The Effect of 3D Virtual Reality Technologies on Learning: A Qualitative Research

by

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Abstract

The research paper explored teachers' lived experiences using 3D printing, holograms, virtual reality, and augmented reality types of tools and these tools' effect on learning in middle schools. The qualitative, phenomenological study introduced 21 teachers' lived experiences who had taught for two years or more about using 3D technologies through web-based surveys. There was insufficient research found on the effect of 3D types of technology like 3D printing, holograms, virtual and augmented reality in K–12 education. The future generation and the world's economic global stance is dependent on educational reform to prepare students for economic success and global competitiveness. Educational reform is dependent on societal changes which is dependent on technology use. The effect on learning outcomes with the use of 3D types of technologies were studied through teachers' lived experiences, and teacher perceptions on the effectiveness of 3D virtual types of technology to enhance learning were examined to help schools and educators make the decision to invest in these types of tools and know how best to engage students in learning. These tools can help support science, technology, engineering, and mathematics (STEM) types of fields to better prepare students for the future. The data results showed a majority of Illinois teachers lived experiences when using 3D types of tools positive for learning outcomes and positive on the quality of learning.

Dedication

I dedicate this dissertation to my late father, Dr. Salah Uddin Shams, who believed in me and helped me to stand tall when it seemed the world was against me. His support gave me the strength to accomplish this dissertation. To my Aunt, Tanseem Ali who showed me the light when I was in the dark. She reminded me an education is something no one can take away from a person and education equals power.

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Table of Contents

List of Tables

Table

Chapter 1: Introduction

The effect of three-dimensional (3D) types of technologies on learning were investigated. Ever since the invention of the Internet, students have been thriving in different learning opportunities involving responsive and adaptive applications where students are able to gain knowledge anytime anywhere (Kashada, Li, & Koshadah, 2018). With the adoption of digital learning technologies in education like computers, students have been provided with additional learning enhancements (Kashada, Li, & Koshadah, 2018). The inclusion of technology in learning has enriched curriculum and motivated students to learn (Gregory & Bannister-Tyrrell, 2017). Implementing and using digital technologies and the Internet have advanced education around the world because the educational system is constantly looking for ways to use emerging technology to enhance learning outcomes (Kashada, Li, & Koshadah, 2018). Digital shapes like computer graphics have introduced 3D media technologies which are at the frontline of digital technology content (Mortara & Catalano, 2018). Once new technologies entered the mainstream, the tools became commonplace and gained importance in educational institutions (Almenara & Robles, 2018).

Three-dimensional technologies have moved away from the entertainment world and have appeared in other fields like educational environments (Mortara & Catalano, 2018). Research on 3D types of technologies and other emerging technologies should continue to be investigated to assure these technologies are providing maximum benefits to students not only in universities but in K–12 education. Kashada et al. (2018) pointed out learning was not enhanced by giving a student a computer. Learning with technology requires combining technology, digital materials, and effective pedagogy (Kashada et al., 2018). Studies like Wang, Zhang, Chen, and

Liang (2018); Qi and Shi (2016); and Waseem, Kazmi, and Qureshi (2017) found 3D technology appearing in architecture, medical, and other higher level teaching programs, but not many studies exist which examine the effects of these tools in K–12 settings. The benefits for future studies can provide teachers with effective tools to empower students into becoming lifelong learners. The previewed major sections of the chapter include (a) background of the study, (b) statement of the problem, (c) purpose of the study, (d) significance of the study, (e) research questions, (f) conceptual/theoretical framework, (g) definitions of terms, (h) assumptions, (i) scope and delimitations, (j) limitations, and (k) summary.

Background of the Study/Problem

Technology is a part of daily life, increasing the pace of everyday activities by bringing about newer ways of doing things (Flavin & Quintero, 2018; Qi & Shi, 2016). Emerging technologies improve the quality of education by making education accessible anytime and anywhere (Qi & Shi, 2016). New technologies are becoming affordable, simpler, smaller, and easier (Flavin & Quintero, 2018). With the advent of the Internet, teaching and learning have evolved outside the classroom and into distance learning where emerging technologies are used in military simulation training, distant medical training, and many other fields of studies (Qi & Shi, 2016). Technology has the ability to empower students to learn hands-on at any time from any location because information is readily available via the Internet (H. Lee, 2013). Hands-on learning is conducive to constructivism, the broad theoretical context within which the dissertation research fits in (Brown, 2015).

Constructivism is the theory behind the knowledge constructing movement in education where students engage with content, others, and previous knowledge to create new knowledge

(Gregory & Bannister-Tyrrell, 2017). Social constructivism and collaborative learning are based on knowledge developed when learners socially interact with a learning environment and other people (Gregory & Bannister-Tyrrell, 2017). Collaborative learning is affected positively when communication technology is integrated in learning as Qi and Shi's (2016) study claimed communication types of technologies which are commonplace include: media streaming, instruction aided by computers, web page design, and even virtual reality (VR). Google, another example of technology which enhances learning, is simple, free and easily accessible (Flavin & Quintero, 2018). The iPhone and other types of mobile digital devices are forms of technology which have sparked innovation by users because smart technologies are portable and provide quick, easy access to the Internet quick and easy (Flavin & Quintero, 2018).

Educational technology has come to the attention of many researchers because this technology is already being used in educational institutions as the popularity of distance learning relies on the Internet and other social media (Qi & Shi, 2016). Vygotsky and Piaget affirmed this belief by endorsing collaborative learning, a component in the online collaborative and constructivist philosophy, as effective learning pedagogy because students experience self-regulation, learn to overcome conflicts, practice communication skills necessary among team members, and reflect on learning while making connections with the world (Gregory & Bannister-Tyrrell, 2017). The possibilities for new technologies are ongoing and continue to exist redesigning tools to increase innovation and encourage students to become constructors of knowledge (Flavin & Quintero, 2018).

Statement of the Problem

Three-dimensional types of tools are being implemented in education, but it is not known how these tools effect learning in the K–12 environment. Almenara and Robles (2018) reported a number of emerging technologies seen in universities which were not heard of before. AR and VR are among the tools gaining popularity which are transforming and improving training curricula (Almenara & Robles, 2018). Technology exists in all aspects of daily life making technology a natural component in education; for example, technology is appearing in medicine and architectural fields of study (Wang et al., 2018). People described using 3D types of technologies as providing rudimentary life experiences which are not possible in the real world (Wang et al., 2018). Continuous efforts to invent new technologies and what new technologies can offer learning environments can prevent barriers which once existed in education when used appropriately (Benitez-Saza, Bustos-Velazco, & Arevalo-Gomez, 2018). Globally, universities in Colombia are requiring graduates to be trained and skilled in emerging technologies related to communication and information to help trainees be better equipped to design, develop, and evaluate educational tools when hired. Colombia is working to configure emerging technologies for different applications like VR (Benitez-Saza et al., 2018).

The research problem is current, relevant, and important because the research helps to understand whether 3D types of technologies like VR have an effect on learning through the experiences of educators. Ford and Minshall (2019) stated even though 3D technology is present in educational settings, a need for research focusing on better implementation is needed. While these tools are being introduced in learning environments, research is lacking on the effect of these tools in K–12 education. Almenara and Robles (2018) alleged research on integrating 3D

types of technologies is still new but confirmed recent research conducted on these innovative types of technologies to show benefits when integrated in the teaching and learning processes. Further research can help to discover how 3D types of technologies should be integrated into elementary learning and to determine the benefits which arise in using these types of tools with content (Ford & Minshall, 2019).

Purpose of the Study

The purpose of the qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and augmented reality (AR) types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades. Rodriguez (2018) argued teachers play a part in creating a classroom climate which can support learning. For example, science, one of the crucial subjects in science, technology, engineering, and mathematics (STEM) education, is one subject lacking student enthusiasm and teachers are the ones who should reflect on teaching practices to explore how science learning is conducted to get more students excited about science (Rodriguez, 2018). Understanding the way teachers are using the 3D emerging technologies and discovering the way these tools affect learning can help other teachers to implement best practice when using the tools from the beginning. This research involved comparing how teachers were using the tools and the effect the tools had on learning which can help other teachers develop ways to implement the tools in any subject matter.

ZSpace was contacted to identify schools using zSpace machines to locate participants and schools were contacted around Illinois to find other schools using 3D types of technologies. After obtaining informed consent from participants and the principals, a coding system was used to collect data anonymously where the schools and the participants were assigned a letter and

number code. Twenty-one middle school teachers were invited to participate in the study. Researcher designed open-ended questions were asked to participants to provide feedback on the phenomenon from the teachers' lived experiences. Google forms was used as the tool to design and implement the open-ended questionnaire. Three-dimensional types of tools are new to education and this study may discover how best to implement these types of tools where learning can increase students' motivation to learn (Almenara & Robles, 2018).

Significance of the Study

The qualitative research study's findings can further knowledge regarding the phenomena of 3D types of technologies and the effect on learning by helping a community of educators develop a sense of understanding on the inclusion of such tools to advance learning. A community of practice can support educators in the profession when members share practices which promote active innovative learning through lived experiences of colleagues from different parts of the world (González-Patiño, 2018; Rodriguez, 2018). Effective educators are intrinsically motivated to continuously improve teaching practices and the profession in which students are copartners (González-Patiño, 2018). Knowing how other colleagues are implementing 3D types of technology into the curriculum can help other educators improve upon teaching practices and learning. Benitez-Saza et al. (2018) claimed educational changes are occurring due to globalization, implementing communication technologies, innovation, and information readily available via the Internet.

Innovation relies on the learner self-managing knowledge based on an ongoing never ending process where the virtual learner is aware of the role played in the dynamics of learning and the demands of the technology used (Benitez-Saza et al., 2018). Virtual education using

digital devices can enable an educator to distinguish between innovative and traditional teaching, effective and ineffective, and between the outdated and updated when the issue comes to learning in a society overwhelmed with information (Benitez-Saza et al., 2018). Mortara and Catalano (2018) claimed learning is enhanced beyond the classroom with the use of technology as technology can introduce the past in realistic ways allowing students to experience historic events and places with new forms of learning. Nontraditional ways include learning about relics as relics are recreated from originals or physically being in a recreation of the historic occurrence as the surroundings are reconstructed via 3D technology tools like virtual environments (Mortara & Catalano, 2018).

Benitez-Saza et al. (2018) concluded learning has no borders when digital technology is implemented as an information tool and there is a need to train educators to perfect and update knowledge about using information and communication technologies where students are capable of accessing pertinent information anytime and anywhere. Teachers' roles are evolving from transmitters of knowledge of a discipline to facilitators, managers, and creators of environments where learning thrives. To be successful, an educator should be mindful of being a continuous learner who is aware of knowing and using current technologies (Benitez-Saza et al., 2018). Ford and Minshall (2019) argued the importance for schools to keep up with the changing times because even libraries are transforming physical spaces to provide a place where people can collaborate and learn from one another. Libraries are joining schools in providing 3D printers and other digital tools to push creativity and for patrons to try new things.

Learning with digital tools requires more than giving students a tool (Kashada et al., 2018). Knowledge requires a mix of factors like being aware of the tool and understanding the

role the tool has in learning, the tool's ease of use, and the infrastructure needed for the tool's successful implementation (Kashada et al., 2018). Studies share how online digital tools and 3D types of technology are affecting teaching and student engagement and how these tools are being used in helping undergraduates, but little is known and shared about elementary and middle schools (Gregory & Bannister-Tyrrell, 2017). The future seems to be related to STEM education, but students are not excited about science-related fields (Rodriguez, 2018). This study is significant because the findings may help educators encourage students in STEM-related courses with an emphasis on science and engineering through the inclusion of 3D types of technologies. Using the right 3D tool may help educators to encourage and excite students to become lifelong learners.

Research Questions

A qualitative study's research questions reveal the path of the research and the kind of knowledge to be discovered (Alase, 2017). The qualitative, phenomenological study explored two questions. The questions were:

Research Question 1: What are teachers' lived experiences on learning outcomes when 3D virtual reality technologies are used?

Research Question 2: How do teachers perceive the effectiveness of 3D types of virtual reality technologies to enhance learning?

Google forms helped design an open-ended questionnaire to provide a way for participants to share lived experiences of using 3D printing, holograms, VR and AR technologies because the Internet is cost effective, efficient in saving time, and provides flexibility for participants to reflect and take time responding (Alase, 2017). Phenomenological research

participants involve a smaller number of individuals' narrating lived experiences where participants explain descriptions of the phenomena (Alase, 2017). Questions included the tool used, the outcome intended, student response when tool used, in addition to the educator's perceptions of the tool and the tool's effect on learning. Additional data was to be collected through interviews either via FaceTime/Skype or voice call to clarify responses if needed.

Educators shared handouts, websites, or other supplemental materials which further clarified how the tool was used and the results the tool produced when learning a particular intended outcome. Data was read and analyzed using Tesch's eight sequential steps; steps include making meaning from the data collected (Creswell & Creswell, 2018). A color coding process was used to identify common themes, words, or phrases discovered in responses since qualitative research involves time and is a crucial step in qualitative studies (Alase, 2017). Rereading responses helped to come up with conclusive themes and findings to finalize what participants experienced with the use of the phenomenon (Alase, 2017).

Conceptual Framework

Educating future generations is important for success when a country's economy is struggling to thrive globally and educating the next generations can be done successfully if educators are effective and can maximize learning (Teeple, 2018). Job demands are changing and evolving with the advancement of technology. Educators need to be mindful of changes in society and the economy, which have an effect on the future of educational practices and on learning models since societies want to compete globally to be the best. The focus is shifting from teaching specific subject matter to specific habits and skills involving problem-solving

techniques to advance a society's intellectual growth, economic possibilities, and national security (Berk, 2016; Teeple, 2018).

Education and pedagogy are constantly affected due to changes in society and the economy where learning outcomes evolve from those changes (Stingu & Iftimescu, 2016). Educators should conform to the demands and the changing times to ensure next generation is capable of surviving and making a better future. Changes in education are evident from the time of the Industrial Revolution when demand for blue-collar jobs were on the rise to meet the needs of manufacturing industries (Stingu & Iftimescu, 2016). As the job market changed, schools focused on preparing students for office-related jobs. In the 21st century, society is concerned with economic, national, and global pursuits (Teeple, 2018). Society has moved away from a *knowledge economy* to an *information society* ((Stingu & Iftimescu, 2016) where learning is focused on productivity in a fast growing economy as technology and information communication technologies are advancing.

One educational reform initiative becoming popular as a new innovation in America, is STEM education (Teeple, 2018). Complicated challenges facing society and the world require various approaches and skills blended into one branch of knowledge focusing on STEM education (Berk, 2016). Stingu and Iftimescu (2016) claimed schools and teachers can educate students for an unpredictable future by making a variety of current technologies accessible to students which promote collaboration type of skills. Educators should exchange best practices and include professional development geared towards training to meet the needs of learners to be successful (Stingu & Iftimescu, 2016). The phenomenological study may help educators recommend which types of 3D technologies to make accessible to students by sharing lived

experiences on best practices and how to meet intended learning outcomes when using these types of tools to enhance learning.

Definitions of Terms

The definition of terms includes concise definitions of key concepts. Key concepts in the study are defined in relation to three-D types of technologies. The definitions use operational and measurable terms where appropriate, either by quotes or paraphrasing from authoritative sources.

Augmented reality (AR): Technology which takes digital and physical details/information in real time through technological devices to achieve a new reality. A user stays in the refined space with the assistance of tablets and smartphones (Almenara & Robles, 2018). Visits are augmented and believed to be onsite and real due to the virtual content presented to the user (Mortara & Catalano, 2018).

Bring your own device (BYOD): Approaches to provision where students bring personal technology devices to school for learning. Examples of mobile devices include mobile phones and tablets (McLean, 2016).

Constructivist theory: Theory which states learning is not simply obtaining knowledge but involves becoming an active member in the process of attaining knowledge. Learning involves developing online environments for students to work collaboratively on problems, introduce issues, and critique others' findings (Gregory & Bannister-Tyrrell, 2017). Constructivism theories claim teachers are not separated from the learning process but are participating facilitators who help construct knowledge (Picciano, 2017).

Digital Revolution: There are two Digital Revolutions. The first revolution occurred when information was digitized, and the second revolution involved digitizing by transforming physical tangible objects in digital files (Rindfleisch, O'Hern, & Sachdev, 2017).

Google Glass: Smart glasses used as a head-mounted device for AR (Pope, 2018).

Head-mounted display (HMD): VR glasses used with headphones, produce the "visceral feeling of actually being in the simulated world" (Freina & Ott, 2015, p. 134).

Holograms: A Greek word where *holos* means *whole* and *gramma* means *message* (H. Lee, 2013).

