.11 PQ Factor Means, Standard Deviations, and Range

	<i>M</i>	<i>SD</i>	Range
Overall	4.55	1.50	1-7
Involvement Factor	4.63	1.43	1-7
Sensory Fidelity Factor	4.64	1.61	1-7
Adaptation/Immersion Factor	4.68	1.44	1-7
Interface Quality Factor	3.74	1.66	1-7

Faculty Perceptions of Learning Findings and Analysis

RQ2 was: *What are faculty perceptions of learning when using VR in automotive technology instruction?* To address this RQ, interviews were conducted with four faculty

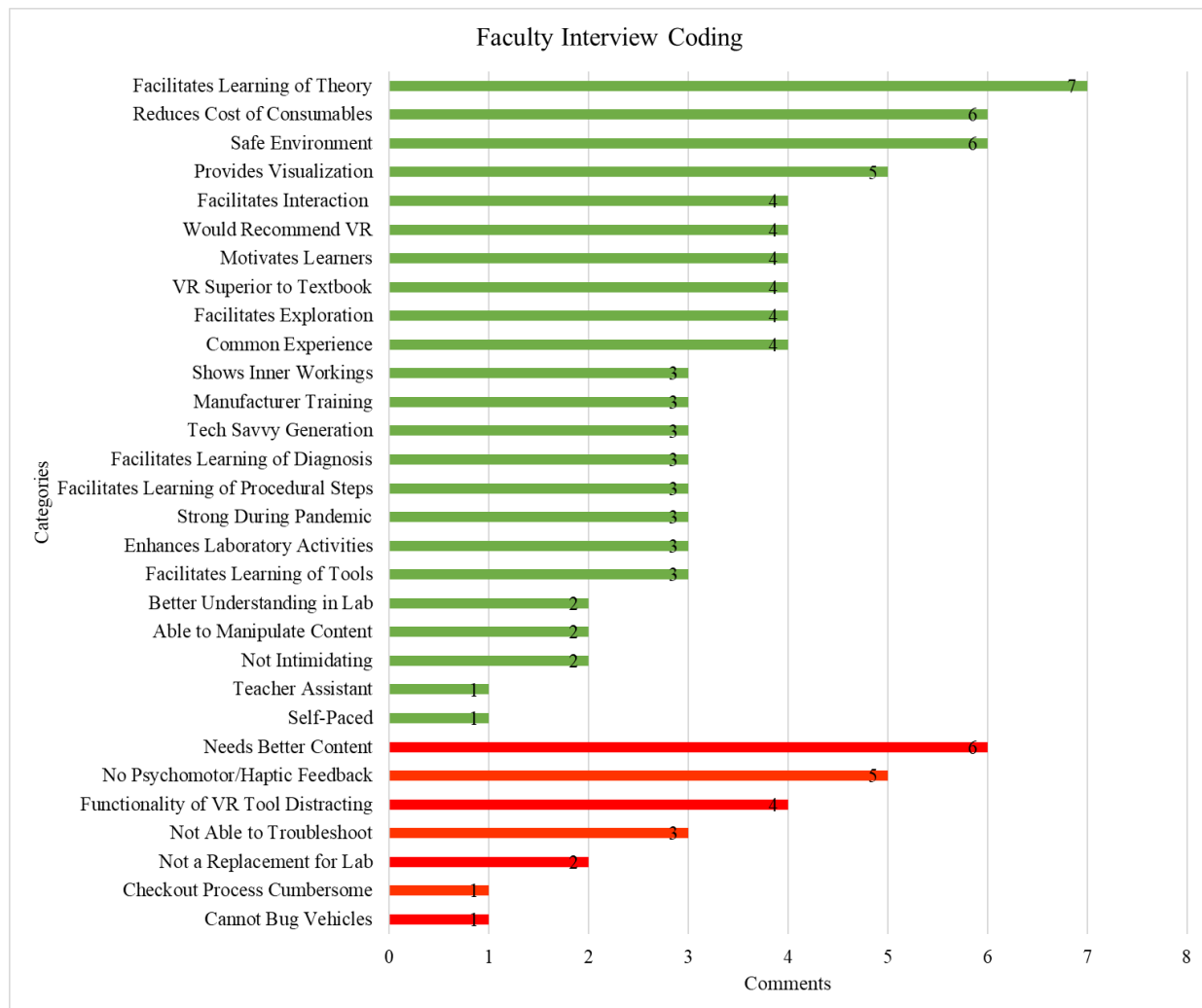
members following the interview protocol (Appendix F). Faculty interviews were conducted, transcribed, and coded. Comments were tallied to determine which words and phrases were used most often in response to the questions. Related comments were categorized and given a one word or a brief phrase title. From the coding, a total of 102 comments and 30 categories emerged. Some categories were marked as having only one comment because they were closely related to another category but offered meaningful standing on their own. After the comments were coded, categorized, and tallied, themes emerged. The first theme was *Positive and Negative Comments*. This was followed by *Motivation*, *Technical Strengths*, and *Facilitation of Learning*.

Positive and Negative Comments

After coding comments and categories, the theme *Positive and Negative Comments* emerged, with 23 positive categories (indicated by green bars) comprised of 80 comments and seven negative categories (indicated by red bars) comprised of 22 comments (Figure 4.1).

Approximately 78% of faculty comments (80 of 102) were answered in a positive manner. Positive comments were those primarily focused on the positive characteristics of VR regarding the impact on automotive education. The three categories with the highest positive comments were: *Facilitates Learning on Theory* (7 comments), *Reduces Cost of Consumables* (6 comments), and offers a *Safe Environment* (6 comments). Six categories had 4 comments, eight categories had 3 comments, three categories had two comments, and two categories with 1 comment. The faculty comments clearly indicated VR facilitated learning in automotive education.

Figure 4.1 Positive and Negative Comments



Positive comment analysis. The first category showing faculty believed VR supported learning was *Facilitates Learning of Theory*. This category had the most comments of any with seven. Each faculty member commented that VR provided learning about automotive theory. They explained it was difficult to get learners to read the textbook, but VR was something they engaged in without much prompting. Participant A shared,

I can see how something like [VR] could help students understand how those systems work a lot better than just reading in a textbook and looking at figures. If you can interact with something definitely will help them learn the systems a lot better.

Faculty also commented that VR could work as a one-on-one facilitator as the technology grows. Participant C noted, “There’s a lot of mentoring and one-on-one that needs to happen, but when you have classrooms that are traditionally 24 plus, 30 plus students, for one instructor it's hard. VR can be that intermediate as the technology develops.”

The second category showing faculty believed VR supported learning was *Consumables*. This category had the second most comments with six. Participant C shared, “For areas where we use a lot of consumables or need a lot of parts, AR/VR will be great to use because, for one, it doesn’t take up that much space we don’t have to continue buying consumables.” It is costly to support hands-on laboratory activities as items break or wear out, and their initial cost can be prohibitive to the point of not having enough for each learner. Because of this, learners must work in groups in the laboratory and may not get the hands-on skills needed. Participant C noted,

I can see the automotive program applying this (VR) whether it's for maintenance, light repair, or for servicing and inspections. More for areas of study where there's a lot of consumables or you need a lot of part mockups like transmissions automatic and manual, and engine repair.

The third category showing faculty believed VR supported learning was *Safe Environment*. This category also had six comments. Learners can hurt themselves or hurt others in their group during laboratory activities and/or damage parts of the vehicle or equipment. VR gives learners the opportunity to practice skills and become familiar with a procedure before attempting it in a laboratory setting. Participant C shared, “Virtual reality can actually help or prevent someone from getting hurt when working in the lab.”

To summarize, approximately 78% of faculty comments were positive regarding the use of VR in automotive education. Many positive comments related to how VR facilitated learning, reduced the need for consumables, and offered a safe learning environment. These findings showed faculty had a positive perception of VR in automotive education.

Negative comment analysis. Approximately 22% of faculty comments (22 of 102) related to this theme. Negative comments primarily focused on the negative characteristics of VR regarding impacting automotive education. The three categories with the highest number of negative comments were: *Needs Better Content* (6 comments), *No Psychomotor/Haptic Feedback* (5 comments), and *Distracting Functionality of the VR Tool* (4 comments). The category *Not a Replacement for Lab* had two comments but tied in closely with other negative categories.

The negative category with the most comments was *Needs Better Content*, with six. The faculty shared how content tended to be generic, such as representing 4-cylinder engine with the main components and sub-components but not the level of detail in a real engine. Although this was good for learners in the beginning courses, those in the intermediate and advanced courses would benefit from a higher level of complexity seen in an actual automotive engine. Participant B said, “I guess I just want more; I want better content. I feel like we’re kind of in the proto or beta phase of things. It could be good but it’s not quite there yet.”

The category with the next greatest number of comments was *No Psychomotor/Haptic Feedback* with five comments. Faculty indicated VR tasks did not give learners an experience of what it would be like performing laboratory tasks on vehicles. For example, in a laboratory activity with a real vehicle, learners would feel heat from certain components, resistance when trying to loosen bolts, the weight of removing a wheel assembly, and the noises related to a component malfunction. Participant B explained, “No haptic feedback, what does it feel like to break a bolt loose? What does it feel like when a component slides into its place, or a clip clicks into place? You’re missing that.” Some of the faculty shared that it gave learners a false sense of

what it was like to repair vehicles because things seemed easy within the VR. This was highlighted by Participant D who shared,

It makes everything feel very easy and a lot of students, when they go to do the real thing, this is really difficult. Especially with like suspension, I have to say, is probably the most on that. If you do it on the computer and everything's just perfect and everything just comes into place. Then you go to try to take a CV shaft out in the real world, and it will come out of nothing like the VR. Okay wait a minute. I took all the bolts out, but you know it's still not coming out. Well, you get to use your little friend air hammer.

The category with the third highest number of negative comments was *Distracting Functionality of the VR Tool* with four comments. Faculty indicated there was a learning curve when it came to the stylus, how the screen was viewed, and the lighting available in the room where zSpace was used. When asked what aspects of VR learners seem to struggle with most, Participant D responded, "Getting the stylist in the proper distance from the screen took some practice." Participant C said, "Getting used to the stylists or the lighting and then the height were difficult." Similarly, Participant B noted, "Learning how exactly to manipulate the models in VR." Considering how this negatively impacted learners, it might be beneficial to have an introductory zSpace navigation module. In addition, improvements to hardware and user interface could help to mitigate this issue.

It is important to note the category *Not a Replacement for Lab* was closely related to the aforementioned categories. It was made a unique category because faculty comments made emphatic statements. For example, Participant D said, "I would say it's definitely not something I would recommend as a sole learning product" and Participant B said, "It is a good kind of primer, but there is no substitute for putting your hands on the vehicle."

