Mixed Reality: A Learners Training Ground in Enhancing Creativity and Critical Thinking of Grade 9 ICT Students

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ABSTRACT

The research was designed to determine the effectiveness of Mixed Reality as a Learners Training Ground in enhancing creativity and critical thinking of Grade 9 ICT students. The study utilized a quasi – experimental research design which implement a researcher-made assessment to eighty (80) ICT students during their 2nd grading period of S.Y 2024 – 2025. Pre – test and post – test was administered to test the significant increase in their critical thinking skills, and a pre-performance and post-performance was conducted to test the significant increase in their creativity. This study is limited in the use of Mixed Reality as an innovation in improving learners' creativity, which focuses on idea generation, idea design and refinement, and critical thinking skills focused on analyzing, synthesizing, and evaluating. This research paved the way to improved students' creativity and critical thinking skills by using augmented virtual reality in practicing their skills and enhancing their knowledge. The results revealed that though a slight increase was observed in the pre-test and post-test levels of the controlled group, it does not develop the mastery levels of the students were majority of the students still at nearly mastered category, while students exposed in augmented virtual reality displayed a noticeable significant difference between the pre-test and post-test scores.

Keywords: Mixed Reality, Creativity, Critical Thinking, Decision-Making, Education

THE PROBLEM AND ITS BACKGROUND

Introduction

The fast emergence of technology requires a high demand of skilled professionals. According to some authors, to be accepted in a job an individual must possess certain competencies. These competencies are classified as systems-thinking competencies, interpersonal competencies, anticipatory competencies, strategic competencies, subject-specific competencies, normative competencies, and action skills [34].

According to several authors, action or practical skills as one of the competencies that is needed by an individual, is defined as the ability to initiate new things, finish task assigned, being confident enough, can deal during unfortunate scenarios, and the capability to produce good decisions [34].

It is a known fact that decision-making plays an important role in every aspect of life, from birth to death. From deciding a newborn's name to deciding for a final resting place, decision making has always played its part. In Technology and Livelihood Education it values skills that are applicable in real-life situations, involving the skill in decision-making. Technology and Livelihood Education offers a variety of areas for Grade 7 and 8 to be taught for each level, allowing teachers to select which area they will teach [90].

In the Philippine setting, schools' divisions offices or sometimes the school administration themselves decides whether which among these areas best suited their learners considering their locale, future needs, and possible career paths. For Grade 7 and 8, learners were usually exposed to eight different areas in TLE where they get to explore theories and concepts for each, not until they enter higher levels of junior high school, they will get to choose which among the areas they have explored they will want to master, as basis for their future career. In the case of Grade 9 and 10 learners they will only get to pick one area of specialization that will be their focus for the next two years. They have got to learn not only the theories but also the skills involved in the course and how each of these skills will be applied, hence Grade 9 learners are required to gauge good

decision-making ability. The skill of decision-making is continually being practiced and enhanced in schools through different practices, one of which is the involvement of critical thinking.

Critical thinking has always been involved in learners' output. The Partnership for 21st century skills include critical thinking as one of the learning skills needed in the 21st century, together with collaboration, cooperation, and creativity. According to Lai [51], critical thinking requires not only the cognitive aspect but also the disposition ability of the learner. According to Ennis (1987), critical thinking is considered as reasonable reflective thinking for it is a part of the decision-making process[8].

The 21st century learning skills include collaboration, communication, creativity and critical thinking. Stauffer claims that these skills are essential to learners' adaptation to technology and needed in the rising age of the internet. These learning skills are somewhat disregarded and are not given attention to some learners due to the rapid rise of technology and mobile game development[87].

Background of the Study

After the CoVid-19 pandemic outbreak, various businesses, and government institutions adopted social interaction provided by technology, resulting in various ways like remote working, telehealth, 3d printing, online entertainment and distance learning [77]. Distance learning uses technological advancement like radio, TV, broadcasting, online learning [2] through augmented and virtual reality involving personal computers and mobile devices [24].

Wexelblat stated that virtual reality (VR) acts as a support to most activities, including education[92]. According to Howard-Jones et al. (2014) [26], immersion is the common term associated with VR. However, the immersion being defined is categorized as spatial immersion. Spatial Immersion is described as being felt present in person in a non-existing reality, VR offers 360-degree experience and is most widely used in training, teaching and learning of various domains. With the use of head mounted displays (HMDs) users can experience the immersive quality of VR [73]. However, since the use of HMD blocks the user area of vision, mobile phone applications where introduced [6].