Industrial Revolution: Started in 1870 (Rindfleisch et al., 2017). Time period in history where the economy was industrialized, and education was centered around training students for blue-collar jobs (Stingu & Iftimescu, 2016). Industrial and technical training were a huge part of the educational reform movement around 1880s and 1890s (Cohen, 1968).

Microsoft HoloLens: Head-mounted device used for holographic and mixed-reality experiences (Pope, 2018).

Mixed reality: Technology which combines AR and VR (Almenara & Robles, 2018).

Oculus Rift: HMD for education when using VR technology (Freina & Ott, 2015).

Online collaborative learning (OCL) theory: A learning theory associated with Harasim which centers on the use of the Internet to offer learning environments which promote collaboration and building knowledge. This theory is associated with social constructivism in which students are encouraged to solve problems collaboratively in a dialogue and the teacher facilitates as a member of the learning community developed (Picciano, 2017).

Samsung's Gear VR: A mobile head-mounted device for VR claiming to be more comfortable (Birt, Stromberga, Cowling, & Moro, 2018).

Science, technology, engineering, and mathematics (STEM) education: Educational reform initiative stressing the need for students to increase knowledge in STEM disciplines for students to compete in any society along with the economy in the hopes students have skills to face daily issues as adults (Teeple, 2018).

Simulations: A seemingly real or physical environment used mostly to help train professionals in work environments like preparing for fire safety or emergencies (Freina & Ott, 2015).

Three-dimensional technology: Emerging 3D technologies changing the way students think, do, learn, and interact. The use of 3D technology like VR headsets and 3D cameras are predicted to grow rapidly over several years and may take over daily experiences in learning environments with many more 3D tools to come (Ng, Sinclair, & Davis, 2018).

Three-dimensional holograms technology (3DHT): Officially recognized in the 1960s (Kalansooriya, Marasinghe, & Bandara, 2015). Three-DHT uses a 3D photograph along with a laser beam to project through an object to allow another ray to project a reflection of light off the first ray making a 3D optical image (Orcos & Magreñán, 2018).

Three-dimensional printing: Allows users to turn digital designs into physical products. A product can be digitized and then modified according to a user's desire. A 3D printer, the device needed to 3D print, turns a digital design into a physical object when this printer layers thin slices of a material, usually plastic, in an additive procedure (Rindfleisch et al., 2017).

Three-dimensional scanning: Creates a digital replica of a physical product/object and then 3D design software helps to create a digital remix of the original physical product/object. Three-dimensional printing hardware helps to print a physical replica of the new version of the original product/object (Rindfleisch et al., 2017).

Virtual reality (VR): A sophisticated relationship between a user and a computer which allows a user to be placed in an immersive digital environment, created artificially when wearing an HMD. A user appears in first person and believes through a user's senses to have moved to an artificial environment because the technology has made the environment appear as an illusion in the user's brain as if the user is participating in the virtual environment (Almenara & Robles, 2018). The user visually perceives the reality through head-mounted devices which allow for sound and includes basic tracking equipment for user's to interact. (Mortara & Catalano, 2018).

Virtual worlds: Computer-based simulations of objects and places which appear lifelike and can include buildings, landscapes, and any objects to make a user believe the user is immersed within the 3D digital environment where the user can manipulate or do any actions inside the virtual world (Domingo & Bradley, 2018; Hakkila, Colley, Vayrynen, & Yliharju, 2018). The user appears and functions in this world as an avatar which can take a human or animal shape (Domingo & Bradley, 2018).

zSpace: An all in one machine with elements of VR and AR to create lifelike experiences through a computer and special glasses (zSpace, 2016).

Assumptions

In conducting this study, assumptions were made. Assumptions included all participants understood the questions being asked, answered and shared lived experiences truthfully and

honestly. Participants were assigned a random code to hide identities making participants anonymous and assuring participants would be honest and open in responses. Society is under the impression mobile devices are powerful tools which promote learning, can reform education, and schools implement new technologies under the premise students are interested in learning only when digital tools are used (Philip & Garcia, 2014). There is a belief about young minds being intrinsically motivated with the inclusion of digital technology (Jacobs, 2012). Teachers are disappointed when students do not show interest in learning, but implementation of certain types of technologies motivate students to engage in the learning process (Jacobs, 2012). The way an educator presents a learning tool is important to achieve the desired learning outcomes, and teachers can learn from other professionals' mistakes and successes. The study's findings can make learning successful from the start for other educators who may not be comfortable with using and implementing new technologies. Rather than accepting the idea technology automatically motivates students in learning environments, studies should investigate how digital tools can promote knowledge. The knowledge attained from study results can help educators learn from other professionals on how best to design instruction where students can use technology tools to maximize learning and build upon knowledge (Jacobs, 2012).

Scope and Delimitations

The coverage of this study intended to include middle schools located in and around Illinois which had used 3D types of technologies within one school year. The research focused on Illinois middle schools since 3D technologies like 3D printing, VR, AR, and holograms were new to K–12 education and locating middle schools was difficult. Since enough participants from Illinois were not located, the research branched outside the narrowed region to look beyond

the selected geographical location. The study consisted of participants shared lived experiences of the phenomenon and the phenomenon's effect on learning. The study focused on the effect of 3D types of technologies on learning from the lived experiences of educators using these types of technology. The findings could be transferable to other longer studies using a quantitative component like including results from teacher created summative assessment scores to show growth in learning from two student control groups; one having access to these types of tools and the other without these tools. The research results may not be generalized to all elementary students, but these results and findings could be a starting point for educators who desire to motivate, engage, and encourage students to become lifelong learners with the use of new and upcoming technologies in order to maximize learning experiences and learning outcomes in classrooms.

Limitations

According to Creswell (as cited in Alase, 2017), qualitative studies are ideal to explore the main issue regarding a phenomenon and is dependent on participant's lived experiences. The design-related limitations included the amount of time and frustration in coding and making meaning out of the numerous lived experience responses from participants. The data included participants' responses to open-ended questions about the use of 3D types of technology and the effect on learning these tools had on learning outcomes. The study results are dependable under the assumption participants were honest and did not provide answers based on others' biased or popular public opinions towards technology use. Dependability and confirmability were established by keeping accurate records and documentation of participant feedback, and final findings were based on the actual words of the participants (Ryan, Coughlan, & Cronin, 2007).

Steps taken to control limitations included double checking final outcomes by participants before publication. The research was strengthened by presenting the explanations of lived experiences of the participants' experiences reputably (Alase, 2017).

Chapter Summary

This research stems from society's dependence on the success of future generations to outdo the present. Education has long been at the forefront of societies to survive and progress. Effective educators have continuously looked for innovative ways to help society create citizens for the future. One way educators can help is to accept new emerging technologies because the next generation is already accustomed to using technology in daily life. According to Rodger Bybee (as cited in Teeple, 2018), an advocate for STEM education, the United States needs a society literate in STEM, and a workforce which is innovative and skilled for the 21st century. This workforce can exist if educators can encourage and excite the younger generation to want to learn and be competitive in a global economy.

Rindfleisch et al. (2017) stated society is overwhelmed in a data-rich world causing a Digital Revolution to exist. Students are exposed and obsessed with social media, web browsing, and online shopping where there are times students generate innovation when transforming digital data into products using new technology tools which include audio, video, and 3D printing (Rindfleisch et al., 2017). To improve education and to keep students engaged in learning, educators have to keep up with new technologies as these technologies emerge in daily life (Jowallah, Bennett, & Bastedo, 2018). VR is one such technology appearing in classrooms but implementing the tool to maximize learning is essential. There has to be a balance between new technologies and teaching practices in classrooms making this study necessary to help

implement new technologies like 3D printing, VR and AR, and holograms where pedagogy is enhanced, and learning outcomes are achieved based on state mandated learning standards (Jowallah et al., 2018). Definitions of relevant terms, limitations, generalizations, assumptions, scope and delimitations have been presented. The next chapter discusses the literature review which includes the literature search strategy, the conceptual and theoretical framework, and the research literature review.

Chapter 2: Literature Review

The chapter reviews literature on 3D VR technologies and these tools' relationship to learning. The problem of the qualitative study is while these tools are becoming common in education, little data exist on the effect on learning in K–12 settings (Jowallah et al., 2018). Since the beginning of time, humans have been contemplating about learning and the methods for learning because people have a natural interest in education (Ipek & Ziatdinov, 2017). Changes in education occur because of social and economic advances, and socioeconomic demands dictate educational outcomes (Stingu & Iftimescu, 2016). Many historical events have influenced education, in particular the Industrial Revolution when manufacturing and blue-collar jobs were in high demand. As times changed and service needs increased, conditions in society required office type jobs. Due to changes in society, technology advancements have been able to influence educational reform more quickly than any other (Stingu & Iftimescu, 2016). To provide effective learning, technology use has increased presence in educational environments resulting in significant revolutions (Orhan-Goksun, Filiz, & Kurt, 2018). The purpose of the qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and AR types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades.

The beginning of the Digital Revolution in education and technology started with the application of the Internet and the invention of personal computers (Rindfleisch et al., 2017). The next Digital Revolution in education is taking place with the application of 3D, VR and AR, and holograms (M. Lee et al., 2018; Rindfleisch et al., 2017). Advancements in technology have made communication and collaboration around the world, transforming learning with the

evolution of global learning communities as one way to improve learning programs (Frydenberg & Andone, 2018; Stingu & Iftimescu, 2016). Technology is rapidly advancing with the invention of new applications, changing the way people explore and interact with the world (Hakkila et al., 2018). Three-dimensional technology is gradually being used in classrooms across the country. Three-dimensional interactive software was not previously leveraged in classroom environments due to certain limitations, which included teachers being unaware of the technology and the high maintenance cost of the tool (Moro, Stromberga, & Stirling, 2017).

Teaching and learning are transitioning away from traditional classrooms to online environments where 3D types of technologies are implemented (Moro et al., 2017). Learning is defined as attaining knowledge which results in comprehending ideas not known before, and for learning to be effective, three elements need to be present: enthusiasm for learning, straightforward goals, and sufficient use in application. When these three elements of learning exist, education becomes most beneficial (Moro et al., 2017). For example, pedagogy is moving away from using two dimensional pictures and videos to interactive environments (Birt et al., 2018).

Educators are constantly looking for ways to make learning engaging in order to make content easily understood and to improve student outcomes (Moro et al., 2017). Stingu and Iftimescu (2016) claimed technology implementation has a vital role in elevating student motivation, changing the way students and teachers communicate, supplementing higher attainment of education, and making resources accessible to more people in less time. Technology is reshaping learning environments and narrowing the gap worldwide (Stingu & Iftimescu, 2016). The challenge is to see how 3D types of technologies can be used to change the

way students learn and teachers teach (H. Lee, 2013). Including teacher perceptions is vital. Throughout history, the evidence shows educators are instrumental in developing educational technologies. Teachers are the ones using these tools in classrooms. Stingu and Iftimescu concluded educational change is dependent on teachers' implementations of technology in the classroom. Orhan-Goksun et al. (2018) agreed teachers have a major role when implementing technologies in the education process and educators who use technologies tend to welcome new technologies in the classroom.

The purpose of the qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and AR types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades. The topics discussed are 3D technology like 3D printing, holograms, VR, and AR and where and how these technologies are used. This study was based upon Harasim's OCL theory, which sets out to redesign formal education by using the Internet to produce learning environments (Picciano, 2017). These online environments stimulate collaborative learning where knowledge can grow and develop (Picciano, 2017). Learning is now collaborative and using AR and VR involves working with others. The other theory which influenced this study was the constructivist theory which advocates allowing learners to construct a personal viewpoint of the world (Ouyang & Stanley, 2014). The previewed major sections of the literature review include the literature search strategy, the conceptual and theoretical framework, and the research literature review. The literature review includes broad categories of 3D technology like 3D printing, holograms, VR, AR, and the concept of bring your own device (BYOD). These 3D technologies are four of the

most popular types of technologies in education; the concept of BYOD could affect how these technologies end up in classrooms.

Literature Search Strategy

Relevant theoretical and empirical articles were located using EBSCOhost and Google Scholar. When an article was not available through an EBSCOhost search, Google Scholar was sought out to locate resources. Key word searches included using words like *integrate* and *history of* to find information about the use of technology. Search terms were used to find research on the different types of technologies discussed in this study. *Integrating virtual and augmented technology in learning*, *3D technology in education*, *virtual reality in education*, *augmented reality in education*, and *history of educational technology* were the search terms used. The following search terms were used separately and together: *integrating technology in the classroom*, *3D technology* and *virtual reality*. Unsuccessful search terms included *teachers education technology integration*. When resources were not found using EBSCOhost, a search was conducted using Google scholar. The search term used for Google Scholar was *3D printing technologies in education*.

Theoretical Framework

The theories which influence this study are the constructivist theory, which implements parts of Piaget, Dewey, and Vygotsky's learning theories, and Harasim's OCL theory (DiPasquale, 2017; Ouyang & Stanley, 2014; Ültanır, 2012). Constructivist theory is centered around active learning where the learner is constructing meaning based on prior understandings (Jin, 2017; Pardjono, 2016; Ültanır, 2012). Three theorists, Dewey, Piaget, and Vygotsky have contributed to the development of the constructivist theory (Pardjono, 2016). Dewey rejected

traditional educational settings in which the teacher was the possessor of knowledge who passed information onto students (Pardjono, 2016). Similar to Dewey's theories, Piaget rejected traditional learning methods and claimed learners cognitively develop when interacting with the world (Pardjono, 2016). Vygotsky added a social aspect to learning in which students internalized learning after being in social learning environments (Pardjono, 2016).

In an OCL environment, Harasim claimed collaboration was vital in an online environment; knowledge occurs when a learner is gathering, organizing, and synthesizing information while participating to construct meaning to apply the knowledge gained (DiPasquale, 2017). During this process, the educator is a facilitator who guides the learners when needed and eventually as the learners develop necessary skills in this environment, the facilitator's responsibilities are reduced (DiPasquale, 2017). Learning in an online collaborative classroom requires students to take on responsibility for learning while students engage in the learning environment and the facilitator is vital in monitoring the learning and discussions taking place while still a part of the larger learning community in the classroom (DiPasquale, 2017). The constructivist approach based on Piaget, Dewey, Vygotsky and Harasim's OCL theory were the two main theories guiding this study because these theories are similar and relate closest to the use of 3D types of technologies. Constructivists emphasize students develop knowledge when students put learning to practice and such instruction should be centered around the psychological developmental needs of students (Ouyang & Stanley, 2014). In a constructivist environment, similar to discovery theory, students learn from doing rather than rote memory (Ouyang & Stanley, 2014).

There have been many educational theories associated with designing and using educational technology, including behaviorism, cognitivism, constructivism, and multiple intelligences (Ouyang & Stanley, 2014). Computer assisted learning was believed to be derived from the theory of behaviorism because learning is based on instruction, which is programmed, and responses of the learner are predictable (Ouyang & Stanley, 2014; Picciano, 2017). Cognitivist theorists like Bruner claimed students develop cognitive abilities at different stages of learning (Ouyang & Stanley, 2014). The constructivist theory focuses on the thinking process of the learner; how a learner receives, processes, and uses information, and how a learner develops critical thinking and problem solving (Ouyang & Stanley, 2014). Huang and Liaw's (2018) research looked at VR from a constructivists approach stressing a learner can develop the ability to solve real-life problems which can instill motivation for a learner. Other constructivists, like John Dewey and Lev Vygotsky believed learning is driven from social encounters where students are actively working, collaborating, and reviewing with other learners constructing knowledge (Picciano, 2017).

Education in the 21st century has seen an influx of new technology and new technology is changing learning as it is being leveraged in all sectors of education just as in all aspects of daily life (Ouyang & Stanley, 2014). Technology is transforming learning with the accessibility of distance education, e-learning, blended learning, and other opportunities for any person at any age to become a lifelong learner (Stingu & Iftimescu, 2016). Students are highly engaged and motivated when using technology in daily life which is why schools have to keep up with changing times (Stingu & Iftimescu, 2016). New 3D technologies are being introduced and advertised promising to bring learning to life in classrooms (Pierce, 2016). The future of

technology in education may be unclear, but the possibilities to improve learning seem endless. The phenomenological qualitative study is important because understanding teacher's perceptions of the use of 3D types of technologies on learning may help explain whether these 3D technologies have an influence on student learning and are worth the investment.

Learning is best enhanced with the use of 3D types of technologies in which students can be intrinsically motivated to grow as learners from real-world experiences in a constructivist or online collaborative environment (Huang & Liaw, 2018). OCL and constructivist theories can be applied to using 3D types of technologies since the learner is actively engaged with the tools to make meaning out of personal and social experiences. OCL and social constructivism are more in common with the study (Picciano, 2017). Both theories are similar because learners are actively solving problems in a constructivist like environment building on previous knowledge to construct new knowledge (Huang, & Liaw, 2018; Picciano, 2017). The instructor takes the role of facilitator who is actively a member of the building of knowledge (Picciano, 2017).