In summary, faculty comments were negative about VR learning in automotive education approximately 22% of the time. Most negative comments focused on the need for better content, the lack of haptic interface, and the distracting functionality of the user interface. Even in these

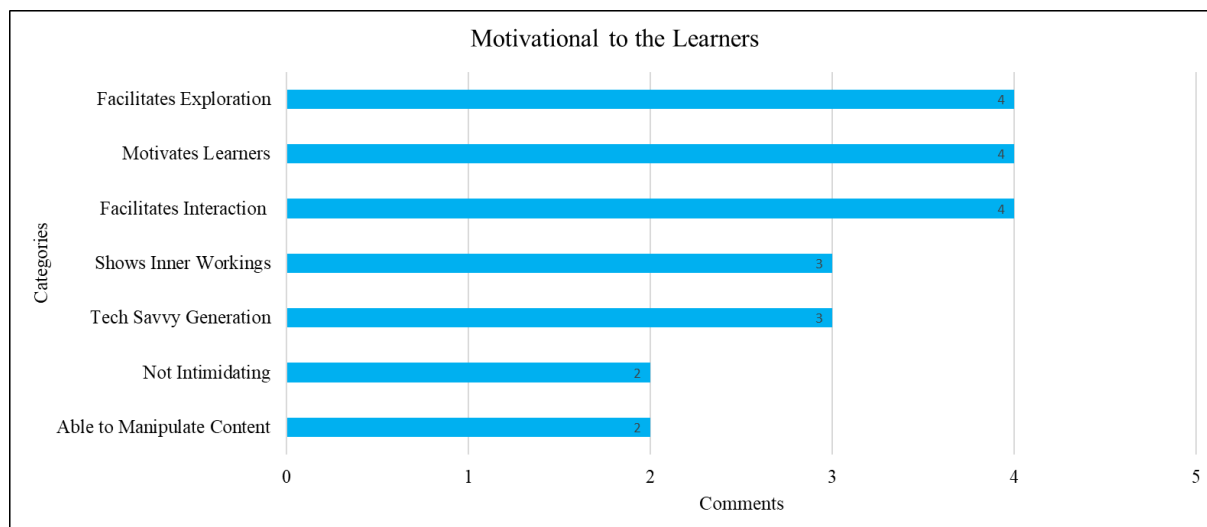
negative comments, there was optimism that negatives would turn positives as VR fidelity improved.

Motivation, Technical Strengths, and Facilitation of Learning

During the coding, the themes *Motivation*, *Technical Strengths*, and *Facilitation of Learning* emerged from faculty comments. A total of 21 categories and 73 comments related to these three themes (only nine categories and 29 comments did not relate to these three themes). Seven *Motivation* categories comprised of 22 comments, three *Technical Strengths* categories comprised of 15 comments, and 11 *Facilitation of Learning* categories comprised of 36 comments. These themes closely related to and offer insight into RQ2: *What are faculty perceptions of learning when using VR in automotive technology instruction?*

Motivation findings. The first theme that emerged was *Motivation* (Figure 4.2). Approximately 22% of coded comments (22 of 102) related to this theme. The theme was defined as comments primarily focused on the characteristics of the VR tool that positively motivated the learners to complete tasks within each automotive course. This theme was important because learner motivation was a key characteristic of adult learning.

Figure 4.2 Findings related to Motivation



The three categories receiving the greatest number of comments were: *Facilitates Exploration*, *Motivates Learners*, and *Facilitates Interaction*, which received approximately 55% of the comments from this theme (12 of 22). It should be noted the theme was titled *Motivation* and one category was titled *Motivates Learners*. The category was chosen because faculty comments referred to how VR interested learners and drew them into the VR activity. Four comments related to the category *Facilitates Exploration*. For example, Participant A shared VR “gave them a chance to explore without having to be physically in class especially during the pandemic.” When learners were drawn to explore, they became immersed and more engaged, which related to increased learning (Bystrom et al., 1999).

The next category was *Motivates Learners*. Faculty offered insight on how learners were motivated. For example, Participant D explained the visual aspect of VR “helps the visual learners which I would say, probably 80-90% of my students are.” The VR activities were personalized as learners were in their own environment, not working with others. This motivated learners during the activity, as Participant D shared, “They really like the instructiveness of it. It’s almost like their own job.” This quote spoke to motivation and the next theme, interaction.

The third category was *Facilitates Interaction*, which is an important part of learning (Bystrom et al., 1999). Participant A explained, “They liked the fact that they were able to interact and see the inner workings of how an engine works, without actually being hands-on so I think that’s the most powerful part of virtual reality.” Participant B shared, “They really like to be able to have these moving models that they could manipulate in space and you see the object in motion.”

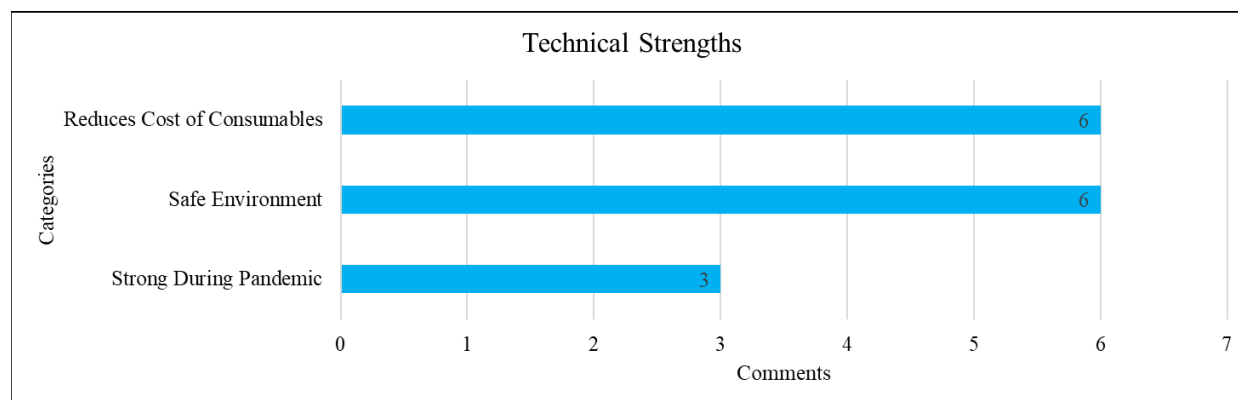
The demographic data showed 68% of the learners were members of the tech savvy Generation Z. Faculty believed the zSpace VR was motivational to these learners. Four faculty

comments stated VR was motivational and 11 comments reflected how VR allowed for interaction and exploration. The fewest number of comments in this theme related to how VR was not intimidating nor was it difficult to manipulate the content. Although only four comments were made, they highlighted faculty thoughts related to the theme of *Motivation*.

In summary, approximately 22% of faculty comments related to *Motivation* when using VR in automotive education. The top three categories related to learner experience in VR regarding exploration, motivation, and interaction. These findings showed faculty perceived learning was taking place when using VR in automotive education.

Technical strengths findings. The second theme was *Technical Strengths* (Figure 4.3). Approximately 15% of coded comments (15 of 102) related to this theme. *Technical Strengths* comments focused on the characteristics of the VR tool, which positively impacted the functionality of each automotive course and the program. This theme was important because learning technology offers value to an automotive program if it facilitates learning, which was paramount.

Figure 4.3 Findings related to Technical Strengths



The first coded category within *Technical Strength* related to consumables and the program budget. Facilitation of automotive learning is an expensive endeavor requiring vehicles, equipment, tools, parts, fluids, and more. When performing laboratory activities like changing

the engine oil and filter, parts and fluids are required. If a learner has not mastered the skill after one attempt, which most do not, additional engine oil and filter changes must take place. If a part of the system is damaged during the activity, which happens during learning, additional repair costs to the automotive program are incurred. Participant B said with VR, “I don’t have to worry about damage and running through consumables and my budget.”

Safety and risk management were the next coded categories of *Technical Strength*. Safety and risk management are critical aspects of any program, especially an automotive program. Property damage, injury, death from the improper use of tools and equipment, not following safety procedures, or misuse of vehicles are risks associated with automotive technology. These can occur from negligence, complacency, or ignorance. VR instruction offers learners the opportunity to understand and practice safety procedures, proper use of tools and equipment, and proper care for vehicles in a safe, risk-free environment. Participant C shared, “There might be some danger to where students might be in some dangerous situations where we would just want students to be familiar with training first before they start to attempt to do something.” Participant B also discussed how VR offers a risk-free learning environment, saying, “I talked about how we reduce risk for the from the faculty side, but from the student side we reduce a little bit of that the risk of failure.” This finding was seen in other studies of VR. For example, VR training for first-responders taught them how to safely respond to an accident in which hydrogen released was released (Tretsiakova-McNally et al., 2017).

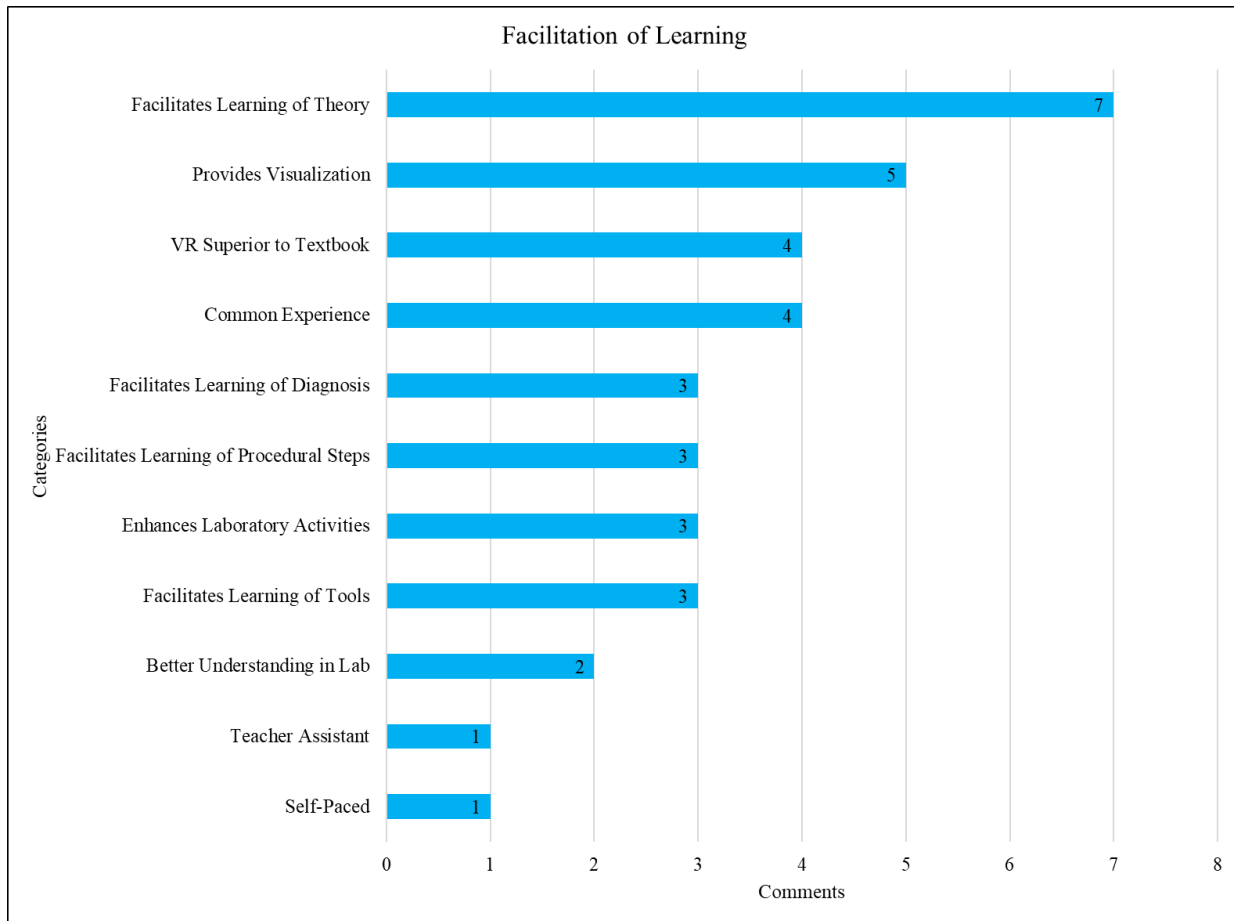
This theme also highlighted the ability of VR to be used during a pandemic. It was notable that the category of *Strong During a Pandemic* was identified. Automotive is a discipline that requires theory and hands-on skill. Although VR does not offer true hands-on experiences, it does function as a mediator between theory and skill.