The literature review presents research findings on four types of 3D technologies: 3D printing, holograms, virtual, and augmented realities in education, and the concept of BYOD. These technologies could affect learning in virtual collaborative environments because knowing the background associated with the tool, the tool's emergence in education, and the tool's implications for learning could help educators improve as facilitators of learning. Learning how others are using these types of tools and the benefits reported from using these tools can help educators understand the tool's existence, the reasoning behind the tool's emergence, and the benefits of implementing these tool's in the educator's learning environment. Knowing these tools have existed for many years and are now entering classrooms should make the

implementation of these tools more meaningful, less stressful for educators, and more engaging for students.

Research Literature Review

Research studies relating to 3D types of technologies are shared from around the world. The literature review discusses what has been discovered about learning with the use of 3D printing, holograms, virtual reality, augmented reality and the bring your own device initiative. The literature review helps to understand the need for further research regarding these tools and their effect on learning.

3D Printing

The Digital Revolution which involved creating and inventing on the World Wide Web is now moving towards applying lessons learned to the real world in the form of tangible objects (Brown, 2015). The global economy is predicted to be influenced by additive manufacturing evidenced by observations on computer technology, the World Wide Web and the Internet (Waseem et al., 2017). The background of the tool, emergence in education, and implications for learning are discussed.

Background of tool. Additive manufacturing involves the process of combining materials by layers to build an object from 3D computer-aided design software or from the scanning of a tangible object (Kostakis, Niaros, & Giotitsas, 2015). The technology has existed for some time and was referred to as "rapid prototyping machine" (Kostakis et al., 2015, p 118). Architects, automobile engineers, aerospace and health care fields have been printing prototypes of parts and products for some time (Kostakis et al., 2015).

Three-dimensional printing turns digital files into solid objects and involves many forms of technology (Brown, 2015; Waseem et al., 2017). A constructivist approach to learning has emerged once again using problem-based learning and hands-on manipulation with the advent of 3D printing (Brown, 2015). Three-dimensional printing involves technologies which produce 3D objects from computer generated designs (Brown, 2015). A traditional printer prints in two dimensions taking into consideration length and width, but a 3D printer prints objects having volume where the object's length, width, and height are considered because a 3D object has X, Y and Z axes which can be measured (Brown, 2015). The low cost of 3D printers and open source software have made it easier for schools to provide this technology to learners. The do-it-yourself movement has made it possible for learners to experiment, design and produce digital models into tangible objects moving from blue prints to actual construction (Kostakis et al., 2015). Knowing the history and background of 3D printing should help educators realize the intended purpose of 3D printing technology and the tool's relevance on learning.

Emergence in education. Changes and trends in learning and teaching are coming about due to students being brought up in a lifestyle which encourages interactivity online as well as new forms of communication, collaboration, creativity, and sharing (Kostakis et al., 2015). Whenever there are new developments and implementation of new technologies, such changes are met with resistance (Kostakis et al., 2015). Another important discovery emerging from economic competitiveness is the emergence of STEM education (Schelly, Anzalone, Wijnen, & Pearce, 2015). Learning involving STEM education has direct links to innovation, economic development, and productivity, but there is a lack of qualified STEM employees for the United States to compete at a global level (Schelly et al., 2015). Shelly, Anzalone, Wijnen, and Pearce

(2015) invited teachers from Michigan to attend a three-and-a-half-day workshop. In this workshop, the educators explored open-source technologies to design a usable open source 3D program (Schelly et al., 2015). Educators concluded 3D printing technologies could offer students a powerful tool for creativity and exploration, and an engaging introduction to STEM topics (Schelly et al., 2015). The same STEM sentiment was claimed in Buehler, Comrie, Hofmann, McDonald, and Hurst's (2016) case study which concluded 3D printing could be used to aid STEM engagement in students with disabilities and fosters do-it-yourself activities with the help of assistive devices.

In the last two decades, 3D printing has started to expand into many educational institutions globally (AbouHashem, Dayal, Savanah, & Strkalj, 2015; Waseem et al., 2017). Countries like Pakistan are increasing the use of 3D printing in everyday society to benefit multiple areas and are beginning to use 3D printing to empower teachers and learners with a compelling way to learn (Waseem et al., 2017). Three-dimensional printing has supported teachers in Pakistan by helping to print models used in the classroom to illustrate hard to understand concepts capturing engineering, architects, and medical students' interest with hands-on learning using printed mini models (Waseem et al., 2017). Research centers in the United Kingdom are studying the use of 3D printing in higher educational institutions in design and art along with the jewelry industries and the Center for Fine Print Research (Waseem et al., 2017). In Greece, Kostakis et al. (2015) observed two high schools experimenting the use of open source 3D printing as a mode for learning and communication.

Research has shown the use of 3D printing in many different medical fields helping students specifically in anatomy (AbouHashem et al., 2015). Attaining human bones for

Sydney's Macquarie University and Western Sydney University was not easy since legal issues and the burial of the body presented problems. Three-dimensional scanning technology made possible the recreation of human bones accurately and similar to real bones without presenting ethical issues (AbouHashem et al., 2015). AbouHashem et al. (2015) predicted the use of 3D printing in other subjects since this technology had already proven effective in the printing of anatomical parts normally difficult to acquire. This technology is likely to develop further with the increased need for improving clinical competencies (AbouHashem et al., 2015). In Su, Xiao, He, Huang, and Deng's (2018) controlled comparative study, 3D printed models of hearts with defects were used. Different types of defected hearts were printed to enhance the congenital heart disease curriculum to help medical students. Su et al. argued utilizing 3D printing technologies to learn about heart disease produced positive results. Learning how 3D printing is being used globally and in higher education could persuade educators in the United States to realize the need for this tool's implementation at an earlier age in the process of learning to encourage innovation, creativity, and global competitiveness

Implications for learning. Pierce (2016) stated there is an increase of articles appearing in technology and educational journals about 3D technology's effect on 3D instruction; companies are advertising and introducing new 3D technologies claiming these tools bring learning to life in classrooms. Reported benefits with 3D technology claim 3D printing is a pivotal discovery in educational technology (Brown, 2015). Brown's (2015) fieldwork study claimed 3D design and production develop spatial skills in students. Spatial skills are considered a special form of intelligence different from verbal and reasoning skills. Spatial ability involves the understanding of 3D relations among objects (Brown, 2015). Buehler et al. (2016) claimed

3D printing could provide students with a powerful tool which could help students be creative, be intrigued to explore, and build an interest in STEM subject matters.

Since 3D printing is entering mainstream education, special needs students are being affected as well. Buehler et al. (2016) were able to implement 3D printing and design into special education. Three functions resulted from using 3D printing: increased interest in STEM activities, the support of educational aids making instruction accessible to all, and the discovery of adaptive devices (Buehler et al., 2016). This tool and the skills involved in 3D printing have the power to enhance STEM education along with career and technical education empowering students to personalize learning (Schelly et al., 2015). Studies have shown students who use 3D printing technologies increase opportunities for success in a future unknown (Brown, 2015). Students can transform visions into real objects while innovative ideas are becoming a reality in engineering institutions using 3D printers (Waseem et al., 2017).

Holograms

Another type of 3D technology making a significant influence on education is 3D holograms. Even though 3DHT has been used in a variety of contexts, this technology has only recently been used in education. Holograms could change the way society creates and shares information like the Internet has changed the way society communicates (H. Lee, 2013). The history of the tool, the emergence in education, and the implications for learning are discussed.

History of tool. Three D holographic technology is seen in communication, military training, entertainment, medical training and virtual AR. For example, 3DHT was used by India's prime minister in the 2012 election where Modi spoke to many places at the same time via a live satellite broadcast. Modi used the 3DHT to project a life like image of himself

(Kalansooriya et al., 2015). Other uses include the CNN 2008 election broadcast in the United States and Michael Jackson's hologram performance at the 2014 Billboard Music Awards (Kalansooriya et al., 2015). An announcer in Chicago was projected on Wolf Blitzer's show taped in New York making possible for two announcers to be present at the same time when each was in a different location. A deceased Michael Jackson was able to perform in a life like hologram to a live audience.

Holograms, sometimes referred to as AR, takes a 3D object of an image or photo and makes the image or photo appear in the real world (Gijevski, 2017). The concept of 3D holographic technology was actually seen in the 1860s with a technique known as *Pepper's ghost* used in the Victorian theaters to project real-life ghosts using a series of many projections and a glass to reflect a surface showing a ghost figure of an actor due to special lighting (H. Lee, 2013; Orcos & Magreñán, 2018). Hologram technology was first introduced in the 1940s by Dennis Gabor who was working to perfect his electron microscope when he ended up inventing the hologram winning the Nobel Prize for Physics (Kalansooriya et al., 2015; Orcos & Magreñán, 2018; Salvetti & Bertagni, 2016). Gabor is recognized as the father of Holography and is the first person to come up with a name for his discovery (Kalansooriya et al., 2015). *Hologram* comes from a Greek word *holos* which means the *whole* and *gramma* which means *message* (H. Lee, 2013).

Three-dimensional holographic technology was not officially utilized till the 1960s when the United States and the Soviet Union improved and developed the technology (Kalansooriya et al., 2015). This technology uses a 3D photograph and a laser beam projecting through an object which allows another ray to project a reflection of light off the first ray, resulting in 3D optical

images (Orcos & Magreñán, 2018). Holograms in 3D enable live and life size 3D sensations of being transported to another place allowing a person to interact with faraway people or places (Kalansooriya et al., 2015). For holograms to work, the projection of the object or person should be in a dark or black room to reflect luminous colors on the reflecting surface (Orcos & Magreñán, 2018). Orcos and Magreñán (2018) stated 3DHT has a magnitude of possibilities in learning environments since holograms can create learning spaces which encourage collaboration from a constructivist's perspective. The authors believe hologram technology is an appropriate tool for the implementation of STEM education specifically motivating students to learn scientific curriculum (Orcos & Magreñán, 2018). Research has shown students viewing holograms as a teaching tool of the future (Orcos & Magreñán, 2018). Knowing the evolution, history, and real-world uses of holograms may help educators realize the potential of this tool in educational environments.

Emergence in education. Realizing the potential technology has for learning is critical because educational programs are being developed alongside technological advancements (Orcos & Magreñán, 2018). Hologram applications are moving away from science fiction to more realistic and unique ways of communicating (Kalansooriya et al., 2015). Research has shown 3D holographic technology is new to education, and H. Lee (2013) as well as Orcos and Magreñán (2018) have claimed this technology provided students with an enriched learning environment where students could visit a virtual world or test a real-world system. Holographic technology is making a significant change in teaching and learning because learning becomes active, constructive, cognitive and social when learners make new meaning (H. Lee, 2013; Orcos & Magreñán, 2018). If holograms are used effectively in education, holograms can have the

potential to help students explore and test real-world processes and systems (H. Lee, 2013). Some of Lee's reported benefits to learning include coordinating tasks in safe environments, increasing collaboration and communication, and being able to view abstract or hard to understand concepts or ideas.

H. Lee (2013) believed 3D holographic technology is not just a delivery method but is becoming an integral part of the learning process where learners are constructing new knowledge (Orcos & Magreñán, 2018). Orcos and Magreñán (2018) agreed with Lee, this tool allowed students to be in control of student learning. Study results have shown motivation was increased in learning the sciences and medicine because this tool made it possible for learners to immerse themselves in a shared environment where the objects or concepts being learned were real and lifelike (Orcos & Magreñán, 2018). Utilizing this technology, students of science could better apply learning to meet the needs of society in the future (Orcos & Magreñán, 2018). Salvetti and Bertagni (2016) conducted case studies and concluded holograms increased engagement of healthcare students in learning than written textbooks. Researchers claimed half the brain is wired for vision which is why images grab attention sooner and are processed faster than text (Salvetti & Bertagni, 2016).

Salvetti and Bertagni (2016) claimed there are many forms of pictures like billboards, charts, graphs, maps, illustrations, and advertisements seen in daily life because visuals are processed 60,000 times quicker than text. Research results found individuals remember 10% of what is heard, 20% of what is read, and 80% of what is seen and done (Salvetti & Bertagni, 2016). Medical students used holograms to enhance visual contact, study diagnosis, and treatment options with the use of 3D programs like holograms providing a realistic look at

patients' state of health (Salvetti & Bertagni, 2016). In a randomized trial study, Hackett and Proctor (2018) found similar results when using 3D visuals in studying bodily structure. Results indicated 3D holograms showed noticeable improvement in learning compared to using printed pictures stressing the real lifelike cues from holographic visuals to better understand spatial anatomy.

Implications for learning. The future of technology in education is unknown but the possibilities to improve learning seem never ending. For example, 3DHT is being implemented in distance learning to provide students with live and lifelike 3D telepresence which can assist in communicating with mass audiences (Kalansooriya et al., 2015). With distance learning, Kalansooriya et al. (2015) alleged benefits from a mixed-method study which included learners being able to communicate in different locations at the same time, bringing famous people back to life, making learning material realistic, and allowing the instructor to appear to learners as if all are in the same place. Kalansooriya et al. administered a survey to experts in distance learning resulting in a majority of the participants selecting 3D holograms over video-based distance learning. Thirty-three percent of the learners believed learning was enhanced when real-time phenomena was experienced and 30% preferred this technology in theoretical and practical ways. Orcos and Magreñán's (2018) exploratory study concurred with Kalansooriya et al. since holograms were found to increase motivation among the sample participants and led to holograms being considered as a possible teaching tool. Holograms was concluded as a suitable tool for STEM education (Orcos & Magreñán, 2018).

One machine claiming the future of learning is zSpace. ZSpace is an all in one machine containing elements of VR and AR to create lifelike experiences on a computer. VR is making

learning immersive and interactive through zSpace STEM labs. The zSpace STEM Labs are student centered learning spaces where STEM-related topics are introduced in a VR environment. ZSpace believes learning is best experienced through doing, and zSpace's curriculum materials are geared towards differentiated learning in all grade levels (zSpace, 2016). Another machine developed for lifelong learning with the power to transform learning using face to face, VR, e-learning, and the ability to communicate globally is e-REAL (Salvetti & Bertagni, 2016).

E-REAL uses 3D holographic visual technology to immerse medical students using high tech medical simulations (Salvetti & Bertagni, 2016). Visuals, when compared to 3D holograms, do not offer the same lifelike quality. From Salvetti and Bertagni's (2016) case studies, the findings indicated 3D holograms offer medical students the ability to study the human body from many perspectives with an interactive medium which completely immerses a user in an interactive ecosystem. H. Lee (2013) stated it best, "Regardless of the type of technology [being used], learning outcome always should have a higher priority than [the] technology itself" (p. 37). Educators need to identify what is to be learned by students and then search for tools which enhance the learners' experience and motivation (H. Lee, 2013).

Virtual Reality

Virtual reality (VR) is a computer-generated virtual environment making a significant effect on education just like 3D technology (Freina & Ott, 2015; K. Lee, 2012). VR is known as immersive multimedia. The history of the tool, the emergence in education, and the implications for learning are discussed.

History of tool. VR displays a fake virtual world creating an environment where the user believes themselves to be present in the virtual world with the use of special equipment (Freina & Ott, 2015; Gijevski, 2017; Hakkila et al., 2018; Liou, Yang, Chen, & Tarng, 2017). The user is in an alternative world where the experience involves most senses like sight, hearing, and touch (Pope, 2018). An individual is immersed in the digital 3D world and can move objects and perform various actions (Hakkila et al., 2018). The user can enhance the experience by wearing an HMD like the Oculus Rift or gloves with sensors, which help the user look around in the environment with head movements (Freina & Ott, 2015; Hakkila et al., 2018; Parong & Mayer, 2018). This "technology completely replaces a real environment with a dynamic stimulating environment which can be explored interactively by users" (Liou et al., 2017, p. 110).

VR is visible in the entertainment world having been featured in fictional stories and films like *The Matrix* (Pope, 2018). Ever since *The Matrix* showed what VR was capable of doing, VR is now making way into the real world and formal education (Pope, 2018). By the late 1980s and early 1990s, the gaming industry began to use VR like Sega and Nintendo but due to costs, both did not make much of an influence (Pope, 2018). Companies like Apple and Facebook have made VR more accessible where teaching can take place in virtual environments (Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017). VR can help learning by providing real-life vivid experiences which would be difficult to offer in a classroom or distant learning course (Chang, Zhang, & Jin, 2016). Knowing the history of VR should help educators realize the potential of this tool in the classroom because VR can make what was once impossible possible like taking a virtual field trip to the moon.