The categories in this theme are important to an automotive educational program. Faculty believed VR reduced the cost of consumables, which can be expensive and take away from other program necessities. By reducing the funds spent on consumables, the program can invest in educational enhancements like instructional equipment and training aids. Faculty commented that VR offered a safe environment for learning, which is paramount in an automotive educational program because of the inherent dangers of working with vehicles, such as high voltages, chemicals, and complicated equipment. Remote learning, as during a pandemic, was also a strength of VR according to faculty. This was especially true with automotive education as part of it must take place in a laboratory. Faculty shared that VR was not yet at the level to replace all laboratory activities but was a viable alternative for remote learning when necessary.

In summary, approximately 15% of faculty comments related to the theme *Technical Strengths*. The top three categories related to the learner experience in VR were exploration, motivation, and interaction. These findings showed faculty perceived safety, cost, and adaptability as advantages to using VR in automotive education.

Facilitation of learning findings. The third theme that emerged was *Facilitation of Learning* (Figure 4.4). Approximately 35% of coded comments (36 of 102) related to this theme, which was defined as comments related to learning taking place in each automotive course and the program. This theme was important because the point of automotive coursework and the program was for learning to occur and thus position the learners for career success in the automotive industry.

Figure 4.4 Findings related to Facilitation of Learning



In each course, learners bring various knowledge and skill levels and they master the material at different rates. The content and pace of each course is often tailored to the median learner. Some learners benefit from more time on a subject and VR allows them to repeat the activity multiple times before going to the laboratory to work on a vehicle. This was highlighted by Participant C who shared,

Something the lecture and lab cannot offer is to allow students to work at their own pace, to go back and redo what they've done. Because sometimes we are working on a part or system and we've closed it up and now we're moving on to a different lab or different task. Being in VR allows them to work at their own pace, kind of going back and forth.

Learners new to automotive technology with no experience working on vehicles are often intimidated and overwhelmed with the complexity of modern vehicles. New learners must

become familiar with the tools and equipment used to service an automobile. VR can help new learners gain important understanding and confidence. For example, Participant B noted, “I would definitely recommend [VR] to other faculty... There’s a benefit of getting an initial visual of what components look like before we go out the actual hands on.” Additionally, Participant C explained, “It provides the foundational knowledge of how the system works. But also lets them know where the parts are located, which fluids or parts that need to be changed as far as belts, wheels, tires, and so forth.”

Textbooks have been part of education for centuries and are integral to learning. They have improved with better graphics, colors, and representations of theories. Generation Z learners are the most technically savvy of any previous generation. The written word in book form can be less appealing than interacting in VR. As Participant A explained,

Lecturing and textbooks are very limited. Especially the textbook because it’s really just dry material, the vocabulary is a little tough for some... I can see how something like VR could help students understand how those systems work a lot better versus just reading in a textbook and looking at figures. If you can interact with something, it will definitely help them learn the systems a lot better.

When servicing, troubleshooting, and repairing a modern automobile, one must learn to follow a logical progression of steps. Without this knowledge servicing vehicles becomes a matter of guesswork. VR facilitates learning of those steps. When responding to an interview question asking if VR helped learners to troubleshoot vehicle systems using logical, traceable steps that lead to identification of the root cause of malfunction, Participant D shared, “Absolutely, yes. That part of [VR] definitely, it did. There’s definitely a step-by-step process and how do you know how to disassemble and reassemble.”

Some faculty struggled with the place of VR in automotive education. They recognized the value for learning but also recognized the value of lectures and laboratory activities. Faculty agreed VR was not able to replace lecture and laboratory activities. For example, Participant C

said, “The way I look at VR is it can be an intermediate step. Like what we’ve been doing, theory and practice... We get theory, then we have VR practice, and then we have the actual lab.”

Faculty believed VR facilitated learning, especially from the perspective of theory, as seven comments related to this category. Four comments were specific to VR being superior to textbooks by providing strong visualizations, common instruction, step-by-step procedures, and an introduction to required tools. Coupled with the strong motivational aspect of VR, faculty believed it prepared learners for the laboratory activities. Two categories were how VR can be used as a teaching assistant and how it allows learners to progress at their own pace. Only two comments from faculty were in these categories but several closely related comments were coded into a different category.

In summary, approximately 35% of faculty comments related positively to *Facilitation of Learning*. Faculty believed VR was superior to the textbook, but not a replacement for lecture and laboratory activities. These findings showed faculty perceived learning was taking place when using VR in automotive education.

Summary of Faculty Perceptions of Learning

Faculty interviews were conducted, transcribed, and coded, and comments were tallied and categorized. The categories resulted in emerging themes. From the coding process, 30 categories emerged from 102 comments. From these, four broader themes were identified: *Positive and Negative Comments, Motivation, Technical Strengths, and Facilitation of Learning*.

Approximately 78% of faculty comments were positive. Most positive comments related to how VR facilitated learning, reduced the need for consumables, and offered a safe learning environment, which indicated faculty had a positive perception of VR in automotive education.

Approximately 22% of faculty comments were negative, most of which focused on the need for better content, the lack of haptic interface, and that VR was not able to replace laboratory activities at this time. Despite these negative comments, there was optimism that the negatives would turn positive as VR fidelity improved.

Approximately 22% of faculty comments related to the theme *Motivation*. The top three categories related to learner experience in VR regarding exploration, motivation, and interaction. These findings also indicated faculty perceived learning was taking place when using VR in automotive education.

The theme of *Technical Strengths* accounted for approximately 15% of faculty comments. The top three categories related to the learner experience in VR regarding safety, consumables, and the ability to repeat activities. These findings showed faculty perceived safety, cost, and adaptability as advantages to using VR in automotive education.

Approximately 35% of faculty comments related to the theme of *Facilitation of Learning*. This was especially evident regarding VR's superiority over the textbook. These findings showed faculty perceived learning was taking place when using VR in automotive education.

The qualitative data from the faculty interviews, which focused on RQ2 (What are faculty perceptions of learning when using VR in automotive technology instruction?), indicated faculty perceived learning occurred with the use of VR in automotive education. The next section compares the related results from the quantitative and qualitative findings.

Faculty Perceptions of Learning and Learners' Level of Presence Integrated

Findings and Analysis

This section presents convergent and divergent findings related to learner levels of presence and faculty perceptions of learning when using VR in automotive instruction. It begins by describing and analyzing the convergent findings from the learners and faculty related to VR in automotive education. This is followed by describing and analyzing the divergent findings from the learners and faculty related to VR in automotive education.

Convergent Findings

Both learners and faculty agreed learning was taking place when using VR in automotive education. The learners' total PQ scores all fell above the scale midpoint of 3.5 ($M = 4.55$, $SD = 1.50$). Two of the four PQ factors more closely indicated learning was occurring, Involvement and Adaptation/Immersion. Learner mean scores for these two factors were the highest of the four factors and their standard deviations the lowest. The mean for *Involvement* was 4.63 ($SD = 1.43$) and the mean for *Adaptation/Immersion* was 4.68 ($SD = 1.44$). This high level of presence indicated learning was taking place.

Approximately 78% of faculty comments were positive whereas only 22% were negative. Among positive comments, approximately 22% were related to the theme of *Motivation*. The top three categories of this theme were *Facilitates Exploration*, *Motivates Learners*, and *Facilitates Interaction*. Approximately 35% of faculty comments related to the theme of *Facilitation of Learning*. The top three categories of this theme were *Facilitates Learning of Theory*, *Provides Visualization*, and *VR Superior to Textbook*. Overall, faculty believed learning was taking place.

Overall PQ mean scores and mean scores for each of the 29 items were above the midpoint of 3.5, indicating a high rate of presence. This indicated learner levels of presence were

positive and suggested learning was occurring. The PQ scores were the highest in the two factors most related to learning, *Involvement* and *Adaptation/Immersion*. Faculty comments indicated they believed learning was taking place. Approximately 78% of coded comments (80 of 102) were positive. Examples of categories from faculty comments included *Facilitates Learning of Theory*, *Facilities Interaction*, *Provides Visualization*, and *Facilities Exploration*. Increasing the fidelity and quality of automotive VR is likely to increase positive faculty comments.

Divergent Findings

Learners and faculty disagreed about VR needing better content and not replacing laboratory activities. Learners strongly believed automotive VR allowed them to examine and manipulate objects. They were involved with the VR and able to anticipate what would happen as they interacted within the VR. Item 8 asked if the VR experience was consistent with their real-world experience. With a mean of 4.41 ($SD = 1.52$), learners thought VR was consistent with a real-world experience. These items had the highest mean scores, indicating the content offered learning, and were aspects of learning that takes place in a laboratory setting.

Approximately 22% of faculty comments were negative. The three categories of negative comments showing divergence were *Needs Better Content*, *No Psychomotor/Haptic Feedback*, and *Not a Replacement for Lab*. Faculty believed VR was not able to replace laboratory activities at this time because of the need for better content and the lack of haptic interface.