Emergence in education. New and affordable VR devices are being released which promise to transform the way individuals look at, understand, and interpret media (Moro et al., 2017). The advent of VR in education seems to be a natural phenomenon because equipment cost has reduced making the technology more affordable and accessible (Hakkila et al., 2018; Hu, Wu, & Shieh, 2015; Moro et al., 2017). VR technology can provide a simulation for real-world training like a house on fire, flight aviation, and medical surgery using computer graphics (Fraga & Mallet, 2018; Newbutt et al., 2016). There are two types of VR: immersive and nonimmersive VR. Immersive VR uses an HMD in conjunction with a computer where a user can manipulate a virtual environment (Parong & Mayer, 2018). Nonimmersive VR displays the virtual world on a computer screen and the user requires a mouse touchscreen, touchpad, or a handheld device (Parong & Mayer, 2018).

Because immersive VR is now affordable and accessible, researchers are studying the effects this technology is having on academic learning (Hakkila et al., 2018; Parong & Mayer, 2018). Parong and Mayer (2018) claimed when students are motivated and invested in learning students become self-confident in abilities and learning becomes intrinsically motivated. The educator is responsible for motivating learners in order for students to become intrinsically involved in learning. Educators test motivation and interest by comparing one media with another teaching the same content. Slideshows, a conventional instructional method to teach science, was replaced with immersive VR in Parong and Mayer's media comparison study. The decision was based on previous research showing positive outcomes when games, simulations, and mixed-reality multimedia were used (Parong & Mayer, 2018). The group of students who

used the VR immersive medium portrayed more engagement, enjoyment, and interest in the session compared to the slide show group (Parong & Mayer, 2018).

VR is believed to be a new and popular technology which educators can use to grab the attention of the learners while still maintaining learning objectives (Parong & Mayer, 2018). Introducing new technologies in education is not a new concept; for example, laptops, tablets, and mobile phones have become common and VR can easily be offered on these devices (Hakkila et al., 2018). In order for VR to be effective, VR has to provide immersion, interaction, and involvement for the user (Hakkila et al., 2018). Three case studies performed by Hakkila et al. (2018) made it possible for VR to help learners visit locations impossible to visit, traveling through time, experiencing dangerous scenarios like training firemen or policemen, and avoiding ethical limitations like practicing surgery or anatomy education. Learners who are visual, auditory, or kinesthetic learners may benefit from implementing VR because it sparks and motivates learners when training or learning something new (Freina & Ott, 2015).

Implications for learning. Studies are linking creative and critical thinking to the immersion of VR technology. VR has shown positive effects on instruction because VR highlights creative thinking. Users can review lessons in a motivating, engaging, and enriching way especially when VR is used for training programs which take place in computer graphic environments (Newbutt et al., 2016). Newbutt et al.'s (2016) exploratory and preliminary study found instructors preferred VR simulations because the tool offered students a different way of learning the same material. Hu et al. (2015) found similar results from a quasi-experimental research study. Hu et al. found interacting with VR allowed students to enhance imagination and instilled excitement in learning and increased attention span. The increased use of mobile devices

and the accessibility of apps is making the use of VR technology possible in any environment (Martín-Gutiérrez et al., 2017). The phenomenological study is necessary because VR exists and offers a different method of presenting content to students. Martín-Gutiérrez et al. (2017) claimed VR is not going away and is already a part of daily life.

Hakkila et al. (2018) studied three case studies involving industrial design university students which resulted in positive feedback from students when using VR technology. These students reported being engaged and recommended using VR with other methods of instruction. Newbutt et al. (2016) reported positive results when using VR systems with autistic students in a pilot study. Studies had been performed before with autistic students but never with HMDs. The pilot study concluded the technology allowed for a motivating, engaging, and normal way to reinforce exercises which were repeated often (Newbutt et al., 2016). VR technologies helped to create a safe space for autistic students to practice social situations where a majority of the autistic students were comfortable using the HMDs and few participants experienced dizziness (Newbutt et al., 2016). To help medical students learn anatomy from a different perspective, Moro et al. (2017) compared VR programs using desktop and mobile platforms in a quantitative study. Moro et al. found similar conclusions about VR reporting students were able to experience 3D models and environments in a fresh way which is vital in the health sciences and medical education.

The influence on learning using VR is reaching as far as China and Taiwan. Dailian Jiaotong University in Dalian, Liaoning, China used a teaching system designed like an animation model focusing on VR technology (Ji & Zhang, 2016). The model used an interactive animation virtual environment which combined animation, VR, and computer networks to

achieve the suitable teaching outcome (Ji & Zhang, 2016). In the comparative teaching study, the university students exposed to the 3D animation found the system using this technology to be more interesting, engaging and captivating compared to traditional teaching methods (Ji & Zhang, 2016). Evidence of 3D types of technology exist in higher education and are enhancing learning experiences in students, but there seems to be less evidence of these tools' use and benefits in elementary and middle schools. The disparity may be due to the cost of implementing these tools or because of technical difficulties and lack of technical support as reported in Domingo and Bradley's (2018) grounded theory.

Even with some drawbacks, VR has been positively received. In Taiwan, many people in society believed educational institutions overwhelmed students with information and ignored creativity in teaching and stimulating the brain towards learning (Hu et al., 2015). Taiwan's Ministry of Education started to review and improve curriculum, teacher practices, and considered ways to enrich students' problem solving and creative thinking skills (Hu et al., 2015). Results indicated when VR was implemented, learners' interactions with the objects helped to create an environment where students were exploring, observing, and actively engaged in the learning process (Hu et al., 2015). Fraga and Mallet (2018) and Masters (2013) showcased Edgar Dale's Cone of Experience which stated the medium used to deliver learning was dependent on the effectiveness of the learning. Based on the cone design, the lower one is on the cone, the more one is learning. The Cone of Experience placed VR learning at the bottom three levels because learning with VR involves active engagement in the process of learning (Fraga & Mallet, 2018; Letrud & Hernes, 2016; Masters, 2013). These last three stages in the cone from the top are *Seeing and Hearing*, which involves retaining 50% when a learner demonstrates or

shows, *Say and Write*, which retains 70% of what is collaboratively learned, and *Do*, which retains 90% of learning and involves firsthand experience (Letrud & Hernes, 2016).

Augmented Reality

Augmented reality (AR) sometimes referred to as a relative to VR is being recognized as one of the major developments in educational technology (Pope, 2018; Saltan & Arslan, 2017). The availability of smartphones has contributed to the increased use of AR in educational environments with positive results (Frydenberg, & Andone, 2018). The history of the tool, the emergence in education, and the implications for learning are discussed.

History of tool. Virtual material like 3D models, animations, two dimensional pictures, or annotations are placed on a real-world view which uses the help of a camera, in which the AR program can locate the augmented scene and depict a virtual content layer on top of the camera image (Laine, Nyugren, Dirin, & Suk, 2016). As the camera position is changed, the augmented content is updated in real time (Laine et al., 2016). Using AR adds to reality unlike VR which replaces reality. AR works with the use of an AR-supported device adding digital information to be related to the activity users are doing (Harley, Poitras, Jarrell, Duffy, & Lajoie, 2016).

Basically, AR supplements the digital world with physical objects, smoothly connecting a user in the present world smoothly connected to digital elements (Birt et al., 2018). AR is not as popular as VR but remains pivotal. Even though individuals do not realize AR's presence, AR is present in everyday society (Pope, 2018). VR utilizes the senses of the user whereas AR reveals extra information to enhance or augment the actual surrounding (Pope, 2018). AR has three main characteristics: a mix of real and virtual, real-time ability, and 3D existence (Saltan & Arslan, 2017).

Myron Krueger was the first to create something known as *artificial reality* known as *Videoplace* using silhouettes in the 1970s (Pope, 2018). The name *augmented reality*, like *virtual reality*, was not established until later when more technological advances were discovered (Pope, 2018). In 1990, Tom Caddell who researched airplanes was the first to come up with the name for this technology (Pope, 2018). Most of the advancements, similar to VR, were geared towards helping the military. VR and AR were introduced in the entertainment world after both became mainstream (Pope, 2018). AR exists when a computer graphic is layered on top of an image. For example, sports analysts use a form of AR when analysts write over screens or when graphics are seen live (Pope, 2018). Microsoft HoloLens and Google Glass are common AR devices (Pope, 2018). The history of AR and the tools emergence could help educators utilize this tool to enhance visuals which can reveal more details than a simple photograph. Saltan and Arslan (2017) confirmed the use of AR and similar tools as enhancing the delivery of content and instructional practices.

Emergence in education. Saltan and Arslan's (2017) scoping review research predicted AR to be implemented in two to three years in higher education and four to five years in K–12 classrooms because results claimed AR has possible benefits in formal education. AR has shown to motivate students and help retain knowledge (Saltan & Arslan, 2017). This tool has become a popular medium in many educational institutions as AR is becoming the preferred instructional tool over others (Harley et al., 2016). Saltan and Arslan's (2017) prediction can be based on two factors. The first relates to mobile AR applications now built into cameras on mobile devices (Frydenberg & Andone, 2018). These mobile devices can scan images causing multimedia content like pictures, maps, hyperlinks, videos or text to overlay on the initial image to make a

new digital phenomenon (Frydenberg & Andone, 2018). AR can be used with other hardware like desktop computers, handheld devices and displays used on heads to augment user information (Harley et al., 2016). The second factor involves educators having students critically think during the learning process. To be successful at this skill, educators should consider using technology applications which are up-to-date, contemporary, and trending (Saltan & Arslan, 2017).

In Saltan and Arslan's (2017) scoping review study, five questions were under investigation. These researchers looked at a variety of topics related to AR from the different technologies used to meet educational outcomes when using AR in both higher education and K–12. The results showed AR helped teachers meet the need to use up-to-date and popular technologies (Saltan & Arslan, 2017). Laine et al. (2016) reported AR as one technology which could combine formal and informal environments to complement blended learning where location was a factor. A mixed-method approach was conducted by Laine et al. which concluded AR was best suited for science education because AR could help to explore and interact with inquiry-based ventures outside class. With the increased availability and development of AR programs, the influence AR can have on users' learning is expected to continue advancing (Pope, 2018). Implementing AR not only helped make science content real but helped mathematics learning. Gün and Atasoy's (2017) mixed-method study involved the use of Google SketchUp, Cabri3D software, and other web-based virtual programs to explore the effects of AR software on students' spatial abilities in mathematics education. Students expressed increased interest in the subject and indicated AR helped to visualize abstract concepts (Gün & Atasoy, 2017).

Implications for learning. Implementing AR applications and 3D real objects was found to significantly increase learning and engagement in students by Gün and Atasoy (2017). Spatial ability is an important aspect of learning to solve math problems. AR instruction significantly increased students' spatial abilities because this tool made it easy for students to see certain important features and be able to move 3D objects like students can in the real world. Scores were higher when AR applications were used to solve spatial ability math problems. Gün and Atasoy concluded AR helped the development of students' spatial abilities. Other benefits of using AR outlined by Harley et al. (2016) included: allowing students to manipulate and observe 3D virtual objects and physical phenomena, understanding difficult concepts and occurrences, working together to talk about real-life problems, and viewing educational scenarios. Educational scenarios included teaming together to partake in difficult and realistic situations and linking informal and formal learning environments.

Frydenberg and Andone (2018) studied the influence of learning new technologies through a program titled TalkTech. TalkTech is a global ongoing study looking into the effect of learning with new technology tools. The study found students developed digital and literacy skills when asked to create AR artifacts. Students developed digital skills when evaluating content to further understand the AR topic of choice, while communicating ideas and collaborating about tools. During the learning process, students developed, rewrote, considered copyright laws, and programmed using many types of media to create the final product. Students processed new ideas while problem solving using free AR digital programs (Frydenberg & Andone, 2018). The TalkTech project further concluded students improved computational thinking skills and skills needed to learn a variety of new technology when actively engaged in

the learning process. Research found students engaged with AR to interpret data, base decisions on facts as students designed, tested, and created final products (Frydenberg & Andone, 2018). Harley et al. (2016) agreed with Frydenberg and Andone when using AR alongside other multimedia in a comparative study of historical differences past and present, AR apps was found to enhance collaborative problem-solving, inquiry-based simulations designed by narration, and interacting with virtual media.

AR is finding ways into history and science education. Laine et al. (2016) claimed there is a lack of motivation in students to study science. Research results showed game-based learning related to real-world experiences can provide the stimulation and motivation needed to learn science (Laine et al., 2016). Placing learning processes in real-world contexts with the help of AR can make the connections with abstract concepts into reality-based learning (Laine et al., 2016). Using the Science Spots Augmented Reality (SSAR) program, the mixed-method study found SSAR to implement a user's many senses to learn about the world while playing in different spots. The results from Laine et al.'s mixed-method study showed the program helped students to learn and conceptualize scientific vocabulary using a platform combining real and virtual objects in a game like environment. Other researchers like Kiryakova, Angelova, and Yordanova (2018) found AR programs able to personalize learning to adapt to student needs. Learners connected with objects and got more information about those objects based on the choices made (Kiryakova et al., 2018). Kiryakova et al. claimed AR had the ability to transform education to smart education because the content and the environment being explored could be modified to a learner's needs and choices like how and when things were introduced to the learner.

Bring Your Own Device

The BYOD initiative began when schools started to implement the one-to-one device for all students but because of costs all schools were not successful in implementing this approach (Cheng, Yuanyuan, & Chau, 2016; McLean, 2016). Technology inventions are changing traditional classroom pedagogy redefining teachers and students' roles making way for alternative ways of learning like distance learning and blended learning (Cheng et al., 2016). The history of the tool, the emergence in education, and the implications for learning are discussed.

History of tool. Ruxwana and Msibi (2018) stated technology implementation in education is not a new initiative since technology has been seen in education for some time as a tool which can positively support learning. Mobile technology is becoming a norm in a society which seems to be connected at all times and accesses "information anytime, anywhere from their own personal devices" (Al-Okaily, 2013, p. 1). The increased use of cell phones and other mobile devices is surpassing the desire for desktop computers as was previously seen in history (Ruxwana & Msibi, 2018). Parsons and Adhikar (2016) and Rae, Dabner, and Mackey (2017) claimed New Zealand schools agreed educational institutions need to change and adapt to latest technologies along with the technological advances taking place in society. New Zealand schools are finding ways to increase digital learning experiences for students by implementing the BYOD initiative (Rae et al., 2017).

Emergence in education. Al-Okaily (2013) reported there remains a gap between students and schools in regard to the devices used by students in daily life when communicating and staying connected. What is being offered in classrooms falls short of what students are used to working with resulting in dissatisfaction and lack of motivation from the student in the

educational system. The BYOD initiative has been gaining attention because educators need to keep up with the most up-to-date trends in learning while consistently motivating students to develop and grow as learners (Al-Okaily, 2013). Educators are tapping into the "information-on-the-go-trend" (Al-Okaily, 2013, p. 1) and using this trend to stimulate engagement can lead to higher levels of success for learners. Globally, educational institutes are realizing the potential mobile devices have on learning. Ruxwana and Msibi (2018) reported in a multimethod qualitative study some universities are beginning to use BYOD to improve education. Another global example is seen in South Africa where educational institutes are beginning to consider implementing new digital tools and the Internet to promote student creativity (Ruxwana & Msibi, 2018). Parsons and Adhikar (2016) warned technology should not be used once in a while in a computer lab but should be used seamlessly as technology is used in daily living if implementation of these tools is to be successful.

If used appropriately, the BYOD has a major effect on helping to access many 3D types of technologies especially in regard to cost. Ruxwana and Msibi (2018) and Hakkila et al. (2018) reported many developing countries are using mobile phones in general education as a valuable learning tool. Smartphones and tablets can help get 3D technology applications; for example, smartphones can be utilized in HMDs when visiting virtual worlds (Hakkila et al., 2018). AR applications can be used to engage students to attend virtual field trips when not possible (Hakkila et al., 2018). Teachers are required to keep up with the changing times and to intrinsically motivate students to develop as lifelong learners. BYOD can help teachers by providing the support educators need to implement contemporary pedagogy and learning

especially when personal devices have become an integral part of students' lives (Cheng et al., 2016; McLean, 2016).

Implications for learning. Mobile devices are supporting new trends in teaching pedagogy in classrooms (McLean, 2016). BYOD bases learning on a learners' personal preferences using a learners' mobile device (Cheng et al., 2016). In Hong Kong, Cheng et al. (2016) conducted an empirical study to look at learner acceptance of BYOD. From the learners' perspectives, the results indicated positive reactions because users found it easy to use personal devices. Learning was centered around the learner and the overall use of the devices made learning boundless (Cheng et al., 2016). Learning was differentiated, adaptable in regard to availability of learning resources, and extended the learning when students shared and collaborated in the learning process.