It is important to note divergent priorities among study participants. The learners sought to gain knowledge and skills whereas faculty were concerned about safety, the financial impact of training to the institution and automotive program, and how to facilitate learning during a pandemic. For example, the theme *Technical Strengths* accounted for approximately 15% of comments from faculty about automotive VR and the comments were positive. The categories in

this theme were *Reduced Cost of Consumables*, *Safe Environment*, and *Strong During the Pandemic*. Each category was a priority to faculty whereas gaining knowledge and skills were the priority of the learners.

The divergence between learners and faculty about the value of automotive VR content and its effectiveness is best understood from each group's perspective. The learners were new to automotive education and young. Approximately 86% of the learners had only taken 1-3 classes and 68% of the learners were aged 18-24. People from this demographic were more likely to learn from the basic content than someone with a higher level of education and experience, i.e., the faculty. The same holds true regarding the value of automotive VR used to replace laboratory activities. The younger and less experienced learners gain much from this medium whereas more educated and experienced learners would require higher fidelity and hands-on training to learn new skills.

Faculty valued the technical strengths of automotive VR, as well as the reduced costs and safer learning environment. These attributes are important for an educational automotive program. Faculty must deal with limited financial resources, risk management, and how to facilitate learning. But what is an important attribute to faculty may not be to the learners. The learners were focused on gaining knowledge and skills as a pathway into an automotive industry career.

Summary of Integrated Findings and Analysis

The quantitative and qualitative data converged regarding the purpose of this study: VR offers educators a valuable tool that can be used to move learners toward success. The quantitative data from the learner surveys focused on RQ1: *What are learners' levels of presence when using VR in automotive technology instruction?* The mean scores for the total PQ and its

four factors were each above the midpoint of 3.5. These findings indicated learner levels of presence were high and learning was taking place. The qualitative data from the faculty interviews focused on RQ2: *What are faculty perceptions of learning when using VR in automotive technology instruction?* Approximately 78% of comments from faculty were positive, with most related to how VR facilitated learning, reduced the need for consumables, and offered a safe learning environment. These findings showed faculty had a positive perception of VR in automotive education.

One aspect where there seemed to be disagreement or divergence was the need for better content. The automotive faculty commented that VR content needed to go further, such as providing diagnostic scenarios. The mean score for three PQ items related to content were high with means ranging from 4.41 for consistency with real-world experiences to 5.32 for ability to closely examine objects. This divergence may be understood from the perspectives of learners compared to faculty. The learners were younger with far less exposure to the breadth and depth of automotive training whereas faculty were more educated and with much more automotive training experience.

Chapter Four Summary

Chapter four presented findings for the quantitative data and qualitative data, then provided a summary and comparison for the two. First, the learners' level of presence was reported and analyzed. These data were gathered by surveying automotive learners using VR at RTC. The PQ 3.0, created and refined by Witmer et. al., was used to answer RQ1: *What are learners' levels of presence when using VR in automotive technology instruction?* The data showed an above average level of presence among learners using VR in automotive education.

Next, the faculty perceptions of learning were presented. These data were gathered by interviewing the faculty who used VR at RTC during automotive instruction. The interview data were used to answer RQ2: *What are faculty perceptions of learning when using VR in automotive technology instruction?* The data showed faculty perceived learning was taking place with VR in automotive education at RTC.

Integrating the findings from the learners and faculty showed learner levels of presence were high and faculty perceived learning was occurring. This was important because the data supported the purpose of this study, showing VR offers educators a valuable tool that can be used to move learners toward success. Chapter Five concludes this study and offers recommendations brought to light from this study.

Chapter 5 - Conclusions and Recommendations

This chapter summarizes key study elements. The chapter includes a summary of the study, summary of study findings, findings related to the literature, unexpected findings, implications, recommendations for further research, and closing remarks.

Summary of the Study

Overview of the Problem

A significant gap exists between the skills required by technical careers and the skills possessed by those just entering this workforce. Approximately 40% of employers in the United States struggle to find qualified people to hire, even for entry-level positions (Laboissiere, 2017). One point of focus for community college vocational programs is to provide the necessary training to equip students with the comprehensive skill sets needed to succeed in today's job market (California Community Colleges, n.d.). Those who attend community college as a pathway to a fulfilling career must learn the requisite knowledge and skills to succeed. The problem this study addressed was in the domain of learning and VR technology in automotive instruction. The study explored whether VR instruction provided learning in automotive technical education, looking at whether VR had a positive effect on learning in community college automotive technology. Little research exists on VR instruction, presence, and the learning taking place in community colleges in general, with no studies in the discipline of automotive technology. Presence is defined as "the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)" (Knerr et al., 1998, p. 32).

Purpose of the Study

The purpose of this mixed methods study was to determine if VR instruction may support learning by measuring learner levels of presence and faculty perceptions of learning when using VR instruction in a community college, automotive technology program. If learner levels of presence are high and the perceptions of faculty are that learning was taking place, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

Research Questions

Two research questions (RQs) guided this study:

- What are learners' levels of presence when using VR in automotive technology instruction?
- What are faculty perceptions of learning when using VR in automotive technology instruction?

RQ1 focused on the learners to determine if using VR felt like they were working on the automobile as measured with the PQ. RQ2 focused on faculty perceptions of learning occurring through VR instruction. If faculty believed VR instruction resulted in learning, this could indicate VR instruction can effectively be incorporated into automotive technology curriculum to teach necessary skills.

Theoretical Framework

The theoretical framework for this study was andragogy – the art and science of helping adults learn. Andragogy was chosen as the framework because the population of learners in this study were adults. The term andragogy was first used introduced by German educator Alexander Kapp in 1883, then introduced in the United States by educator Eduard C. Lindeman in his book *The Meaning of Adult Education*, first published in 1926. The framework of andragogy was popularized in the United States by Malcolm S. Knowles (1913-1997). Knowles did extensive

work developing andragogy into a theoretical framework in the 1960s and continued building on the framework throughout his life. This framework was introduced in his book, *The Modern Practice of Adult Education: Andragogy versus Pedagogy* (Knowles, 1970).

Methodology

This study employed a mixed methods approach. Creswell and Plano Clark (2010) defined mixed methods as an approach that collects, analyzes, and integrates both quantitative and qualitative data. Quantitative data focus on numbers and analysis via statistical procedures. In contrast, qualitative data are more narrative in nature and focus on people's perceptions. The quantitative portion of this study was non-experimental and descriptive, in which learners enrolled in a community college automotive technology course utilizing VR instruction were surveyed. The qualitative portion of the study was comprised of interviews with faculty teaching courses using VR to assess their perceptions of learning occurring during instruction.

The study employed a quantitative approach to explore learner presence during VR instruction through a survey, the PQ 3.0 developed by Witmer et al. (2005). The PQ 3.0 is comprised of 29 questions and was designed to measure learner levels of presence in VR (see Appendix E). The questions drill into four groups (i.e., factors) contributing to presence: involvement, sensory fidelity, adaptation/immersion, and interface quality. Involvement is the ability of the user to control VR events and how VR responds to user actions. Sensory fidelity is the quality of the sensory interactions and appearance within the VR environment. Adaptation/immersion is related to the proficiency of VR interaction and how quickly a user can adjust to the environment. Interface quality is whether the control devices and display contribute to or distract from the ability to concentrate and perform a given task in the VR environment. Witmer and Singer (1998) performed reliability and validity analyses. Their findings supported

the questionnaire's reliability and validity. The questionnaire was given to the learners using both SurveyMonkey and paper copies to measure total presence, presence level for each item, and level of presence for each factor during VR instruction for automotive technology. The requirements for participants surveyed were:

- Must be currently enrolled at Renton Technical College (RTC)
- Must be currently taking, or took during the previous quarter, a credit-bearing automotive technology course
- The course must incorporate VR instruction
- Willing to voluntarily complete the survey

The qualitative methodology explored the perceptions of faculty regarding learning occurring from VR instruction. This was done through faculty interviews. The researcher conducted Zoom interviews approximately 30 minutes in length and consisting of 14 questions. Four RTC faculty were interviewed who were assigned to teach automotive technology courses requiring the use of VR. The researcher developed, tested, and asked the interview questions. The faculty were interviewed with the focus on their perceptions of learning occurring from the VR instruction. The criteria for faculty participants were:

- Instructor of record for one of the courses required to use VR instruction
- Must be teaching one of the quarters between summer 2021 and fall 2022

Data Collection and Analysis

This section describes how the research data was collected, what data were collected, and how they were stored. Approval from the Kansas State University (KSU) and RTC institutional review boards (IRBs) was obtained before conducting any research and gathering data. The quantitative data were collected from RTC automotive learners using a survey, the PQ 3.0

developed by Witmer et al. (2005). The qualitative data were collected from RTC automotive faculty using interview questions developed by the researcher.

Quantitative data collection. The quantitative data for this study was collected using the PQ 3.0, which measures learner presence when using VR instruction. This survey was chosen because of its high reliability and validity. Additionally, it was the most cited instrument for measuring presence on Google Scholar (Schwind et al., 2019). Once IRB approval was received, the quantitative data collection process began. The researcher established a working relationship with the lead automotive faculty member at RTC for assistance with coordination and communication throughout the study. The RTC faculty coordinator sent an email to eligible learners introducing the researcher and study. At the same time, the researcher worked with the RTC faculty coordinator to establish a three-week timeframe for the learners to complete the survey during the selected instructional quarters, between summer 2021 and fall 2022. The participants were encouraged to take the survey within a short time after one of their VR instructional sessions, in the second half of the quarter, so their experience was fresh in their minds and they had an opportunity to become familiar with the VR. The researcher followed up with an email to the prospective participants to further explain the study and solicit participation (Appendix B). All eligible learners were sent an informational letter and consent form containing a link to the survey (Appendix C). After the survey was launched, the researcher followed up with email reminders to complete the survey after two, five, and 10 days.

Quantitative analysis. After scoring and cleaning the data, descriptive statistics were calculated as there was no comparison to another group or between variables within the group. Once the data were scored, the mean and standard deviation were calculated for each of the 29 items of the PQ 3.0, the four factors, and the overall presence score. The standard deviation

represents the variance in the scores and shows how homogeneous the group was in terms of their means. Standard deviation is a measure of disbursement, or the spread of the data from the mean in terms of statistical distance.

The scores from the PQ were analyzed for each individual participant and for the group. First, the PQ was scored for each individual participant, indicating the level of presence for each item, for each of the four factors (involvement, sensory fidelity, adaptation/immersion, and interface quality), and the total level of presence. Second, using the data for the entire group, the mean, standard deviation, and range were calculated to assess each item, the four factors, and the total level of presence.

Qualitative data collection. The qualitative data for this study was collected using semi-structured interviews to understand faculty perceptions of learning using VR automotive instruction. The semi-structured interview format was chosen because it allows the researcher to ask additional open-ended questions. In a semi-structured format, the questions serve to introduce topics and can be used to guide the participant into a deeper response (Lochmiller & Lester, 2016). The interviews were recorded using Zoom and lasted about 30 minutes each.

Qualitative analysis. Qualitative data differ from quantitative data in that qualitative data are subjective. Researchers must quantify the subjective qualitative data to allow for analysis and interpretation of the data. Once the faculty interviews were complete, the data were coded and reviewed for themes. The researcher first transcribed the interviews and became familiar with the data by watching the recordings multiple times and reading over the transcriptions two to three times. Next, the researcher began coding the data from the transcriptions, looking for units of text, themes, and closely related comments across interviews. The coding utilized the exact words of the participants to minimize researcher bias. Coding is defined as, “Dividing the text

into small units (phrases, sentences, or paragraphs), assigning a label to each unit, and then grouping the codes into themes” (Creswell & Plano Clark, 2010, p. 208). The codes from each interview were categorized and a legend of the categories and codes was produced. The codes from each interview were tallied and a frequency table was created to identify themes emerging most often in the data. Lastly, the codes and themes were interpreted.

Quantitative and qualitative integrated data and analysis. The mixed methods analysis employed a convergent parallel design (Creswell & Plano Clark, 2010). The researcher collected the quantitative and qualitative data concurrently, analyzed both separately, interpreted both separately, then compared and relate the results of both with an overall interpretation. The quantitative and qualitative results were provided in a joint display comparison noting the convergent and divergent findings.

Significance of the Study

This study was significant because it examined if VR instruction may be a useful tool for community college automotive technology education. If the data indicated a link between presence and learning, then it could serve as an example of how VR could be used in automotive technology instruction to facilitate learning. If the data does not indicate a link, then those tasked with curricula development and instruction could look elsewhere for technology that will better aid the learning process in automotive technology education. If learner levels of presence were high and the perceptions of faculty were that learning occurred, it may indicate VR offers educators a valuable tool that can be used to move learners toward success.

Review and Summary of Findings

This section reviews the study findings. The data for the quantitative findings was collected from the automotive learners at RTC by means of a PQ survey. The data for the

qualitative findings was collected from the automotive faculty at RTC by means of an interview. The qualitative and quantitative data were integrated to determine convergent and divergent findings.

Learner Levels of Presence

Presence was defined as a psychological state of *being there*. Levels of presence in VR are based on “the fidelity of its sensory components, the nature of the required interactions and tasks, the focus of the user’s attention/concentration, and the ease with which the user adapts to the demands of the environment” (Witmer et al., 2005. p. 289.).

The quantitative portion of this study determined learner levels of presence using the PQ. Once the PQ was completed, the mean score for each item and the overall mean were calculated. The highest mean from the participants on the PQ instrument was item 15 ($M = 5.32$, $SD = 1.81$), which asked about participant ability to closely examine the objects in VR. The lowest mean on the PQ was item 23 ($M = 3.59$, $SD = 1.77$), which asked about the amount of control participants experienced using the stylus and glasses in VR. The lower mean indicated learners thought the user interface interfered with performing tasks.

The mean for each item on the PQ survey was above the midpoint of the response scale, which was 3.5. These scores, coupled with the fact that Witmer and Singer (1994) found a high correlation between learning and presence, were a strong indication learning was taking place.

The four factors of the presence questionnaire. To provide a robust measure of presence, Witmer et al. (2005) identified four factors related to measuring presence and refined their PQ instrument by focusing items on these factors. The factors are:

- *Involvement.* A natural interface that facilitates the ability to control activities in the environment, increasing engagement

- *Sensory Fidelity*. How well the virtual environment (VE) permits active search or examination of the objects in the VE
- *Adaptation/Immersion*. The perceived ability to interact with and operate in the VE and how quickly users can adjust to the VE experience
- *Interface Quality*. Perceived quality of the VE interface and the extent to which it does not interfere with activities in the VE

Involvement. The factor of *Involvement* relates to a natural interface that facilitates the ability to control activities in the VE, increasing involvement. This factor seeks to determine if the participant feels they are in the VE performing the given activity. The greater the involvement, the greater the presence. Participants in this study scored above the scale midpoint with an overall mean of 4.63 ($SD = 1.43$). This was a positive indication of presence and supported that participants were learning.

Sensory fidelity. The factor *Sensory Fidelity* can enhance or distract users and thus increase or decrease involvement and immersion. The higher the level of sensor fidelity, the higher the level of presence and vice versa. The participants in this study scored above the scale midpoint for *Sensory Fidelity* with an overall mean of 4.64 ($SD = 1.61$). This was a positive indication of presence and supported that participants were learning.

Adaptation/Immersion. The factor *Adaptation/Immersion* is characterized by perceived proficiency of interacting with and operating in the VE and how quickly users adjust to the VE experience. This is often the sensation people describe when enjoying a good book, saying they were immersed in the story. Higher levels of immersion are associated with higher levels of presence. Participants in this study scored above the scale midpoint with an overall mean of 4.68

($SD = 1.44$). This was a positive indication of presence and supported that participants were learning.

Interface quality. The factor *Interface Quality* is characterized by perceived quality of the VE interface and the extent to which it does not interfere with activities in the VE. The system quality can either increase or decrease the time it takes to adapt to VR. The higher the quality, the faster users adapt to VR. Higher ratings for *Interface Quality* were associated with higher levels of presence. Participants in this study scored above the scale midpoint with an average mean of 3.74 ($SD = 1.66$). Although the overall score for this factor was above the midpoint, it was the lowest of the four factors. Learning was taking place, but improving the quality of the interface could raise the overall PQ scores and level of presence.

Demographics. The responses to the demographic questions revealed the majority of the 37 participants were males aged 18-24 who had taken 1-3 automotive courses, which was representative of community college automotive learners. The number of participants was low and two of the demographic categories were overwhelmingly grouped, gender and number of courses taken. The gender demographic showed the overall mean score was higher for females, but only 5% of participants were female making it difficult to know if this would hold true with a larger group of participants. The demographic of age showed those aged 25 and older had a higher overall mean than those aged 18-24. Participants who had taken 1-3 courses had a higher overall mean than those who took four or more courses, which may indicate those newer to automotive instruction have the highest level of learning from VR.

Summary of learner levels of presence. The quantitative data from the learner surveys focused on RQ1 was: *What are learners' levels of presence when using VR in automotive technology instruction?* The highest item mean on the PQ instrument was for item 15 ($M = 5.32$,

$SD = 1.81$), indicating participants were able to closely examine objects in VR. In contrast, the lowest mean on the PQ was item 23 ($M = 3.59$, $SD = 1.77$), which referred to the how much the control devices interfered with performing tasks.

Items on the PQ can be grouped into four factors: *Involvement*, *Sensory Fidelity*, *Adaptation/Immersion*, and *Interface Quality*. Participant means were above the scale midpoint on all four factors. Ratings for *Involvement* ($M = 4.63$, $SD = 1.43$), *Sensory Fidelity* ($M = 4.64$, $SD = 1.61$), and *Adaptation/Immersion* ($M = 4.68$, $SD = 1.44$) were similar and about 1.6 points above the midpoint. The mean for *Interface Quality* was the lowest of the four factors ($M = 3.74$, $SD = 1.66$).

The data on the learner demographics showed the overall mean for females was high, but only 5% of participants were female so it is not possible to draw conclusions regarding difference by gender. In terms of age, those aged 25 and older had higher mean ratings than those aged 18-24. Lastly, participants who had taken 1-3 courses had a higher overall mean than those who had taken four or more classes.

Overall, the data indicated learners had a positive level of presence with the use of VR in automotive education. The means for each item as well as each factor was above the midpoint of 3.5. These findings indicated learner levels of presence were positive and learning was taking place.

Faculty Perceptions of Learning

This section reviews the findings related to faculty perceptions of learning when using VR in community college automotive education. The data were categorized into positive and negative comments from the faculty, which are presented first. This is followed by a review of

the top categories commented on by faculty: *Motivation*, *Technical Strengths*, and the *Facilitation of Learning*.

Positive comments. Approximately 78% of faculty comments regarding the use of VR in automotive education were positive. The majority of positive comments related to how VR facilitated learning, reduced the need for consumables, and offered a safe learning environment. These findings showed faculty had a positive perception of VR in automotive education.

Negative comments. Faculty comments regarding learning from VR in automotive education were negative approximately 22% of the time. The majority of the negative comments focused on a need for better content, a lack of haptic interface, and the distracting functionality of the user interface. Even in these negative comments there was optimism that the negatives would turn positives as VR fidelity improved.

Motivation. Approximately 22% of the positive faculty comments related to learner motivation when using VR in automotive education. The top three categories related to the learner experience in VR regarding exploration, motivation, and interaction. These findings showed faculty perceived learning was taking place when using VR in automotive education.

Technical strengths. Approximately 15% of positive faculty comments related to *Technical Strengths*. The top three categories related to the learner experience in VR regarding safety, cost of consumables, and remote instruction. These findings showed faculty perceived safety, fiscal, and adaptability advantages to using VR in automotive education.

Facilitation of learning. Approximately 35% of positive faculty comments related positively to *Facilitation of Learning*. The top category related to VR's similarity but superiority over the textbook. These findings showed faculty perceived learning was taking place when using VR in automotive education.

Summary of faculty perceptions of learning. The qualitative data from the faculty interviews focused on RQ2: *What are faculty perceptions of learning when using VR in automotive technology instruction?* Approximately 78% of faculty comments regarding VR in automotive education were positive whereas only 22% were negative. Three themes emerged from the positive faculty comments: *Motivation*, *Technical Strengths*, and *Facilitation of Learning*. *Facilitation of Learning* received the highest percentage of comments with 35%. *Technical Strengths* received the lowest percentage of comments with 15%. Motivation received 22% of the comments. The data indicated faculty perceived learning was taking place with the use of VR in automotive education.

Integrated Finding of Learners and Faculty

The quantitative and qualitative findings showed VR offers community college automotive educators a valuable tool to move learners toward success. Mean scores for each item on the PQ and overall mean scores for each of the four factors were above the scale midpoint of 3.5. These findings indicated learner levels of presence were positive and learning was taking place. In terms of qualitative data, approximately 78% of faculty comments were positive. Positive comments related to how VR use in automotive education facilitated learning, reduced the need for consumables, and offered a safe learning environment. These findings showed faculty had a positive perception of VR in automotive education. The learners and faculty agreed learning was taking place though VR in community college automotive technical education. This was supported by the data, which indicated presence was positive and learning was taking place.

One aspect where there seemed to be disagreement or divergence was the need for better content. The automotive faculty commented the VR content needed to go further, such as by providing diagnostic scenarios. Learner means for three of the PQ items related to content were

high, with means between 4.41 and 5.32 for items related to real-world experience, ability to closely examine objects, and ability to focus on the task. This divergence may be understood from the perspective of the demographics of the learner compared to the faculty. The learners were younger with far less exposure to the breadth and depth of automotive training whereas the faculty were more educated with much more automotive training experience.