Parsons and Adhikar (2016) conducted a mixed-method study in which teacher, student, and parent perspectives were considered when implementing BYOD in New Zealand. These researchers reported positive results in digital skills of both students and educators. Using mobile devices showed an increase in learning involving communication and collaboration among students and students showed growth in personal social development (Parsons & Adhikar, 2016). Rae et al.'s (2017) case study involving three educators had positive results, but educators preferred consistent professional development be provided in order for teachers to have confidence in implementing the devices.

Chapter Summary

The literature review identified the topics of 3D printing and design, holograms, VR, and AR technologies. The concept of BYOD was discussed since these devices can have an effect on

the affordability and accessibility of 3D types of technologies making way into schools for all students. This study is based upon the constructivist and Harasim's OCL theory, which emphasize collaborative learning to be an active process where learners build new knowledge collaboratively (Breen, 2013). Studies have shown educational reform from the perspective of technology changes in society over time because technology advances have taken over daily life as the need to stay connected increases (Al-Okaily, 2013; Kostakis et al., 2015; Ouyang & Stanley, 2014; Stingu & Iftimescu, 2016). Research supported the need for educational pedagogy to move away from traditional teaching to one which uses up-to-date technology to keep students engaged and one which requires educators to become facilitators of learning.

The literature review presented the use of 3D technology tools in mostly higher educational institutes, the presence of 3D technologies globally in other countries, and the benefits in using these tools in different aspects of learning. Research showed these tools becoming vital to educational reform and leading the way to changing how learners engage (Birt et al., 2018). With the low cost of some immersive 3D types of technologies by suppliers like Oculus Rift, Google Cardboard, and Samsung's Gear VR and the increase use of personal mobile digital devices, many educational institutions could begin to implement these tools (Birt et al., 2018). There was a gap in the literature because these technologies are new to education and there are not enough studies mentioning the use of 3D types of technologies in elementary and middle schools in the United States. This research topic is viable because further research is needed in the field of 3D technology especially if 3D technology is being immersed to make learning interactive for students (Brown, 2015). This study is necessary to obtain teacher perspectives from middle schools using these technologies to determine whether or not these

tools are worth the time and financial investment. Chapter 3 discusses the methodology used, research design and rationale, the role of the researcher, research procedures, data collection, data analysis, reliability and validity, and ethical procedures.

Chapter 3: Methodology

AR and VR applications are bringing a different kind of understanding to learning, real-world objects, and phenomenon (Frydenberg & Andone, 2018). Globally, there is an ongoing study looking into the effect these technologies have on learning (Frydenberg & Andone, 2018). As these technologies are emerging in education, students are starting to use mobile devices bringing new possibilities to enhance learning experiences such as virtual environments (Frydenberg & Andone, 2018; Muñoz-Cristóbal et al., 2015). Three-dimensional printing technologies have the possibility to strengthen STEM education, and careers in technical programs, which stress skilled trades, applied sciences, and career preparedness (Schelly et al., 2015). These technologies can empower students because students are actively participating and engaged in cross-curriculum activities (Schelly et al., 2015).

The purpose of the qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and AR types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades. Two questions guided the study:

Research Question 1: What are teachers' lived experiences on learning outcomes when 3D virtual reality technologies are used?

Research Question 2: How do teachers perceive the effectiveness of 3D types of virtual reality technologies to enhance learning?

This research is a qualitative, descriptive research study, which uses open-ended questions to depict participants' lived experiences (The SERVE Center, 2008). The major sections of this

chapter include research design and rationale, role of the researcher, research procedures, data collection, data analysis, reliability and validity, ethical procedures, and summary.

Research Design and Rationale

The qualitative research study used the phenomenology research design because the qualitative methodology with the descriptive design best discovers lived experiences of participants (Alase, 2017). Qualitative methodology looks at the perspectives of the participants and explores an individual's in-depth perceptions because this method views the world as a complicated, social, and ever-changing world (Cranmore & Wilhelm, 2017; Park & Park, 2016; Sloan & Bowe, 2014). The qualitative research study viewed the world through the individual's experiences, the meanings assigned to experiences, the language used in communications, and the things which prompted individual outlooks and actions regarding 3D types of technologies (Ramani & Mann, 2016). Qualitative studies are best carried out in natural environments to provide educators a comfortable arena to share true perceptions, inner experiences, and lived experiences from classroom events (Ramani & Mann, 2016). Qualitative methodology is best known to shape and improve vital questions pertaining to education-related policies and practices (Kozleski, 2017).

The research design is based on Edmund Husserl, a well-known 20th-century philosopher recognized as the founder of modern phenomenology, who believed obtaining exact descriptions of experiences communicated by participants helps researchers to understand the nature of the experience (Phillips-Pula, Strunk, & Pickler, 2011). The interest was in the use of 3D types of technologies and the technologies' effect on learning from educators' lived experiences. The phenomenological design looked into the details of a participant's world as this design examined

the participants' personal viewpoints of an object, event, or phenomenon such as 3D types of technologies (Sloan & Bowe, 2014; Smith & Osborn, 2008).

Phenomenology as a research design is appropriate for the study because phenomenology is known to be the study of phenomena as individuals experience the phenomena (Sloan & Bowe, 2014). This design is best for the study because lived experiences of teachers in relation to the particular subject of 3D types of technologies used in learning was under investigation. Data was collected and analyzed to describe the meanings of teachers' lived experiences to bring more understanding of the phenomena of 3D types of technologies inclusion in middle school education (Tuapawa, 2017). A phenomenological study was suitable for answering the research questions and fit the context of using 3D types of technologies in an educational setting. Teachers described lived experiences on learning outcomes when using 3D types of technologies and the effectiveness of these tools to enhance learning through open-ended questions. The design was appropriate for answering the research questions because teachers could easily share lived experience of using the 3D technologies in the classroom from personal perspectives. The benefit and advantages of a qualitative, descriptive study was being able to examine learning and teaching styles, learning of and implementing different interventions, investigating different methods and outcomes like behavior, viewpoints, and professionalism which cannot be studied by assigning numbers in a quantitative research (Ramani & Mann, 2016).

Role of the Researcher

In a qualitative study, the researcher's role was to collect data from participants, ask questions, listen or take notes, and then ask more questions to get a better understanding of the views of the participants (Creswell & Creswell, 2018; Sloan & Bowe, 2014). One duty the

phenomenology researcher had was to make meaning of the participants' experiences regarding the phenomena and to tell the perspectives using participants own language (Alase, 2017). As a qualitative researcher, the researcher was mindful of not influencing the data collected and to not judge or interpret for the participant (Korstjens & Moser, 2017). A qualitative researcher was the instrument who collected and interpreted the data (Xu & Storr, 2012). The role of the researcher in the study was to voice the opinions of the participants without any bias and to analyze the data to find common themes (Xu & Storr, 2012). The researcher had three main responsibilities identified by the Belmont Report. The first responsibility was respect for individuals by asking for volunteers with no coercion after ensuring participants understood the study. The second responsibility was beneficence which was to ensure no harm to individuals and organizations resulted, keeping identities of participants/locations discreet, and treating all participants equally. The third responsibility was justice which was to give each participant the same preference in the study (Miracle, 2016; National Institutes of Health [NIH], 2018).

Research Procedures

The company, zSpace, which provides an all in one machine integrating AR and VR technology (zSpace, 2016) was contacted to identify schools using zSpace labs for participants and calling local schools to inquire about the use of 3D types of technologies. Participants were selected preferably from schools located in Illinois and then contacted via e-mail. To solicit additional participants, educators who were using 3D types of technologies were asked to help identify and locate other teachers who had been teaching for two years using 3D types of technologies. Twenty-one teachers from middle schools were invited to participate in the study once confirmation was established 3D types of technologies were implemented in the

participants' classrooms or teaching environments. The search for participants expanded to other middle schools outside of Illinois since there were not enough teachers located in the desired geographical area.

Population and Sample Selection

The sampling method was snowball sampling, which is a nonprobability method (StatPac, 2017). Snowball sampling is used when the starting population is minimal or unknown. The method required the aid of primary data sources to help locate other possible data sources for the study by referral (von der Fehr, Solberg, & Bruun, 2018; Waters, 2015). Three-dimensional, AR, and VR technologies are new to middle school education and there was a lack of information about teachers and districts who implemented these types of technologies. Snowball sampling was critical because the starting population was unknown without the help of primary participants. Additional individuals were identified by the initial participants who knew the candidate requirements for the study (von der Fehr et al., 2018; Waters, 2015). Individuals were invited to participate in the study via e-mail. The background of the researcher and details were shared with the teachers to obtain interest and consent to participate in the study (Appendix B). This information was prepared in advance in the form of a letter drafted and sent via electronic mail (Appendix A).

Qualitative research does not require large numbers of a population to understand the problem or questions as would be the case in a quantitative research (Creswell & Creswell, 2018). Creswell and Creswell (2018) suggested a phenomenology include between three and 10 participants. Fifteen middle school classroom teachers preferably working in Illinois were expected to participate, but 21 classroom and special teachers in surrounding areas volunteered

and were included in this study. The target population included teachers because educators are at the center of integrating technology to help students engage in the learning process (Heintzelman, 2016). Some of the participants were teachers who were identified from various educational conferences having used 3D types of technologies. These teachers were unknown to the researcher personally. Middle schools in Illinois having a VR/AR lab were identified with the help of zSpace. The criteria for selecting teachers involved participants having implemented a zSpace machine or any other form of 3D, VR, and AR technology in the classroom and teaching for at least two years. Colleagues and a personal contact from one Illinois school were contacted since there were not enough participants who used 3D types of technologies or willing to partake in the study.

Instrumentation

In qualitative research, the researcher is the main instrument (Creswell & Creswell, 2018). The researcher did not depend on other researchers' instruments because the researcher carefully designed the questions to obtain details of the experience or phenomena from the participants (Creswell & Creswell, 2018; Tuapawa, 2017). Uniquely designed open-ended electronic questions were created to assure participants provided information without influence from the interviewee (Alase, 2017), and the participant was free to express the case from personal viewpoints and expertise (Smith & Osborn, 2008). The main instruments were electronic because data collected online increases the research's validity and reliability more than face-to-face surveys and an online data collecting method can be sent to participants in a quick manner using the Web in seconds (Kılınç & Firat, 2017). Research suggested, participants stated a sense of freedom to express opinions openly when asked to fill out an online survey, because

online questionnaires are adaptable and autonomous in nature (Kılınç & Firat, 2017). Data was collected from the online questionnaire and the participants' shared supplemental materials like web pages or handouts.

Questionnaires. Data resulting from a qualitative study are descriptive in nature and consist primarily of words used by the participants (Creswell & Creswell, 2018), so a written open-ended questionnaire was designed by the researcher to obtain teacher lived experiences about using 3D types of technologies and the effect these tools had on student learning. An open-ended questionnaire was used to elicit participant feedback and perceptions on the tools used, the effect of the tool on learning objectives, and how students were using them (Appendix C). Participants are likely to be more open and straightforward in an anonymous electronic type of survey. Kılınç and Firat (2017) claimed some advantages to using online instruments included easier collection of data, faster mode of collecting data from many participants, less chances of losing data, increased volunteer participation, and greater ease of asking difficult questions. Online data collection tools save information automatically and can store information without additional cost. Kılınç and Firat's reported participants were able to express viewpoints freely without hesitation in an online environment better than other types of mediums.

Interviews. Interviews via FaceTime/Skype phone calls were intended to be used primarily to clarify responses from the questionnaire and to provide participants an opportunity to expand on responses. Notes were to be typed, and the recordings were to be transcribed and uploaded to Google Drive after the interviews if needed. Member checking was conducted to allow the interviewee to recheck for misunderstandings in the transcription of the online questionnaire to validate the participants' lived experience in a qualitative research (Koelsch,

2013). Phone interviews are cost effective and are private in nature but were not needed in this study (An, 2017). Phone interviews would have allowed participants to add on to already submitted viewpoints to make the information collected richer, clearer, and deeper in meaning (An, 2017). The interviews were not needed since the participants were clear in presenting lived experiences of the phenomenon in the online questionnaire and explained the intentions of the supplemental materials shared.

Other Forms of Data

Other forms of collecting data to understand the participants' perspectives were from Google documents, web pages, and other forms of handouts and resources teachers used to implement with the technology. Technological developments are assisting in qualitative research and data collection (Moylan, Derr, & Lindhorst, 2015). The handouts and supplemental materials teachers chose to share provided further data on what the teacher was intending to teach with the use of the 3D types of technology. The teachers provided analysis of these artifacts with explanations since the study was about the lived experiences of teachers using 3D types of technologies. Including these instruments along with the online questionnaire assures triangulation. Triangulating the data involved collecting data from other sources which made the data collection reliable (Creswell & Creswell, 2018). Looking at more than one source checked for accuracy of the information. The shared documents and supplemental materials may help to determine and support how teachers perceived 3D types of technologies in relation to learning.

Data Collection and Preparation

Technology advances have produced new tools and applications which can increase results quicker and easier (Moylan et al., 2015). The instrument used to collect data is Google

Forms which helped design and develop open-ended questions centered around the phenomena being investigated. Google Forms is an instrument which can help to create and analyze surveys written in a questionnaire format. This instrument was easy to use, could be modified as needed, and displayed data in ways a researcher can manipulate the data (Lindsay, 2016). Google Forms is a free survey tool and is password protected which easily and accurately can help to collect data (Laskowski, 2016). The confidentiality of participants and schools willing to participate was protected. Since web-based types of surveys are becoming more popular as mail-based surveys are becoming obsolete, Google Forms was used to design the open-ended questions (Baatard, 2012). The Google Form questionnaire web link was provided to the teachers participating to reflect uses of the 3D types of technology tools. Google Forms provided an electronic copy of the responses to the survey.

As data was being collected through Google Forms, Google Sheets was generating a report as responses were received from participants (Laskowski, 2016). Google Forms is password protected and only the researcher had access to the data. The Google Sheets document could be downloaded as an Excel spreadsheet document for backup or each questionnaire could be printed out. Excel was selected because the software and the sorting feature are easy to use. This software allows a researcher to see commonalities as the data can be sorted according to a particular criteria or word (Laskowski, 2016; Lindsay, 2016). Each electronic Google form interview was printed out to read over and find common words and phrases used by participants. A new Google Drive account was created to store all study documents and data separate from personal Google Drive accounts.

Data Analysis

The eight sequential steps by Tesch recommended by Creswell and Creswell (2018) to decipher the data for meaning were implemented. The first step involved sorting and arranging the data by the different schools who participated. The second step was to read the information shared for meaning and to note any common ideas, words or phrases within the responses from participants. The third step was to begin a coding system. Color coding similar words or phrases helped to see the data in a different way. The data was looked at and read over again to determine the similarities and differences in themes and codes found. A narrative explanation of the findings was drafted and a table of the most common words and themes by participant and questions were generated. The teachers explained the documents, handouts, and other supplemental materials used and whether the students learned what was intended to be learned from the materials. Responses related to the supplemental materials were sorted and examined for any similarities in words, phrases, or common themes. Any handwritten notes generated from phone interviews would have been examined, coded, and organized using the same eight steps if there was a need (Creswell & Creswell, 2018).

Participant and school identities were anonymous since a coding system was applied to identify participants from different schools. The coding system used assigned a random letter to represent the participating school and the participants assigned an additional random number to keep identities private. Data was input in a Google Sheets document coded as respondent A1 or B1 depending on which school's teacher had completed the questionnaire. The coding system was kept private. Teacher perceptions were collected to find common meaning, interpretations, and themes from the open-ended responses received. Text information was recorded digitally via

the computer through Google Drive. The data was categorized and sorted by which school had submitted information and then analyzed by key words, phrases used, and the different themes evident from the responses. Organizing data into categories respected the data because the categories remained close to the language the participants used (Elliott & Timulak, 2005). Spreadsheets helped visualize and process data in charts, tables, themes and patterns to help make meaning of the data (Moylan et al., 2015). A display was designed to communicate the results as a visual. The table displayed the common words, phrases, or themes evident from the data received.

Electronic responses were generated by Google Drive and then sorted and analyzed for commonalities in responses. Teachers were asked to share and explain any handouts or supplemental materials used with the technology either by sharing a copy of the document if electronic or sending the document via e-mail. The teacher was asked to describe and explain the purpose in using the documents and what the intent was for the resources. Receiving electronic data ensured participants could express lived experiences and feelings openly about the research topic and made sorting and organizing data easier and quick (Creswell & Creswell, 2018). Creswell and Creswell (2018) stated coding data by hand can get intense even when few participants exist. The classifying and categorizing of similarities and differences of the themes and key words requires reflection on what is shared by teachers regarding the phenomena in question, 3D types of tools, to draw a conclusion about the use of 3D types of technologies (Arseven, 2018; Elliott & Timulak, 2005). Based on the responses, themes were determined as to whether or not learning was impacted positively and if schools should invest in these types of technologies to enhance student learning experiences.

Reliability and Validity

Validity was ensured with the integrity in applying the methods selected (Noble & Smith, 2015) and reliability was ensured by analyzing the data in a consistent manner. Credibility was established when personal bias was avoided in findings and the research process was credible enough to be applied to similar research studies (Noble & Smith, 2015). Validity was evident when the data collected was shared with the participant for approval (Cranmore & Wilhelm, 2017). The reliability of data and validity of interpretations and conclusions could be affected by the mood of the educators partaking in the questionnaires. Reliability of the instrument was evident when more than one school participated in the study using the same instrument (Heintzelman, 2016). The data was conformable because the results reflected the outcomes of the study. The online responses were kept in a Google Drive making the data results evident, clear, and safe (Noble & Smith, 2015). Confirmability existed since the words of the participants were maintained in analysis. Request for handouts, supplemental materials, or resources teachers used with the technology helped to see what teachers intended students to learn from using the technology. The phone interviews would have helped to clarify responses received if needed. All perspectives were represented using participant responses verbatim to support research questions. Kilınç and Firat (2017) reported specialists in the field stating validity and reliability were increased in a qualitative study when the participants volunteer to participate without coercion.

Ethical Procedures

The research fulfilled regulations set by the Institutional Review Board (IRB) and the NIH (2018) guidelines for research. Ethical issues did not occur because personal opinions did

not interfere with a participant's viewpoints (Sanjari, Bahramnezhad, Fomani, Shoghi, & Cheraghi, 2014). Particular attention was given to avoiding personal bias because the researcher works in a classroom using VR/AR and 3D technologies. The participants' identity was safeguarded, trusting relationships were established, integrity of the research study was highlighted, and any wrongdoing was avoided (Creswell & Creswell, 2018). Participant's identities were kept anonymous and confidential complying with informed consent (Sanjari et al., 2014).

The appropriate informed consent was obtained from participants and principals were informed of the study (Creswell & Creswell, 2018). Respect for persons involved informing the studies details and having participants decide whether or not to commit to the study without coercion (Creswell & Creswell, 2018). Questions were designed to not lead the participant and not reveal personal or private information (Creswell & Creswell, 2018). Precautions were taken when designing this research to avoid any form of bias including researcher opinions (Galdas, 2017). Every precaution was taken to protect persons' identity and persons from any kind of harm to abide with beneficence. Codes were assigned to participants and the school. Participants were treated fairly through justice and criteria was looked at before selecting participants. Letters and forms of communication in the study were included for IRB review. The data and information pertaining to the study was kept in storage for five years in a separate Google Drive account (Creswell & Creswell, 2018).

Chapter Summary

The qualitative descriptive phenomenological study relied on lived experiences of teachers about a particular phenomenon, 3D types of technologies (Creswell & Creswell, 2018;

Phillips-Pula et al., 2011). The study looked into the perceptions of educators using 3D types of technologies and the impact the tools had on student learning. The qualitative study asked 21 teachers via an electronic open-ended questionnaire to make a conclusion as to whether or not 3D types of technologies effect learning. The major sections in the chapter discussed the study's research design, role of the researcher, procedures, reliability and validity, and ethical procedures. Requirements for IRB and NIH are implemented. The next chapter discusses research findings and data analysis results.

Chapter 4: Research Findings and Data Analysis Results

The previewed sections of Chapter 4 include (a) data collection, (b) data analysis, (c) reliability and validity, and (d) summary. The process of how participants were contacted, identified, and then coded are explained. A brief description of the participants is shared, the method of collecting data is discussed, and deviations from the data collection are stated.

The purpose of this qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and AR types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades. Teachers' viewpoints are considered because educators create environments in which students can engage in learning and are instrumental in making a climate supportive to continued learning (Rodriguez, 2018). The process of collecting data is discussed where the findings are analyzed, and themes are recognized based on the two research questions under investigations.

Research Question 1: What are teachers' lived experiences on learning outcomes when 3D virtual reality technologies are used?

Research Question 2: How do teachers perceive the effectiveness of 3D types of virtual reality technologies to enhance learning?

Research Question 1 was further broken down into additional questions asking participants to identify which tool was being used, what the learning outcomes were, and what the tool was intended to be used for. This information provided a better understanding of why the teachers believed the tool had an effect on learning and the expertise involved in planning to use 3D types of tools. Research Question 2 was broken down into additional questions asking participants' opinions on the tool's effect on what was intended to be learned and how the

participant believed the tool had an effect on student behavior or attitude in regard to the tool during the learning process. Participants were asked if supplemental or teacher created materials were used which could further support how learning was enhanced through these artifacts.

Data Collection

The snowball sampling method was used to identify participants since the starting population was not known. This method is considered beneficial in identifying data sources with the help of primary sources (von der Fehr et al., 2018; Waters, 2015). A sales associate was contacted at Creative Learning Systems to provide a list of teachers and schools who had a SmartLab installed since many of the schools contacted to participate in this study declined participation due to not implementing the 3D types of tools under investigation. The sales associate e-mailed a list of schools and teachers in Illinois with contact information who were using a SmartLab. SmartLab's guaranteed there would be 3D printing and maybe some sort of VR usage in those schools. A total of 31 middle school administrators were contacted to introduce the study. Middle schools contacted via electronic mail included schools around Illinois; some had a SmartLab from Creative Learning Systems and others had zSpace machines. A few middle schools were recommended by teachers who agreed to participate.

The significant or unusual circumstance encountered during the data collection was the difficulty in locating middle schools using these tools. Due to the newness of the tools under investigation, any middle school educator who had been teaching for two years or more and used 3D types of tools was considered as a participant. If the teacher worked in a middle school and used one or more of the tools with middle schoolers, the educator was invited. In cases where schools using 3D types of technology was not known, administrators were contacted to introduce

the study and to find teachers from the school who would qualify to participate. The administrators were asked to share teacher contact information believed to qualify for the study. Teachers who were identified at a specific school were sent an invitation via e-mail the same day (Appendix A).

Out of the 31 middle schools contacted, 12 schools agreed to participate. The number of participants from which data was collected totaled 21. Thirteen females educators and eight male educators filled out a consent form. Seven participants work in the same school as the researcher. The researcher has no influence or supervisory role over these participants. Initially, 15 middle school teachers were to be invited to participate but due to the newness of the technology and many middle schools just beginning to implement these types of tools, more than 15 participants were accepted to share lived experiences of the phenomena. This was the first deviation in the study.

The time frame for data collection and response rates were from two to three weeks totaling a little over a month. The time frame included initial contact, receiving signed consent forms, and receiving replies to the online questionnaire. The wait time took longer than was anticipated for administrations to give approval for staff to participate and then the staff to find time to complete the online questionnaire. The third deviation in the study involved not needing to do any follow-up Skype interviews since participants were very clear and detailed in the online questionnaire. Teachers explained their purpose in using supplemental materials and resources in the online questionnaire.

After one week, the schools, principals, and teachers who did not respond to an e-mail, were contacted again as a courtesy follow up to the original e-mail or contact. The researcher did

not want to overburden the participants or the school administrators so three to four days lapsed before follow-up contact was made. The second deviation from the data collection plan was shortening the original invitation e-mail to principals and administration and shortening the invitation e-mail to teachers in order to solicit their approval quicker.

Correspondence records were compiled in a password protected Google drive as a Google sheets document to keep track of schools which were contacted, participants who agreed to volunteer in the study, and participants who turned in a signed consent form. As soon as a participant agreed to be a part of the study, the consent form was sent for signature (Appendix B). Once the signed consent form was received from teachers, the forms were immediately uploaded to a password protected drive for safe keeping. The forms were sent back as a scanned document or as a picture file.

The link to the Google Forms questionnaire was shared with the participant without delay via e-mail (Appendix C). The questionnaire form was designed to let participants edit and review responses if needed. The fourth deviation involved modifying the original questions slightly to reflect the research questions better. Allowing participants to edit the form enabled participants to review and edit their responses and provide a copy of what was shared. Google Forms is preferred since it generates charts and organizes data being collected. Structured and semistructured questions were included in the original questionnaire (Appendix C). The questionnaire form reset so participants could fill out the form as many times as they needed depending on how many tools were used with middle school students. Three teachers never fulfilled the requirements and were eventually dropped from the study after waiting three weeks from their initial invitation and agreement to participate.

Schools were assigned a random letter of the alphabet and educators were assigned a letter and a number indicating how many educators participated from a particular school. Educators using 3D types of technologies ranged from science, math, foreign language, and social studies. Special staff participating included STEM facilitators, technology coordinators, innovative space coordinators, and instructional coaches. This information showed where and by whom 3D types of tools are being implemented. The middle school grades ranged from fifth grade to eighth grade. Table 1 presents the 12 schools and the 21 participants' codes, gender, grade level taught, and professional title.

Data Analysis and Results

The data results were obtained via electronic means protected in a Google Drive specially created for the study. Google Drive is password protected so as participants completed the questionnaires, the data was being collected via a secure drive. The questionnaire was designed for teachers to share lived experiences using 3D types of tools and the effect these tools had on students and learning.

Tesch's (as cited in Creswell & Creswell, 2018) eight sequential steps were used to decipher the data. All transcripts from the online questionnaire were printed, reviewed, and organized by the 3D type of tool used. There were only three tools used: 3D printing, AR and VR. No one indicated using holograms in middle school. Due to the almost similar nature of AR and VR, the two were categorized together.

Table 1

Research Participants

Middle school	Code	Gender	Grade level	Professional title
School A	A1	Male	7–8	STEM facilitator
	A2	Female	5	Science/math teacher
	A3	Female	5–8	Instructional tech coach
	A4	Female	5	Math/science teacher
	A5	Female	5–6	Spanish teacher
	A6	Female	5	Science teacher
	A7	Female	7–8	Math teacher
School B	B1	Male	6–8	STEM facilitator
School C	C1	Male	Prek–8	Innovation space coordinator
School D	D1	Female	6–8	Tech integration coach
School E	E1	Male	6–8	STEM facilitator & communication media arts
	E2	Female	6–8	Library information specialist
School G	G1	Female	6–8	Science teacher
School H	H1	Female	7–8	Student services/athletic/activities director/STEM Club teacher
School J	J1	Male	K–8	District technology director
School L	L1	Female	7	Social studies teacher
	L2	Male	6–8	Director of bands/science, technology, engineering, arts, and mathematics (STEAM) facilitator
	L3	Female	6–8	Teacher–STEAM
School N	N1	Male	5–8	Technology integration specialist
	N2	Female	5–8	Technology–STEAM teacher
School P	P1	Male	6–8	Teacher/computer tech

As the questionnaires were read, certain striking statements or words were highlighted in step one of the analysis for each of the tools. Step two and three involved reading the online questionnaire responses again and highlighting words and phrases which were repeated among the participants. During the analysis phase, a table was organized with the research questions along with the common phrases and words used by participants for each of the questions relating

to the studies objectives. Discrepant data contradicting the viewpoints of the majority were considered and mentioned in the analysis to show there are still concerns within the educational community about using 3D types of tools (Tsai et al., 2016). The data was coded in relation to the questions asked and themes resulted in the final steps of the data analysis. Coding was based on identifying common words or phrases participants used most often in their responses for each question. Analyzing the common words and phrases using a spreadsheet table helped to develop major themes and conclusions.

Once the common words, phrases and themes were identified and highlighted, the participants and their schools were randomly coded to protect the school and the participants' identities. A list was generated in the password protected Google drive and random letters were first assigned to schools. Participants from those schools were assigned the same letter and a number to indicate how many participants volunteered from a particular school as displayed in Table 1. The random codes were applied to protect confidentiality. The confidentiality of participants and schools was protected because no personally identifiable information was mentioned in the study.

Table 2 shows the emerging themes from research participants in regard to 3D printing. The themes indicate the qualitative findings of the teacher's perceptions and experiences of using 3D printing with middle school students. The data looks at three main topics from teacher perspectives. These include student response to tool, how the tool effected specific learning outcomes, and the tool's effect on learning in terms of engagement and motivation. Responses revealed mostly positive experiences.

Table 2

Themes Emerging From Research Participants About 3D Printing

Interview question	Theme
How did students respond to the 3D printing tool/software?	Participants perceived 3D printing to be liked by students
What are your perceptions on the learning outcomes when 3D printing was used?	Three-D printing had a positive effect on learning
In your opinion, did 3D printing have an effect on learning?	Three-D printing is an effective tool for learning

Teacher Perception on Student Response to Using 3D Printing

Thirteen participants perceived student responses to using 3D printing to be well liked. Teachers stated, "Students liked it," "Enjoyed the experience," "They love it," "Learn faster than teachers," "very engaged and interested." Educators realized "engagement level drastically increases" and "more students participating with greater accuracy." Two participants shared students expressing concerns like, "some struggle with visualization" and some were "initially anxious."

Teacher Perceptions on Learning Outcomes When 3D Printing Used

All participants shared positive perceptions regarding learning outcomes. Each teacher explained how the intended outcome for the activity was met when implementing the tool. Teachers stated students had "better grasp of three-dimensional thinking and problem solving," "to create something virtual, and then to have it print out in reality gives students a tactile way to visualize their ideas," "makes it more real for students," "student engagement is greatly increased when using this type of 3D technology (3D printing)," and "This engagement seems to motivate students to persevere, think critically and push their creativity." Most educators agreed

"the students are better able to meet the learning outcomes" because "I think it definitely helps students achieve learning outcomes by making concepts more concrete."

Other teachers seemed positively surprised to see the true effect this tool had on learning outcomes. Teachers perceptions included, "Furthermore, this type of technology pushes their learning toward redefinition—the students can do with this technology things that without it would be inconceivable" and "I think the 3D printer allow my students to be creative and produce something not possible without the 3D printer." Two teachers mentioned how 3D printing helped with math skills. These teachers stated, "CAD skills actually improve thought process and concept skills," "3D printing actually brings 3D math skills to life encompassing the final output of all three tools," and "They gain important understanding of math concepts and also grow in visual special reasoning."

Teacher Perception on 3D Printing's Effectiveness on Learning

All participants agreed 3D printing is effective for learning. Teacher feedback included: "extremely effective," "increases effectiveness," "quicker learning," "enhanced learning," and "augment and further student learning." The tool is effective because it "supports the taught concepts and utilizes real-world use," "provides real-world skills," "learning becomes an experience," and "raises engagement and retention." Other participants believed this tool "allows to make connections for future applications," "unlocks student creativity," and "creativity, problem solving, and motivation propelled." One teacher shared, "I think the 3D printer allow my students to be creative and produce something not possible without the 3D printer." While one teacher stated this tool is "easy to use, free, lets students create objects impossible by hand" another teacher reminded educators "sound pedagogy and instructional strategies are needed."

Educators overwhelmingly believed learning is enhanced and enriched positively when this tool is used. From the participant responses, students are highly engaged and motivated with the excitement of what this tool can offer in terms of the learning process.

The themes which emerged from the data for using supplemental materials with 3D printing included supplemental materials being used to help students learn independently and become independent learners. Majority of the respondents stated supplemental materials were used to enhance learning experiences for students, so learners become more independent learners. Statements like "gives students a starting point," "become better acquainted to technology," "enable students to move forward independently," "allows them to work independently at their own pace," and "tutorials to ensure that they had specific skills" were some of the common words and phrases shared. Some of the supplemental materials were teacher created websites and others were actual handouts explaining how to get to tutorials or provided the lesson plan for students to follow along to complete a unit of study. The instructors who used supplemental materials stated supplemental materials enhanced the learning experience of students when using 3D printing and were used "to develop foundational skills and background" knowledge and "provided follow along directions."

Table 3 shows the emerging themes from research participants in regard to AR and VR. The themes indicate the qualitative findings of the teacher's perceptions and experiences of using AR and VR with middle school students. The data looks at three main topics from teacher perspectives in regard to AR and VR. These include student response to tool, specific learning outcomes when tool used, and the effectiveness of learning in regard to engagement and motivation. Responses revealed mostly positive experiences.

Table 3

Themes Emerging From Research Participants About Augmented/Virtual Reality

Interview question	Emerging theme
How did students respond to the AR/VR tool/software?	Participants perceived AR/VR being liked by students
	Participants indicated some students mentioned challenges in using AR/VR
What are your perceptions on the learning outcomes when AR/VR was used?	Augmented/virtual reality had a positive effect on learning
In your opinion, did AR/VR have an effect on learning?	Augmented/virtual reality are effective tools for learning

Teacher Perception on Student Response to Using AR and VR

Two themes emerged from this inquiry. The first theme was a favorable one. Sixteen participants stated students "absolutely loved it." Similarly, others had the same sentiment as, "They LOVED it," "engagement level drastically increases—more participating," "super engaged with the technology—asked more questions than if they had just read the information out of a book," and "very enthusiastic! Lots of positive comments." One teacher shared, "students were very engaged—able to make connections—compare and contrast realistically observing." Teachers who used VR and AR, show students are amazed at the ability of this tool to make experiences come to life as students explored what the tool was capable of doing.