Summary of Findings

Chapter Four reported the findings for the quantitative data, the qualitative data, and then provided a summary and comparison of the two. First, the learner levels of presence were reported and analyzed. These data were gathered by surveying automotive learners using VR at RTC. The PQ 3.0 (Witmer et. al., 2005) was used to answer RQ1: *What are learners' levels of presence when using VR in automotive technology instruction?* The data supported an above average level of presence among learners using VR in automotive education.

Next, the faculty perceptions of learning were reported and analyzed. These data were gathered by interviewing the faculty who used VR at RTC during automotive instruction. The interview data were used to answer RQ2: *What are faculty perceptions of learning when using VR in automotive technology instruction?* The data showed faculty perceived learning was taking place with VR in automotive education at RTC.

Integrating the findings from the learners and faculty showed learner levels of presence were high and faculty perceived learning was occurring. Faculty and learners disagreed about the need for better content. The instances of agreement far outweighed the instances of disagreement. This was important because the data supported the purpose of this study, showing that VR offers educators a valuable tool that can be used to move learners toward success.

Findings Related to the Literature

Findings from this study supported the literature reviewed in Chapter Two. The three findings discussed in this section related to Generation Z learners, the benefits of VR training in automotive education, and the unexpectedly slow pace with which VR is being adopted in automotive education. This study built on these related works to enrich the scholarly data related to the use of VR in community college automotive education.

Generation Z is a tech savvy generation. They grew up with cell phones, laptop computers, and video game franchises like Call of Duty, Grand Theft Auto, FIFA World Cup, and Minecraft. Crowley-Barnett et al. (2020) discussed how game-based education (GBE) is becoming more popular in medical education and learners reported GBE offered a positive way to learn., especially for younger learners raised with technology.

This study supported the literature regarding how community college learners are tech savvy and familiar with VR in the form of popular video games. The learners scored high on PQ survey items asking if they felt involved in the VR, if they were proficient interacting within the VR, and how quickly they adjusted to the VR, with mean ratings of 4.55 and above. This showed learners were comfortable, quick to catch on, and involved with VR. Each of these items indicated learning was taking place. Faculty also commented on how well this generation of community college automotive learners respond to VR. Faculty's top categories of positive comments regarding VR in automotive education included *Facilitates Learning of Theory*, *Facilitates Interaction*, *Motivates Learners*, and *VR is Superior to Textbooks*. Both previous studies and this study supported the use of VR in education for Generation Z learners.

An article presented in the literature review, *Virtual Reality System for Training in Automotive Mechanics* (Quevedo et al., 2017), proposed a VR training system be established to

train various positions within the automotive industry. The paper discussed the benefits of using graphics created when a vehicle, its systems, and components were designed and manufactured, to create VR training for vehicle service and repair technicians. It implied vehicle manufacturers could incorporate VR in their service information to assist repair technicians in resolving vehicle malfunctions.

Both the learners and faculty in this study agreed VR helped them understand vehicle theory and system operations, which are essential for diagnosing and repairing vehicle malfunctions. zSpace VR content offered learners theory and step-by-step processes required for automotive diagnostics and repair. The learner overall mean score on the PQ was 4.55, which was above the scale midpoint of 3.5. Moreso, the learner mean score for item 9, *Were you able to anticipate what would happen next in response to the actions that you performed*, was 4.95, which was above the overall mean of 4.55 demonstrating a high level of presence and indicating learning was taking place. Positive faculty comments indicated learning was taking place, as demonstrated by categories like *Facilitates Learning of Theory*, *Shows Inner Workings*, valuable for *Manufacturer Training*, and *Facilitates Learning of Procedural Steps*. Each of these categories were essential for resolving vehicle malfunctions.

One article presented in the literature review discussed that despite improved access to technology, VR instruction had not been adopted as expected. A literature review conducted by Kavanagh et al. (2017) addressed this issue. The study reviewed 99 papers relevant to VR in education and reported the most common issues and limitations with its use. Thirty-five papers presented issues and limitations broken down into four main themes: overhead, input problems, output problems, and usefulness. Next, 11 common codes were established: training, cost, input hardware usability, recognition inaccuracies, lack of feedback, insufficient realism, software

usability, motion sickness, ineffectiveness, lack of engagement, and no reported issues. The three limitations occurring most often in the articles were software usability, lack of engagement, and cost. The literature review concluded education was using VR instruction but there are still issues to resolve.

This study found the overall mean score on the PQ survey, a measure of presence, was 4.55 ($SD = 1.50$), which was above the scale midpoint of 3.5. Although this was above the scale mean, it is likely a higher fidelity VR would increase the overall mean, which would indicate a higher level of presence. It should be noted engagement and presence are not synonymous but may be perceived as such depending on how the research was presented to the participants, i.e., when the literature review by Kavanagh et al. (2017) reported lack of engagement, they were referring to many of the elements comprising presence. Faculty were also reluctant to accept VR. They expressed this through their negative comments, which resulted in categories of *Needs Better Content*, *No Psychomotor/Haptic Feedback*, and *Not a Replacement for Lab*. These issues supported studies finding VR instruction had not been adopted as expected.

Study findings were in alignment with the literature reviewed in Chapter Two. However, it went beyond current studies on VR in education by focusing specifically on presence and VR use in community college automotive education from both the faculty and learner perspective.

Unexpected Findings

The researcher put aside biases and expectations, to the extent possible, when conducting this study. With that said, the following items were unexpected. Regarding the methodology of the study, it was unexpected an incentive and a paper copy of the survey would be needed to entice learners to participate. The Covid pandemic and its impact on gathering data was also unexpected. One of the strengths of the zSpace VR platform was that it could be used during the

pandemic for instruction. Despite this, it was difficult to get the data due to a drop in enrollments, technical and check-out issues with the VR units, and difficulty soliciting surveys from remote learners. In future studies, the researcher would offer incentives and provide the survey in both paper and electronic formats from the beginning, and it would be anticipated that management of the VR platform would go more smoothly with experience gained through this pandemic and improvements to the platform.

Regarding faculty interview questions, it was unexpected the program learning outcomes (PLOs) and course learning outcomes (CLOs) were not always precise enough to provide valuable feedback. Some PLOs and CLOs were well written and applicable to the courses but for other courses they applied in a vaguer way that made answering some of the interview questions difficult. The researcher would improve the interview questions and attempt to develop them with less ambiguity when conducting further research.

Regarding the results, it was unexpected the VR reporting capabilities were so poorly understood and utilized. Only one of the faculty members interviewed was familiar with the reporting capabilities and none of the faculty used the reporting regularly or at all. This researcher thought the reporting would be used for determining remediation or justifying the expense of the VR platform but neither of those were reported.

Implications and Recommendations

This section presents implications, recommendations for future research, and concluding remarks. The implications were from a practical perspective relating to community college automotive education. The recommendations for future research are meant to stimulate thought on possible research topics for future researchers. The concluding remarks pull together the key points from this chapter and offer some implications from this study.

Implications

This section reports on implications that can be drawn, though not explicitly proven, from this study. The implications from this study were:

- Virtual reality could be a viable supplement for textbooks and laboratory activities
- Better support is needed for faculty using VR in automotive education
- Improving the user interface within automotive VR is likely to increase presence and learning
- If the sensory fidelity of the VR was improved, it is likely presence and learning would increase
- A deeper level of content for VR in automotive education is needed

If these implications are acted on, the level of presence while in VR is likely to increase and with the increase in presence, there would be an increase in learning. The first implication relates to how VR can be used to supplement textbooks and laboratory activities.

Supplement to textbook and laboratory activities. VR could be a viable supplement for textbooks and laboratory activities based on the findings of this study. Some of the positive comments from faculty interviews stated how it was difficult to get learners to read the textbook, but VR helped learners understand the theory and they were motivated by it. For example, Participant A explained how VR “could help students understand how those systems work a lot better than just reading in a textbook and looking at figures. If you can interact with something it definitely will help them learn the systems a lot better.” Giving learners a better understanding of how automotive systems operated was a foundational step toward vehicle service and repair.

One of the negative categories emerging from the faculty interviews was *Not a Replacement for Lab*. Several faculty comments indicated VR was a supplement but not a

replacement for laboratory activities. Comments described VR as not being viable as a sole learning project and not being a substitute for hands-on experience with a vehicle. However, as the fidelity and content of automotive VR improves, it is likely the supplemental value of VR as an educational tool will also improve.

Better support for faculty. Faculty need better support for using VR in automotive education based on the findings from this study. When asked for examples of how the VR reporting system showed improvement in learner knowledge and skills, only one of four faculty members interviewed was familiar with the reporting system, and one was unaware the reporting system existed. Only one of the automotive faculty members interviewed had a complete understanding of the VR system and its reporting capabilities. There is a great deal of new technology in automotive education. The vehicle itself is changing rapidly to the point the industry is pushing to get autonomous vehicles marketed. Some new vehicle technologies include advanced driver assist systems (ADAS), the use of LIDAR, and fully electric-powered drivetrains. The technology to service and repair these systems is being deployed at a fast pace to match what is equipped on the vehicles. Faculty must stay current on training and new modalities, like VR, to facilitate learning. If these new educational modalities are too complicated to be understood they will not be used to their full potential. Faculty needs support, education, and training on VR for it to succeed in educating learners.

Improving the user interface. Improving the user interface within automotive VR is likely to increase presence and learning based on the findings of this study. The lowest rated items on the PQ related to the user interface, such as naturalness of interactions, mechanisms controlling movements, delays in system reaction times, visual quality of the interface, and interference from the control devices to perform assigned tasks. These items also related to how

the learner interacted within VR. It should also be noted the factor *Interface Quality* had the lowest overall mean of the four factors at 3.74. Increasing the realism and ease of interaction within the automotive VR would increase the level of presence and learning.

It is expensive to achieve the user interface ease and detail as in some of the most popular video games like Call of Duty or FIFA World Cup. One of the biggest reasons why the user interface is not as great as in gaming is because education is not a large enough market to generate billions in revenue from VR like the gaming industry. As the use of VR in education increases and the market grows, the user interface will improve. If a VR company wants to increase its share in the educational market, increasing the quality of the user interface will increase presence and learning, which will cause more faculty to be drawn to it because of what it offers the learners.

Increase sensory fidelity. If the sensory fidelity of the automotive VR was improved, it is likely presence and learning would increase based on the finding of this study. Although the *Sensory Fidelity* factor had the highest overall mean at 4.64, Witmer et al. (2005) determined this factor influenced the *Involvement* and *Adaptation/Immersion* factors. By raising the mean score of *Sensory Fidelity*, the overall mean scores for *Involvement* and *Adaptation/Immersion* would also increase. These increases would noticeably raise the overall presence score.

Development of a deeper level of VR content. A deeper level of content for VR in automotive education is needed based on the findings from this study. Automotive service involves performing regular maintenance like changing oil and rotating tires, as well as repairing vehicle malfunctions such as determining the root cause of a vehicle that will not accelerate at an appropriate rate. Faculty stated VR was good for facilitating learning when it came to system operations and performing a step-by-step process, but they wanted more specific automotive

systems where they could master the requisite procedures and skills for determining the root cause and repair for a vehicle malfunction. Faculty shared how the content tended to be generic, such as representing a 4-cylinder engine with the main components and sub-components but not the level of detail in a real engine. Although this was good for the learners in the beginning courses, those in intermediate or advanced courses would benefit from a higher level of complexity seen in an actual automotive engine. This deeper level of VR content would help learners master requisite skills for intermediate to advanced level diagnostics and repairs. A learner with this deeper level of knowledge and skill will have greater opportunities and earn a higher salary in the automotive industry.

Recommendations for Further Research

VR has been around for some time with manifestations in the 1930s with the introduction of the *View-Master*. Technology progressed greatly since that time, such as computers with greatly improved processing speed, improvements to coding languages to write a myriad of VR simulations for different disciplines, and faster Internet connectivity to run VR simulations. This has grown in an industry whose goal is to provide high fidelity VR simulations at a less expensive price point for education. Because of this, a number of important studies could be conducted in this field. This researcher recommends future studies based on the following research questions:

- Is using VR in automotive education cost effective? Is it more or less expensive to use VR as compared to other delivery methods in education, i.e., instructor-led lectures, supervised laboratory activities, and virtual field trips?
- What are the strengths and challenges of the most used VR content platforms in community college-based career and technical education?

- Would the use of VR improve learning in disciplines other than community college automotive, i.e., nursing, welding, manufacturing, horticulture, police officer training, and fire technology?
- What VR administrative tools help or hinder the design, development, and assessment of curriculum integrating VR into automotive education? For example, is setting up the system difficult, is there a user-friendly helpline, can faculty easily deploy the system or it is time-consuming and complicated to use? Are the reporting features rich and is it simple to input and track the learners?
- Would VR instruction in K-12 and graduate institutions increase learning?
- Do VR training platforms with high *Interface Quality* have a higher level of presence? Witmer et al. (2005) determined, relevant to the PQ survey, *Interface Quality* increases the factors of *Involvement* and *Adaptation/Immersion*. With these three factors increasing, the level of presence, and hence learning, should increase.
- Does VR offer advantages or disadvantages for automotive learners from low socio-economic backgrounds? Such a study could focus on disadvantaged learners in countries with a large educational system like the United States or countries with few schools and resources where vehicles and expensive repair equipment is not available.
- Is VR instruction more effective for older or younger learners, female or male learners, or learners new to a field as compared to those experienced in the field? A study could be conducted focused around the demographics of the learners.
- What is the effectiveness of VR corporate automotive training? For example, is it cost effective for Ford Motor Company to incorporate VR into their sales, service, and parts training? Is it more effective for basic or advanced level training? Does it allow

quality training for parts of the world that sell their products but do not have a training facility within a particular region?

- Would VR learning improve with more robust haptic interface mechanisms? For example, headphones, gloves, or standing/seated on a movement/vibration platform. The military uses a higher level of haptic interface but how can this be incorporated into corporate or education institutions?
- What are the overall retention and success rates when supplementing an automotive course with VR? A study could be conducted where learner retention and success rates in a course supplemented with VR instruction is compared to one without VR instruction.
- Would learning increase if the fidelity of VR increased? The benchmark of high fidelity in VR would be games like Call of Duty, Grand Theft Auto, FIFA World Cup, and Minecraft. Would a level of fidelity like these VR games increase the level of presence and learning?
- Would the job skills of automotive learners increase if VR was integrated into instruction? This could be determined with a survey of employers of recent graduates from a program integrating VR instruction as compared to a program not integrating VR instruction.

This list of recommendations for further research is not exhaustive. As technology increases and costs decrease, the fidelity, availability, and use of VR in education is likely to increase. It is important more research is conducted to offer programs and institutions data regarding VR as it relates to learning.

Concluding Remarks

This study found learning was occurring when using VR in community college automotive education. This conclusion was reached by surveying the learners and interviewing the faculty. VR is growing at an accelerated rate in all areas of life, including gaming, social media, advertisement, work, and education. More research is needed regarding the use of VR in community college automotive education. Some of the key areas in need of research include VR as a viable supplement or replacement for textbooks and laboratory activities, the development a deeper level of content for VR in automotive education, and better support for faculty using VR in automotive education.

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Appendix A - KSU Institutional Review Board Approval Letter



TO: Martha Ellis
Educational Leadership
363
Manhattan, KS 66506

Proposal Number: IRB-10757

Bluemont

Hall

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 06/23/2021

RE: Proposal Entitled, "Virtual reality instruction in automotive technology education at Renton Technical College."

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §104(d), category:Exempt Category 1.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

Electronically signed by Rick Scheidt on 06/23/2021 3:44 PM ET

TO: Martha Ellis
Educational Leadership
363 Bluemont Hall
Manhattan, KS 66506

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 06/30/2021

RE: Proposal #IRB-10757, entitled "Virtual reality instruction in automotive technology education at Renton Technical College."

MODIFICATION OF IRB PROTOCOL #IRB-10757, ENTITLED, "Virtual reality instruction in automotive technology education at Renton Technical College"

EXPIRATION DATE: Exempt

The Committee on Research Involving Human Subjects (IRB) has reviewed and approved the request identified above as a modification of a previously approved protocol. **Please note that the original expiration remains the same.**

All approved IRB protocols are subject to continuing review at least annually, which may include the examination of records connected with the project. Announced in-progress reviews may also be performed during the course of this approval period by a member of the University Research Compliance Office staff. Unanticipated adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB, and / or the URCO

It is important that your human subjects activity is consistent with submissions to funding / contract entities. It is your responsibility to initiate notification procedures to any funding / contract entity of any changes in your activity that affects the use of human subjects.

Electronic Signatures

Signed by Rick Scheidt (rscheidt@k-state.edu)

Reason: Chair

Signed at 06/30/2021 3:35 PM ET

TO: Martha Ellis
Educational Leadership
363 Bluemont Hall
Manhattan, KS 66506

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 08/19/2022

RE: Proposal #IRB-10757, entitled "Virtual reality instruction in automotive technology education at Renton Technical College."

MODIFICATION OF IRB PROTOCOL #IRB-10757, ENTITLED, "Virtual reality instruction in automotive technology education at Renton Technical College"

EXPIRATION DATE: Exempt

The Committee on Research Involving Human Subjects (IRB) has reviewed and approved the request identified above as a modification of a previously approved protocol. **Please note that the original expiration remains the same.**

All approved IRB protocols are subject to continuing review at least annually, which may include the examination of records connected with the project. Announced in-progress reviews may also be performed during the course of this approval period by a member of the University Research Compliance Office staff. Unanticipated adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB, and / or the URCO

It is important that your human subjects activity is consistent with submissions to funding / contract entities. It is your responsibility to initiate notification procedures to any funding / contract entity of any changes in your activity that affects the use of human subjects.

Electronic Signatures

Signed by Phill Vardiman (pvardiman@k-state.edu)

Reason: Chair

Signed at 08/19/2022 2:35 PM ET

RTC Institutional Review Board Approval Letter



RENTON
TECHNICAL
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Sent via Email

Renton Technical College
Institutional Review Board for the Protection of Human Participants in Research

Exempt Letter

Date: June 30, 21

Application Number: 6-30-21DR

Principal Investigator: Douglas Redman

Faculty Supervisor (if relevant): Martha Ellis

Project Title: Virtual reality instruction in automotive technology education at Renton Technical College

Dear Douglas:

Your Request for Approval of Research – IRB Application Form has been evaluated by an IRB committee member and was found to be Exempt research, which does not require further IRB review. The study may proceed as planned.

The IRB will not require you to renew this research should contact with human participants extend beyond one year.

Please retain this letter for your records.

Sincerely,

Jichul Kim, IRB Chair



RENTON
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Sent via Email

Renton Technical College
Institutional Review Board for the Protection of Human Participants in Research

Exempt Letter

Date: September 15, 2022

Application Number: 6-30-21DR

Principal Investigator: Douglas Redman

Faculty Supervisor (if relevant): Martha Ellis

Project Title: Virtual reality instruction in automotive technology education at Renton Technical College – MODIFICATION

Dear Douglas:

The modification of the above listed study has been evaluated and approved by an IRB committee member. The study may proceed as planned.

The IRB will not require you to renew this research should contact with human participants extend beyond one year.

Please retain this letter for your records.

Sincerely,

Lia Homeister

Lia Homeister, IRB Chair

Appendix B - Learner Participant Recruitment Letter

Dear Learner,

Thank you for taking the time to consider participating in this study. My name is Douglas Redman. I am an Associate Professor of Automotive Technology/Advanced Transportation at College of the Desert in Palm Desert, CA and a graduate learner at Kansas State University working on my doctoral degree. You are receiving this request to participate in this study because you are enrolled in one of the Automotive Courses at Renton Technical College that incorporates virtual reality instruction.

The purpose of this mixed-methods study is to determine if virtual reality instruction may be a valid methodology for learning by measuring the learners' levels of presence and the faculty perceptions of learning when using virtual reality instruction in community college, automotive *technology* education. I am requesting that you participate in the study by taking a 29-question survey on presence. "*Presence* is defined as the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale)." (Knerr et al., 1998).

This survey is anonymous. Neither your name nor any other identifiable information will be recorded. It is important for you to participate to assure educators are aware of the latest effective methods for instruction and learners may pathway through to their chosen career efficiently and successfully. Your participation will be greatly appreciated!

Participation in this study involves:

- A time commitment of approximately 10 minutes
- Completion of a 29-question survey using both SurveyMonkey and paper copies
- Three questions on demographics

Each participant who completes a survey will receive a raffle ticket. You may only complete the survey one time no matter how many courses you are taking at Renton Technical College. A winning raffle ticket will be selected at random from each automotive course that meets the criteria for participation in this study. The winner of the raffle will receive an automotive tool valued at approximately \$50. Only one winner per class. Once the needed number of surveys are collected this incentive will end.

For more information about this study, please contact the researcher, Douglas H. Redman, by email at [REDACTED] or phone at [REDACTED].

Thank you!

Douglas H. Redman

Researcher; KSU Graduate Learner

Study Title: Virtual Reality Instruction in Automotive Technology Education at Renton Technical College

Appendix C - Learner Participant Information and Consent

Learner Participant Information and Consent Form Virtual Reality Instruction in Automotive Technology Education at Renton Technical College

Researcher: Douglas H. Redman

Email: [REDACTED] or [REDACTED]

Phone: [REDACTED]

THANK YOU!