The other theme emerged due to some challenges with these tools. Two teachers pointed out "some had motion sickness with VR" and "a small number of students feel dizzy or nauseated." Two other participants mentioned students responded "positively" initially but added, "some programs hard to get but once students got the hang of tool, they would explore deeply into programs." Another teacher stated students "were happy to play on it for a while."

The issues of nausea and motion sickness was evident in the review of the literature but for few individuals as in this study. Newbutt et al. (2016) mentioned dizziness and nausea as one hurdle to implementing these types of tools, but stated new systems were being designed for head gear to prevent dizziness in the future. These challenges are important and should be taken seriously so as to prevent these types of experiences for the minority of students who experience sickness from the tool.

Teacher Perceptions on Learning Outcomes When AR and VR Used

Eighteen of the participants responded positively in regard to their perceptions on learning outcomes when using AR and VR tools. Statements like, "met and exceeded the learning outcomes," "brought a topic in science to life," "learning outcomes enhanced due to increased interest," "nice enhancement to curriculum" because students "experience something they wouldn't normally have access to in classroom," "engaged students: present, excited, ready to learn topic," "more engaged—willing to discover things on their own," "students were more apt to challenge themselves to be more creative," and "outcomes accomplished—students not actively aware they were learning—think fun games" were shared. One teacher noticed, "students certainly are more engaged while using VR or AR. It makes learning more concrete." Another teacher responded positively but recommended suggesting, "Learning outcomes were met quickly. I do feel the students need to have some background or knowledge beforehand."

Three participants were more cautious of using these tools. The first and second participant stated, "Not sure it furthered understanding of learning outcome," "it depends on tool—this one met outcomes." The last participant advised, "have to focus students away from entertaining aspect to learn why it is entertaining." In regard to learning outcomes for an activity,

educators agree the tool is engaging and makes learning more enjoyable for students making outcomes achievable quicker. The advice given is to make sure the learning outcome is the goal of the activity when using this tool, since students may become focused on the entertaining aspect of this tool.

Teacher Perception on AR and VR's Effectiveness on Learning

Twenty-four perceptions made by participants were positive in regard to these tools' effectiveness on learning in terms of engagement and motivation. Teachers expressed many positive statements like, "This tool allowed students to share their knowledge in such an engaging, immersive way," "Highly effective—student engagement—generated a lot of questions," "Extremely effective—shows what happens in body which we cannot see in real life—helped visual learners," "gives them excitement about learning," "it increased interest in topic," "can see and interact which you cannot do with other tools," "they got to explore parts of the world they might never travel to," "fully immersed in a world," and "highly interactive—pushed learning to new levels." Responses show these tools promote engagement and motivation in the learning process because the tools bring to learning what was impossible in the past like exploring faraway places.

In regard to AR, a participant shared,

> Kids were asking a lot of questions which showed that these tools got the kids curious and engaged in the topic. It changed the way teachers interacted with kids. The teachers were more like learning partners than the "teacher" of the class.

Other participants believed the tools were "somewhat effective" and

> Can be very effective as long as there is a clear educational purpose in mind. It is important to have a clear plan of the outcomes. VR can transform learning for students and transform the ways in which teachers teach!

Another participant pointed out "They [VR and AR tools] are in the beginning stages. I think they [tools] get kids engaged. Some of the programs seem to offer more than others." Only one participant stated, "did not believe tool had an effect on learning." Educators believe these tools are effective for engaging and motivating students but advise having a clear plan for implementation for the tool to be effective.

The themes which emerged from the data for using supplemental materials with VR and AR included supplemental materials being used to help students learn independently and become independent learners. A majority of the respondents stated supplemental materials were used to help students be more independent in their learning and to provide more guidance. Statements like "help students become self-directed learners," "outlining expectations," "guided questions provided to make careful observations," "utilized precreated lesson plans," and "supplying materials and resources to work independently" were some of the common words and phrases shared. Some of the supplemental materials were teacher created handouts to provide instructions for how to access and utilize the tools, handouts and guidelines provided by the software to guide and help students to be self-directed in the learning process, and web pages, some designed by teachers and others by the software to use with tool.

Table 4 includes themes which emerged from participants sharing views on using 3D types of tools in general and any other ideas, opinions or perceptions about 3D types of tools.

Participants who shared their viewpoints about 3D types of tools perceived these tools as being effective. There were some participants who cautioned educators about these tools even though they considered these types of tools to be transformational and effective.

Table 4

Themes Emerging From Research Participants Overall Perceptions on 3D Types of Tools

Interview question	Emerging theme
In your viewpoint, how do you perceive the effectiveness of the 3D, virtual reality, augmented reality, or hologram types of technology used to enhance learning in general?	Participants found value and effectiveness in using 3D types of tools for learning
Are there any other perceptions you would like to share about this particular 3D technology, AR, VR, and or hologram tool?	Participants perceive 3D types of tools as a new way to learn in today's classrooms

Teacher Perceptions on Using Tools to Enhance Learning in General

Participants stated words and phrases like "extremely effective," "very effective," "highly effective," "incredibly effective," and "engaging and immersive, redefined learning." One participant went as far as to state "It is incredibly effective. It is incredibly engaging and immersive and allows students to redefine their learning in ways unlike any other technology I've used in the past." Others felt there was potential in these types of tools in general and can be effective if used in addition to curriculum.

While most participants found value and effectiveness in using 3D types of tools for learning, other teachers stated, "Tools still have a way to go in terms of impact on learning but certainly, a lot of potential," "can be effective if implemented correctly," "very effective as long as there is a clear educational purpose in mind. It is important to have a clear plan of the

outcomes. VR can transform learning for students and transform the ways in which teachers teach!," and "great tool but still emerging one—requiring patience, flexibility and skill to navigate."

A teacher warned to "be mindful of the technology/pedagogy and content knowledge" when using these types of tools and one teacher stated, "A lot of potential to use VR to enhance learning—need a lot of time dedicated to learning the program to make meaningful lessons, learning outcomes, supplemental materials and clear connections to curriculum." Another teacher advised to "clean the materials as a lot of students will want to use it." Three-dimensional types of tools are engaging, effective, and can transform learning. Since these tools are new to middle schools, participants suggested the need for professional development. Teachers may be comfortable in using these tools more often if content knowledge is at the center of implementation.

Other Perceptions Teachers Had on Tools Shared by Educators

Teachers who shared viewpoints are in agreement 3D types of tools are becoming the "new way to learn and educate and prepare for a world unpredictable" and "truly redefines learning for students." Perceptions shared about 3D printing include: "The way prints light up students' faces make it all worth it," "Kids get excited to be able to utilize these things—hands-on learning," and "3D printers getting ubiquitous in education which is exciting." One participant pointed out, "3D printers are very expensive—does not provide equitable opportunity for lower socioeconomic schools." Three-dimensional printing was seen as the tool most often used in middle schools and is believed to be transforming learning. Students are becoming intrinsically motivated to learn as they design a digital object and make it a reality.

Participants who referred to AR and VR stated students were "extremely engaged and excited to be in class," "VR like simulating is great for today's classroom," "VR is the future of education," and "VR allows others to be transported to a different world." One teacher remarked, VR "can share a powerful story to help us understand others or ourselves better" and "VR provokes empathy like how book collections do." VR when immersed with curriculum intrinsically motivates students to be more engaged learners as they go a step beyond books and pictures.

Two participants pointed out professional development is needed. Teachers stated, "We should be trained on the great programs in our curricular areas" and "District should provide more time to explore VR to make it more effective in delivering this tool to students." One teacher believed Google Expeditions, an AR tool, should "allow students to interact in ways beyond 360 degree image to keep students engaged in expedition." The idea of providing professional development for teachers has come up more than once in the study. Participants believe setting aside time to build curriculum and instruction around these tools is essential to achieve these tools' potential in meeting the needs of learners.

Reliability and Validity

This study assured reliability by ensuring the analysis of the data was performed in a consistent manner. Credibility was established by avoiding personal bias in the results and using exact words of the participants to conclude results demonstrating integrity. The data collected was shared with the participants to assure any additions or corrections could be made to the original questionnaire by allowing them to edit responses. Participants were able to review, edit, and attain a copy of the responses. The reliability of the data and the validity of interpretations

and conclusions can be affected by the mood of the educators or by participants' personalities when answering the questions. Many participants are under pressure with daily routines and some are reluctant to change. The participants gained no financial benefit and only shared lived experiences in regard to the phenomena under investigation. Reliability of the instrument is evident because 21 educators from 12 different schools participated in the study and the same instrument was used.

Transferability is possible since the 21 study participants do not teach in the same middle school and are from different parts of Illinois. The experiences shared from these educators can be applied to other contexts and situations relating to using 3D types of tools in elementary schools. The conclusions and results are dependable and supported by the data collected. The actual words and phrases of participants are used. The data is confirmable since the findings are actual outcomes from participant responses. Confirmability is assured because the findings are the direct quotes, words, and phrases from the data collected (Korstjens & Moser, 2017). Evaluations of the findings, interpretations, and recommendations reported in the study are all supported by the data to affirm dependability (Korstjens & Moser, 2017).

Chapter Summary

Chapter 4 presented the purpose of this study, the research questions, the participants, and how the data was analyzed. Themes were developed based on the tool used by participants in relation to the two research questions. The phenomenological results depict the lived experiences on learning outcomes when 3D VR technologies were used and how teachers perceived the effectiveness of 3D types of technologies to enhance learning. Participants perceived 3D printing, AR and VR types of tools as having a positive effect on learning and participants

considered these tools to enhance learning. Supplemental materials when used were to help students become more independent learners and varied from web pages, online tutorials, and handouts. The next chapter discusses the findings, interpretations, and conclusions, limitations, recommendations, implications for leadership, and conclusion.

Chapter 5: Discussion and Conclusion

The purpose of the qualitative, phenomenological study was to explore teachers' lived experiences of using 3D printing, holograms, VR, and AR types of tools and these tools' effect on learning in K–12 education with an emphasis on the middle grades. The study was conducted because of the lack of information about these types of tools' effect on learning in elementary and middle schools and to determine if these tools are worth the investment. The research attempted to answer two questions.

Research Question 1: What are teachers' lived experiences on learning outcomes when 3D virtual reality technologies are used?

Research Question 2: How do teachers perceive the effectiveness of 3D types of virtual reality technologies to enhance learning?

The data findings indicated majority of Illinois teachers lived experiences in regard to using 3D types of tools being positive for learning outcomes and having a positive effect on the quality of learning (Tables 2 and 3). Most participants believed learning outcomes were achieved when using 3D types of tools due to the students' positive responses when using these tools. The perceptions on the effectiveness of these tools on learning was favorable with many teachers stating the tools were "highly effective" and "pushed learning to new levels." The participants believed the use of these tools would continue to enhance learning and learning in general going forward into the future (Table 4). Participants were in agreement 3D types of tools are becoming the "new way to learn and educate and prepare for a world unpredictable" and students become "extremely engaged and excited to be in class."

Supplemental materials provided a means for students to become more self-directed and independent in the learning process. Majority of the participants used supplemental materials to help students "become better acquainted to technology," "enable students to move forward independently," and to "help students become self-directed learners." The previewed sections of this chapter include a summary of the findings, interpretations, and conclusions in relation to the two questions under investigation. The summary is followed by the study's limitations and recommendations. Chapter 5 ends with the implications for leadership.

Findings, Interpretations, Conclusions

The data results confirm 3D types of tools are just now being implemented in middle schools because many middle schools in Illinois are still behind in these tools' implementation in education. The review of the literature described the use of 3D technology tools in higher educational institutions, these tools' use in other countries, and the benefits of these tools' use in different areas of learning. For example, globally, 3D printing has been expanding in higher educational institutions as far as Pakistan, Greece, and Australia. The literature review involved exploring 3D printing, holograms, VR and AR and the BYOD initiative. The BYOD initiative was a product of redefining classroom pedagogy and student teacher roles in a learning environment. BYOD devices can tap into student engagement and connect the school and a student's daily life (Al-Okaily, 2013).

This research addressed the gap in the current literature in regard to 3D types of tools in the middle grades. The future of education is advancing towards VR technologies and other web-related technologies because teaching is moving away from traditional methods to teaching which uses different forms of media (Qi & Shi, 2016). Holograms were not evident in middle

schools around Illinois but are slowly becoming popular. Several non-peer-reviewed articles are appearing in the media about the use and availability of hologram applications on hand held devices for K–12 education.

The literature review discovered technology is not only changing daily life but is reshaping learning environments. The findings confirm for learning to become progressive with the times, teachers need to consider student engagement in the learning process (H. Lee, 2013). Peer-reviewed literature agrees educators have to bridge the gap between schools and students' daily life outside the classroom to increase motivation (Al-Okaily, 2013). Considering teacher perspectives is important to a successful change in pedagogy. According to Stingu and Iftimescu (2016), teachers are the ones who can lead the way to designing learning opportunities which are engaging and hands-on for students which is why teacher perspectives and lived experiences are considered.

Harasim's OCL theory was used as the bases for this study because this theory focuses on recreating traditional learning environments into collaborative ones in which the teacher is viewed as a facilitator and knowledge is constructed using the constructivist approach (Picciano, 2017). This style of learning was evident when using 3D types of tools. In the study, an educator using AR for the first time with a class shared, "With Google Expeditions, every teacher noticed that the left lung is smaller than the right lung because the heart has to fit there. They [teachers] told the kids, 'I didn't know that before'" and "It changed the way teachers interacted with kids as well. The teachers were more like learning partners than the 'teacher' of the class." Another educator using a VR simulator stated, "I have also seen an increase in outside connections.

Students often come in class and bring up things that happened outside of class that connect to something we did on the simulation."

Learning is becoming more collaborative and when using tools which support 21st-century skills, students' "learning becomes active" where these types of tools are "the new way to learn and a way to educate our students so that they are prepared for a world we cannot predict in 15 years." The study's findings confirm 3D types of tools can make learning an active process where knowledge is gained through learners collaborating (Breen, 2013). Participants confirmed by stating, "By allowing others to be transported to a different world" with the use of VR, "we can share or take in a powerful story that helps us understand others or ourselves better," "Kids seem to get excited to be able to utilize these things—as hands-on learning not just book and packet learning," and "Virtual tools like the simulation I used are great for today's classrooms. Students are extremely engaged and excited to be in class."

The study of the literature pertaining to 3D printing concluded positive results going as far as predicting students are be able to transform visions into reality (Waseem et al., 2017). This study's participants confirm results from the literature review with statements in regard to students using 3D printing like students were "engaged and excited" similar to Pierce (2016) who reported companies selling 3D technologies are claiming to bring learning to life. Other participants agreed stating, "student engagement is greatly increased when using this type of 3D technology (3D printing). This engagement seems to motivate students to persevere, think critically and push their creativity," "students feel like they are creating rather than just learning," "CAD skills actually improve thought process and concept skills. Three-dimensional printing actually brings 3D math skills to life encompassing the final output of all three tools,"

and "They [students] are excited by the new technology and proud that they can use it to create something they have imagined."

VR findings in the study confirmed results attained from the literature review. Newbutt et al. (2016) discovered educators preferred VR simulations because this tool offered students a different way of learning the same material by making learning engaging, enriching, and motivating. Teachers in the study confirmed these sentiments with responses like, "The learning of the heart and blood system was easy to see in this virtual program. It was even better than a quick movie excerpt," "Virtual reality allows teachers to provide this necessary authentic learning," and

> The engagement level drastically increases. Students who are disengaged in the traditional classroom come to life. . . . We have seen increase in retention with the lessons they learned while using the 3D tech. . . . Nothing scientifically proven but when reviewing content and such, more students are participating with greater accuracy of information.

Another participant stated, "Students gain knowledge in a way that isn't possible through books and videos. They get to explore at their own pace and focus their learning on their interests. It brings them to places they couldn't go otherwise." As students were exploring the circulatory system, one teacher perceived "students gained a deeper understanding of the system" when using VR. VR is a "nice enhancement to the curriculum and allows students to experience something they wouldn't normally have access to within the classroom" and "This technology brought a topic in science to life that is typically hard to explain to students from just pictures in a textbook."

In regard to AR, the literature review found AR programs having the ability to transform a traditional education to a smart education personalizing learning (Kiryakova et al., 2018). Smart education involves implementing modern technologies to help prepare students to better adapt to an unknown future (Dumancic, 2019). Studies found with the use of AR, formal and informal learning combined to provide more realistic learning experiences (Harley et al., 2016). When combining the use of AR and other multimedia, a history lesson enhanced collaborative problem solving (Frydenberg & Andone, 2018; Harley et al., 2016).