Thank you for taking the time to participate in this important study. If you choose to take the survey, and I hope you will, please take your time in answering each question.

DESCRIPTION OF THE RESEARCH

This survey will be used in a research study looking at presence and learning in community college, automotive technology, virtual reality (VR) instruction. “*Presence* is defined as the subjective experience of being in one place or environment (the computer-generated environment), even when one is physically situated in another (the actual physical locale).” (Knerr et al., 1998). This research will help to determine the learner’s level of presence in virtual reality instruction.

WHAT WILL MY PARTICIPATION INVOLVE?

You will be asked to complete a survey. This survey will take approximately 10 minutes to complete.

ARE THERE ANY RISKS TO ME?

There is no perceived risk associated with participating in this survey. This survey is voluntary and there is no penalty for not participating nor for not completing the survey once it is started.

ARE THERE ANY BENEFITS TO ME?

No direct benefits to you are expected. This study will be valuable in informing community and technical college faculty about learner presence and the learning that is taking place when using virtual reality instruction. You may request a copy of the study once it is published.

Each participant who completes a survey will receive a raffle ticket. You may only complete the survey one time no matter how many courses you are taking at Renton Technical College. A winning raffle ticket will be selected at random from each automotive course that meets the criteria for participation in this study. The winner of the raffle will receive an automotive tool valued at approximately \$50. Only one

HOW WILL MY CONFIDENTIALITY BE PROTECTED?

This study is anonymous. Neither your name nor any other identifiable information will be recorded. The study will simply state that the participants are learners in the Automotive Technology Program at Renton Technical College.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

Please contact Douglas H. Redman at [REDACTED], [REDACTED], or at [REDACTED] with any questions, comments, or concerns. You may ask questions about the study before and/or after you participate in the survey.

If you have concerns about the way the research was conducted, you may also contact the Institutional Review Board (IRB) office at comply@ksu.edu or at 785-532-3224. **Your participation is voluntary, and you have the right to withdraw from the study without penalty at any time.**

By accessing this survey, you consent to participating in this study.

Appendix D - Faculty Participant Consent

Faculty Participant Information and Consent Form
Virtual Reality Instruction in Automotive Technology Education at Renton Technical College

Researcher: Douglas H. Redman

Email: [REDACTED]

THANK YOU!

Thank you for taking the time to consider participating in this important study. If you choose to be interviewed, and I hope you will, please take your time in answering each question.

DESCRIPTION OF THE RESEARCH

This interview will be used in a research study looking at what is learned from virtual reality instruction in community and technical college, automotive technology. This research will help to determine if learning may be taking place when virtual reality automotive instruction is used.

WHAT WILL MY PARTICIPATION INVOLVE?

You will be asked to complete an interview over Zoom. This interview will take approximately 20 to 30 minutes to complete.

ARE THERE ANY RISKS TO ME?

There is no perceived risk associated with participating in this interview. This interview is voluntary and there is no penalty for not participating nor for not completing the interview once it is started.

ARE THERE ANY BENEFITS TO ME?

No direct benefits to you are expected. This study will be valuable in informing community and technical college faculty about learning taking place in virtual reality instruction. You may request a copy of the study once it is published.

HOW WILL MY CONFIDENTIALITY BE PROTECTED?

This study is anonymous. Neither your name nor any other identifiable information will be recorded. The study will simply state that the participants are learners in the Automotive Technology Program at Renton Technical College.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

Please contact Douglas H. Redman [REDACTED]

[REDACTED] with any questions, comments, or concerns. You may ask questions about the study before and/or after you participate in the interview.

If you have concerns about the way the research was conducted, you may also contact the Institutional Review Board (IRB) office at comply@ksu.edu or at 785-532-3224. **Your participation is voluntary, and you have the right to withdraw from the study without penalty at any time.**

By accessing this interview you consent to participating in this study.

Appendix E - Presence Questionnaire (Ver 3.0)

Directions: Read each statement carefully and select the best answer.

NOT AT ALL			SOMEWHAT			COMPLETELY
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Example of scale

1. How much were you able to control events?
2. How responsive was the environment to actions that you initiated (or performed)?
3. How natural did your interactions with the environment seem?
4. How much did the visual aspects of the environment involve you?
5. How much did the auditory aspects of the environment involve you?
6. How natural was the mechanism which controlled movement through the environment?
7. How compelling was your sense of objects moving through space?
8. How much did your experiences in the virtual environment seem consistent with your real-world experiences?
9. Were you able to anticipate what would happen next in response to the actions that you performed?
10. How completely were you able to actively survey or search the environment using vision?
11. How well could you identify sounds?
12. How well could you localize sounds?
13. How well could you actively survey or search the virtual environment using touch?
14. How compelling was your sense of moving around inside the virtual environment?
15. How closely were you able to examine objects?
16. How well could you examine objects from multiple viewpoints?
17. How well could you move or manipulate objects in the virtual environment?
18. How involved were you in the virtual environment experience?
19. How much delay did you experience between your actions and expected outcomes?
20. How quickly did you adjust to the virtual environment experience?
21. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?
22. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?
23. How much did the control devices interfere with the performance of assigned tasks or with other activities?
24. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?
25. How completely were your senses engaged in the experience?
26. How easy was it to identify objects through physical interaction, like touching an object, walking over a surface, or bumping into a wall or object?
27. Were there moments during the virtual environment experience when you felt completely focused on the task or environment?
28. How easily did you adjust to the control devices used to interact with the virtual environment?

29. Was the information provided through different senses in the virtual environment (e.g., vision, hearing, touch) consistent?
(Witmer et al., 2005) Presence Questionnaire Item Stems (Version 3.0)

The following questions were used to compare and contrast the survey data from the participants who completed the survey. Your information is anonymous, including your answers to the following questions. Thank you!

What is your gender?

Male Female Other: _____ Prefer not to answer.

What is your age:

18-24 25-39 40-55 55+ Prefer not to answer.

How many automotive courses have you taken at Renton Technical College?

1-3 4-6 7-10 10+ Prefer not to answer.

Appendix F - Faculty Interview Questions

1. What aspects of the virtual reality instruction did learners seem to struggle with most? Please explain.
2. What aspects of the virtual reality instruction did learners seem to enjoy most? Please explain.
3. Did the virtual reality instruction help the learners achieve the following program learning outcome? Please explain.
Troubleshoot vehicle systems using logical, traceable steps that lead to identification of the root cause of malfunction.
4. Did the virtual reality instruction help the learners achieve the following program learning outcome? Please explain.
Perform repairs using the proper tools and diagnostic equipment as per manufacturer's specifications.
5. Did the virtual reality instruction help the learners achieve the following program learning outcome? Please explain.
Diagnose and repair of vehicles to NATEF certification standards.
6. Did the virtual reality instruction help the learners achieve the following course learning outcome? Please explain.
Demonstrate the necessary skills to perform maintenance and light repairs on vehicles per NATEF guidelines.
7. Did the virtual reality instruction help the learners achieve the following course learning outcome? Please explain.
Perform heating and ventilation system diagnostics and repairs. / Perform engine cooling system diagnostics and repairs.
8. Did the virtual reality instruction help the learners achieve the following course learning outcome? Please explain.
Pass the ASE Certification Test.
9. Did the virtual reality instruction offer the learners something additional that other methods like lecture and laboratory activities do not? Please explain.
10. Please tell me how virtual reality instruction affected hands-on, lab activities.
11. Did the virtual reality reporting system show that the learners were improving their automotive knowledge and skills? If yes, what are some examples?
12. Would you recommend virtual reality instruction to other automotive faculty? Please explain.
13. Any perceptions about learning, when using virtual reality instruction, you would like to include that you have not? Please explain.
14. What areas of auto technology, if any, might you consider or recommend using VR instruction in addition to lectures or traditional labs?

Appendix G - PQ Participant Scores vs. Items and Factors

Scale	Participant 1	Participant 2	Participant 3	Participant ...
Item 1	-	-	-	-
Item 2	-	-	-	-
Item 3	-	-	-	-
Item 4	-	-	-	-
Item 5	-	-	-	-
Item 6	-	-	-	-
Item 7	-	-	-	-
Item 8	-	-	-	-
Item 9	-	-	-	-
Item 10	-	-	-	-
Item 11	-	-	-	-
Item 12	-	-	-	-
Item 13	-	-	-	-
Item 14	-	-	-	-
Item 15	-	-	-	-
Item 16	-	-	-	-
Item 17	-	-	-	-
Item 18	-	-	-	-
Item 19	-	-	-	-
Item 20	-	-	-	-
Item 21	-	-	-	-
Item 22	-	-	-	-
Item 23	-	-	-	-
Item 24	-	-	-	-
Item 25	-	-	-	-
Item 26	-	-	-	-
Item 27	-	-	-	-
Item 28	-	-	-	-
Item 29	-	-	-	-
Total Presence Score	-	-	-	-
Presence Factors	Participant 1	Participant 2	Participant 3	Participant ...
Involvement	-	-	-	-
Sensory Fidelity	-	-	-	-
Adaptation/Immersion	-	-	-	-
Interface Quality	-	-	-	-

Note. The presence questionnaire (PQ) consists of 29 items. Number of participants: XX.

Appendix H - PQ Mean, Standard Deviation and Range

Scale	M	SD	Range
Item 1	-	-	1 - 7
Item 2	-	-	1 - 7
Item 3	-	-	1 - 7
Item 4	-	-	1 - 7
Item 5	-	-	1 - 7
Item 6	-	-	1 - 7
Item 7	-	-	1 - 7
Item 8	-	-	1 - 7
Item 9	-	-	1 - 7
Item 10	-	-	1 - 7
Item 11	-	-	1 - 7
Item 12	-	-	1 - 7
Item 13	-	-	1 - 7
Item 14	-	-	1 - 7
Item 15	-	-	1 - 7
Item 16	-	-	1 - 7
Item 17	-	-	1 - 7
Item 18	-	-	1 - 7
Item 19	-	-	1 - 7
Item 20	-	-	1 - 7
Item 21	-	-	1 - 7
Item 22	-	-	1 - 7
Item 23	-	-	1 - 7
Item 24	-	-	1 - 7
Item 25	-	-	1 - 7
Item 26	-	-	1 - 7
Item 27	-	-	1 - 7
Item 28	-	-	1 - 7
Item 29	-	-	1 - 7
PQ Total	-	-	1 - 7
Factors of Presence			
Involvement	-	-	1 - 7
Sensory Fidelity	-	-	1 - 7
Adaptation/Immersion	-	-	1 - 7
Interface Quality	-	-	1 - 7

Note. The presence questionnaire (PQ) consists of 29 itmes. Number of participants: XX.