Participants in this study who used AR seem to be in agreement with the findings from the literature study. Participants stated, "They [students] feel they are doing something 'cool' and progressive. Something that matches the world they live in and the working world they will be entering in the future" and "Students were very engaged. Therefore, they were able to make connections as well as compare and contrast by realistically observing Mexican culture." This educator believed certain "cultural competence cannot be fully achieved without 'visiting' or 'experiencing' the culture." Another educator shared, "It is incredibly engaging and immersive and allows students to redefine their learning in ways unlike any other technology I've used in the past." The educator added, "this technology allows the viewers to be transported to a location, look around, and then understand through pop-up information, what happened in this particular place. It helps make the experience more 'real' for the viewer." Another participant using 360 Exploration stated this tool "allows students to truly experience learning. Rather than read about or look at visuals, students can experience true phenomenon."

The viewpoints which conflicted from the majority or deviated from the norm were recognized because educators are continuously looking for ways to improve learning

experiences. These concerns and perceptions can be used to further enhance the implementation of 3D types of tools. Most of the participants bringing up concerns felt positive about these tools but wanted to make sure educators were cautioned "to be mindful of the technology/pedagogy and content knowledge," "can be effective if implemented correctly," "can lead to gaming and not learning," "sound pedagogy and instructional strategies are needed," "effective if used in addition to other materials, discussions etc.," and "need a lot of time dedicated to learning the program to make meaningful lessons, learning outcomes, supplemental materials and clear connections to curriculum." In the same sentiment, two educators pointed out the necessity for the district to "provide more time to explore VR to make it more effective in delivering this tool to students," and "We should be trained on the great programs in our curricular areas." Other participants mentioned some of the challenges with VR and AR tools. Four participants stated, "motion sickness," "a small number of students feel dizzy or nauseated," "some struggle with visualization," and "initially anxious." Only one participant stated "no" to did the tool have an effect on learning.

Limitations

The limitations included not knowing how few middle schools were behind in implementing or using 3D types of technologies like 3D printing, VR, AR and holograms in Illinois. Middle schools are just beginning to design pilots centering around using VR in curriculum. The limitation was finding educators who used one or more of the tools under investigation in middle schools around Illinois. The study was able to reach further out into Illinois geographically to find credible participants who met the requirement of teaching for more than two years and who had implemented the tools under investigation. Credibility is

assured with triangulation of the data. An online questionnaire was conducted alongside collecting supplemental materials used with the phenomenon in question. The study is credible because member check was used when participants were given the opportunity to correct or add to responses in the online questionnaire. The consistency in the findings supported the use of supplemental materials when using 3D types of tools in order to provide a variety of means for learners to become more independent, self-directed, and focused in achieving learning outcomes.

The results of the study can be transferable to educators in other middle schools around the world and in different grade level educational institutions implementing 3D types of tools. This study was limited to any middle school educator using 3D types of tools in Illinois. Higher institutions are using more advanced types of tools as discovered in the literature review which may have some influence on results and lived experiences. The context of the study method can be implemented to other grade levels in trying to understand these tools' effectiveness for learning. The data presented is dependable and trustworthy since the findings are consistent with the data collected. The exact words and phrases of participants were used to draw conclusions. Confirmability is assured because the study outcomes are completely based on participant feedback.

Recommendations

The phenomenological study investigated the use of 3D types of technology in middle school from the perspectives of educators in Illinois. Three-dimensional types of tools are emerging in schools and educators are beginning to wonder how these tools can be used effectively as enhancements to promote learning. Participants' lived experiences were positive when using 3D types of technologies to meet learning outcomes and teacher's perceived the

effectiveness of 3D types of tools supplement learning. There was indication from the data professional development is needed to develop pedagogy along with these new tools. Thoma, Hutchison, Johnson, Johnson, and Stromer (2017) discovered obstacles which prevent new technology implementation in curriculum was partly due to time constraints, resources, and professional development. Districts have to make time to provide resources and professional development in order to bridge the gap between students' home life and learning spaces if these tools are to be used successfully to enhance learning experiences for all learners.

Trust and Maloy (2017) conducted a similar type of study focusing on 3D printing projects to determine the impact 3D projects had on student learning. The researchers concluded even though 3D printing was new to education, the teachers found 3D printing projects having the ability to encourage and support students reinforcing 21st-century skills. Other researchers concerned with the future of education and the role technology will play in the future include Dumancic's (2019) who wrote a paper discussing how learning has evolved from traditional teaching to one which has implemented the use of a variety of digital technologies. These digital technologies allow students to learn at one's own pace and from previous knowledge. Dumancic stressed the need and reasoning for a transformation of traditional learning spaces to ones which are centered around smart learning. Smart learning environments can be both physical and virtual in nature and can provide opportunities for learners to self-teach and personalize learning (Dumancic, 2019). Lifestyles and technologies are rapidly changing to improve the quality of life and Dumancic claimed educational institutions do not meet the requirements for what is to come in the future.

This study's findings and the limitations discussed encourage further research due to the newness of these types of tools. Middle schools are beginning to implement these types of tools into the curriculum which may provide better perceptions in regard to 3D types of tools effect on learning in future. Future research should involve student perspectives and different types of methodologies to study different perspectives of the use of 3D types of technologies. Qualitative data could be collected in future studies to look at assessment scores comparing the use of different 3D types of tools and these tools' effect on learning in various disciplines. A larger population and geographical location could be studied to compare to smaller geographical locations. These tools are still new to middle schools but in time the use of these tools may become more common. Further research should be conducted for the effect of holograms since this technology was not evidenced in middle schools and is predicted to be the next upcoming innovative tool seen in schools.

Implications for Leadership

The way people learn has continuously changed throughout history. Teaching and learning are evolving from traditional education to an independent learning style in which technology plays a critical role. The implementation of 21st-century skills and the introduction of STEM education is indication of pedagogy changing along with the skills students need to be successful in the future (Wan Husin et al., 2016). Knowing pedagogy must keep up with the rapid changes in technology innovation, and the researcher's study drawing attention to the lack of literature on the use of 3D types of technologies like 3D printing, VR, AR, and holograms in middle school education, there is a need for effective teachers. Schools are in need of leaders who put students first and do what is necessary to design a meaningful education (Mu'in, 2018).

Teachers should become effective leaders who consider the needs of the learners and do what is needed to provide the tools necessary to design a quality education for all students.

To keep up with the changing times, educators need to find ways to intrinsically motivate students to become independent lifelong learners equipped with necessary skills to adapt to future life. Change is inevitable. Dumancic (2019) introduced the coming of smart cities in which living will rely on improved technology. According to Dumancic, smart cities will require smart education in order for people to adjust to a new futuristic lifestyle. Artificial intelligence (AI) is another form of technology on the rise. Grosz and Stone (2018) claimed AI will affect transportation, home, healthcare, public safety, and education. AI will probably affect education in all areas even lower socioeconomic schools. Grosz and Stone stated plans are being made to develop teams who will work together to enhance education. This study is going to help educational leaders consider the implementation and planning for new kinds of technologies in classrooms. From the data results, the conclusion drawn is these types of tools are worth the investment to enhance learning experiences for students.

Conclusion

The future of education offers many opportunities for change and innovation. Research and this study's findings indicate 3D types of tools like computer games and simulations are supporting different areas of learning. These types of tools help in problem solving and decision making and even motor skills (Struppert, 2010). Many factors influence education besides technology like globalization, and 3D types of tools can help to provide innovative ways to meet the all-encompassing needs of all learners (Struppert, 2010). With these exciting transformations taking place in education, a need for teachers who are future-focused is essential (Reinsfield,

2018). With the recent types of VR and on-demand approaches becoming common, teachers who accept change and implement technology into instructional practice stand out from others. Districts need to provide the support teachers need and design infrastructures to support new and innovative technologies with a future-focused mindset. Future-focused curricula have to include opportunities for active engagement, collaboration, creativity, risk taking, and inquiry (Reinsfield, 2018). Funding these types of opportunities is seen as one challenge but should be overcome to meet the needs of all learners. Educational entities have to become world leading institutions where innovative learning environments help students to adapt to an ever changing world (Reinsfield, 2018).

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Appendix A: Recruitment E-Mail

Date
Name of Participant
School Address
City, State, Zip

Re: The Impact of 3D Virtual Reality Technologies on Learning: A Qualitative Research by Sabiha Rahman

Dear <Name of Participant>:

My name is Sabiha Rahman and I am a student at American College of Education. I am writing to invite you to participate in my research study about the use of 3D, virtual and augmented reality types of technology in middle schools. You're eligible to be in this study because you have been teaching for two years or more and have implemented one or more of these tools. I obtained your contact information from your schools' website or zSpace.

If you decide to participate in this study, you will be asked to provide answers to online questionnaires specific to your use of 3D types of technologies. Contact with you will be through Google Form links, electronic mail, phone via Skype or FaceTime, and by snail mail if necessary. Your time will be valued, and these forms of communication will be short. Remember, this is completely voluntary. You can choose to be in the study or not. Agreeing to participate in no way binds you to the study. At any time, you may withdraw. If you'd like to participate or have any questions about the study, please email or contact me at SR.ACE2018@gmail.com or text at 630-254-9067.

Thank you very much.
Sincerely,
Sabiha Rahman
5/6 STEM Teacher
American College of Education

Appendix B: Informed Consent Cover Letter–Teacher

Future Research Participant:

You are being invited to participate in this research because it is believed you have the experience and the expertise as a twenty-first century educator to contribute your knowledge to fellow educators, so other educators can better understand the new and innovative trends in education involving 3D types of technologies including but not limiting augmented and virtual types of reality on learning.
Please look over and read this consent form and feel free to ask any questions now, during or after participating in this research study.
Project Title:
The Impact of 3D Virtual Reality Technologies on Learning: A Qualitative Research

Lead Researcher: Sabiha Rahman-Shams **Organization**: American College of Education

Email: SR.ACE2018@gmail.com

Lead Researcher's Faculty Member: Dr. Sarah Everts, PhD

Organization and Position: American College of Education | Instructional Faculty Dept. of Leadership & Administration

Email: Sarah.Everts@ace.edu

Introduction
My name is Sabiha Rahman-Shams. I am a student at American College of Education. I am doing research under the guidance and supervision of Dr. Everts PhD., Instructional Faculty Dept. of Leadership & Administration. I am sharing some information about this project and invite you to be part of this research. Before you decide, feel free to talk to anyone you feel necessary about this research.

Purpose of Research
You are being asked to share your perceptions on the inclusion of 3D types of technologies in specifically middle schools and the impact on learning the tools have. The qualitative phenomenology study will investigate your feelings and beliefs about the use of these types of tools and if these tools truly are worth a school's investment.

Through this study, educators will get the inside scoop with feedback from actual educators using these types of technologies in classrooms with students.
Brief description of methodology
The research will use a qualitative phenomenology approach. The study consists of online questionnaires sent to educators in middle schools in schools in and around Northern Illinois. The participants will be asked to provide answers to the online questionnaire specific to the

participant's use of 3D types of technologies. Contact with participants will be through Google Form links, electronic mail, phone via Skype or FaceTime, and by postal mail if necessary. The research focuses on two main questions: What are teachers' lived experiences on learning outcomes when 3D, virtual and augmented reality technology are used?, and How do teachers perceive the effectiveness of 3D, virtual and augmented types of technology to enhance learning?

Participant Selection:

You are being invited to participate in the study because you meet the criteria for being an educator who has been teaching for two years or more and have used 3D, virtual or augmented types of technologies with your students.

Voluntary Participation:

Participation is entirely voluntary and there is no obligation for you to participate in this study. If you so choose, you do not have to participate. If you do choose to participate, you have the right to withdraw at any time during this study without any backlash or fallout. Please note, once a completed survey and your anonymous response has been received you cannot withdraw the received responses from the study.

Procedures:

You are invited to take part in this research project. If you accept, you will be asked to answer online questions electronically once you have met the criteria for the study. You may be invited to participate in additional face-to-face interviews, phone interviews, or to take additional electronic interviews if additional information is required for further elaboration or explanation of received information/data. You will be asked to share any documents or handouts relating to the use of these types of technologies to study.

Time Required:

The surveys will take 10 minutes of your time. You may be asked to partake in additional follow up online interview/surveys to better understand responses or information shared which should take no more than 10 minutes of your time. Most responses will be electronic and can be replied at your earliest convenience. Respect for your time will be considered.

Risks:

Any information shared by you throughout the research will remain confidential information. You do not have to answer any question or take part in the online interviews if you don't wish to. You do not have to give any reason for not responding to any question. You will be assigned a code to further protect your identity in the study. Please remove student names on student work shared and avoid taking videos revealing student faces or any form of identity.

Benefits:

There are no direct benefits for the participant of the study accept the satisfaction of sharing your expertise and knowledge which will help other educators and schools who may fear implementing 3D types of tools to know if these tools enhance learning. Educators and schools will see the different ways you implement these types of tools and how they are used to decide whether or not to implement and/or invest in 3D types of technologies during the middle school years.

Confidentiality:
Information you share will not be shared with anyone outside of the research and will be kept confidential. The data collected is password protected and any conversations via phone or email will be kept private and sealed in a secure place by the researcher only. Individual responses will be coded so responses will remain anonymous and kept confidential. The data will be shared during the doctoral dissertation process but will be presented in a coded format for confidentiality. Only unidentifiable data will be published by the researcher to protect the identity of the school and the educator. At the conclusion of the study, the data will be destroyed.

Sharing Results:
Results, findings, and conclusions will be shared with participants as the study is concluded. It is hoped the published study will give insights to other educators in middle schools around the world of how some Chicagoland suburbs experienced the impact of 3D types of technology on learning in the middle grades.

Right to Participate or Withdraw:
You have the right to voluntarily participate in this study. If at any time in the study, you believe you want to withdraw from this research, you are free to do so.

Questions About the Study:
If you have any questions, please ask at any time. You may contact Sabiha Rahman at SR.ACE2018@gmail.com or text at 630-254-9067. This research plan has reviewed approval by the Institutional Review Board of American College of Education. The IRB committee assures the research participants are protected from harm. If you have questions for this committee, please email questions to: IRB@ace.edu.

Certificate of Consent:
I affirm I have read over this consent cover letter. I understand I am being invited to partake in this research study to which I willingly agree to participate. I have had the opportunity to ask questions about the study and all my questions are answered to my satisfaction. I certify I am 18 years or older.

(Print or Type) Name of Participant: _____
Signature of Participant: _____ Date: _____
I affirm the participant was given opportunities to ask questions about the study, and any questions the participant has asked, have been answered to the best of my knowledge. I affirm the invited participant has not been forced or persuaded into giving consent, and the consent has been given freely and voluntarily by them. A copy of this Consent Form is provided to the participant.
(Print or type) Name of Lead Researcher: _____
Signature of Lead Researcher: _____

I have communicated or witnessed the accurate reading of the assent form to the invited participant, and the invited participant has had the opportunity to ask questions. I affirm the invited participant has freely given consent to participate voluntarily.
(Print or type) Name of Lead Researcher: _____
Signature of Lead Researcher: _____ Date: _____
KEEP THIS INFORMED CONSENT COVER LETTER FOR YOUR RECORDS.

Appendix C: Teacher Questionnaire

Please answer the questions if you have used or implemented a 3D, virtual or augmented reality technology with your students. Please fill out one questionnaire per tool.
If emailing samples or sharing docs, please email or share with this email:
SR.ACE2018@gmail.com .

*3D types of technology include and are not limited to-3D printers, software, and SketchUp

*Augmented (AR) and Virtual Reality (VR) tools include but are not limited to: Virtual reality glasses like Oculus Rift, zSpace, Google Cardboard, Samsung Gear, Simulations like Car Mechanic, No Limits Roller Coaster Simulator, Flight Simulator, or Kerbal Space Program.

1. Your first and last name
2. Name of School
3. Title of Class or Subject you teach:
4. Class period:
5. What were the learning outcomes for the activity using the tool or tools?
6. Which tool was implemented (Name of either a 3D, augmented, or virtual technology)?
7. How was the tool intended to be used?
8. How did students respond to the tool?
9. What handouts or documents accompanied this activity? Please provide a copy of what you used via email or paste the shareable link after your response.
10. What are your perceptions on the learning outcomes when 3D virtual reality technology was used?
11. In your opinion, did the tool have an effect on learning?
12. Explain how the tool had an effect:
13. In your viewpoint, how do you perceive the effectiveness of the 3D,VR, or AR type of technology used to enhance learning?
14. If there are any student samples, videos, student work, pictures, etc., please share them after removing any and all identifiable information and please explain what you are sharing. (You may email it or include a shareable link here).