According to Statista Research Development, Southeast Asian countries experience an estimate rise of 32 million mobile game users from 2018 – 2023. With this, learners being exposed to mobile games continue to rise, and expected a drastic rise of over 60 million users in 2027[88]. On the other hand, Crabtree & Saransomrurtai (2021), found that there is a massive decline in education satisfaction in the world from 2019 to 2020 with Southeast Asia being ranked first, and having Indonesia and Philippines as the largest contributor [18].

The educational satisfaction of residents with learners attending junior high school in the Philippines fell from 89% on 2019 to 59% on 2020, resulting to a 30% difference, making Philippines as the top contributor in the decline of educational satisfaction [18]. And on the same year, mobile game users' statistics showed a 43 million rise of mobile game users in the Philippines, with 74% using mobile devices [89]. Thus, the rising number of learners who uses mobile phones and mobile game users affects the educational satisfaction of the learners in the Philippines. As Department of Education introduce Policy Guidelines in K to 12 Basic Education Program (DepEd Order No. 21 S. 2019)[deped.gov.ph/wp-content/uploads/DO_s2024_010.pdf], with a goal of having K to 12 graduates being globally competitive acquiring the different 21st century learning skills. Recently the Department of Education introduced a new curriculum called MATATAG. This curriculum aims to improve the K to 12 curricula by focusing more on the 21st century skills program particularly in communication skills, life and career skills, learning and innovation skills, and information, communication, and media technology skills (DePed Order No. 10, S. 2024). Prudencia D. Fule Memorial National High School (PDFMNHS) continued to find ways to establish these goals. However, in Information and Communications Technology (ICT), we experienced a constant low performance score on assembling computer hardware.

Gorman et al. (2022) states that virtual reality (VR) can engage learners and improve their practical skills. According to Krokos et al., (2019), learners who experience VR have better retention than those learners who just access learning through desktop or mobile instructions[49]. According to McClarty et al., (2012), digital

games are anchored on the principles of sound learning, provides room for assessment, personalized learning, and more engagement to learners, and teaches 21st century skills[60].

This study aims to use the technological advancement of mixed reality as a tool in enhancing creativity and critical thinking of learners.

Conceptual Framework

The use of mixed reality in education, especially in teaching information and communications technology was anchored on different learning theories. Such theories are the constructivist learning, situated learning, cognitive load, and experiential learning. The use of mixed reality helps learners to relate previous knowledge to that of existing ones (Huang et al., 2010). With this in thought, using the technological advancement of mobile phone technology and mixed reality applications, the way students learn could be developed enhancing both their creativity and critical thinking skills [38].

Another theory that supports the use of mixed reality in learning is the situated learning theory. According to Lave & Wenger (1991) learning could be obtained through constant repetition of an action, hence, supporting the idea of using mixed reality as an application in practicing and enhancing their skills in ICT[5].

The use of mixed reality was also supported by the cognitive load theory. Under cognitive load theory, defined by Sweller (1988), that to maximize learning of an individual, an overload of information should be avoided. Overloading of concepts and ideas being taught to learners could lead to not understanding the topic being discussed. To lessen the discussion of concepts and ideas, other forms of instructions such as the use of technology could be used [70].

Working with mixed reality in education as a part of instruction builds a new experience for learners for which they could learn by doing a task [48]. According to Kolb (2014), learning through experiences undergoes to a 4-stage process, these processes are concrete learning, reflective observation, abstract conceptualization, and active experimentation. Integrating new concepts and using mixed reality as a tool in enhancing creativity and critical thinking was highly supported by Kolb's experiential learning theory.[47].

A study of Cipresso, Giglioli, Raya and Riva (2018) show that although mixed reality is defined differently by research, it highlights the use of three common factors, immersive quality, presence in the computer-generated environment, and interactivity on the task[17].

Runco and Jaeger (2012), states that the standard definition of creativity is both novel (original and fluent) and flexible[76]. According to Bloom et al. (1956) that critical thinking can be classified into three categories, this involves analyzing, synthesizing, and evaluating [44].

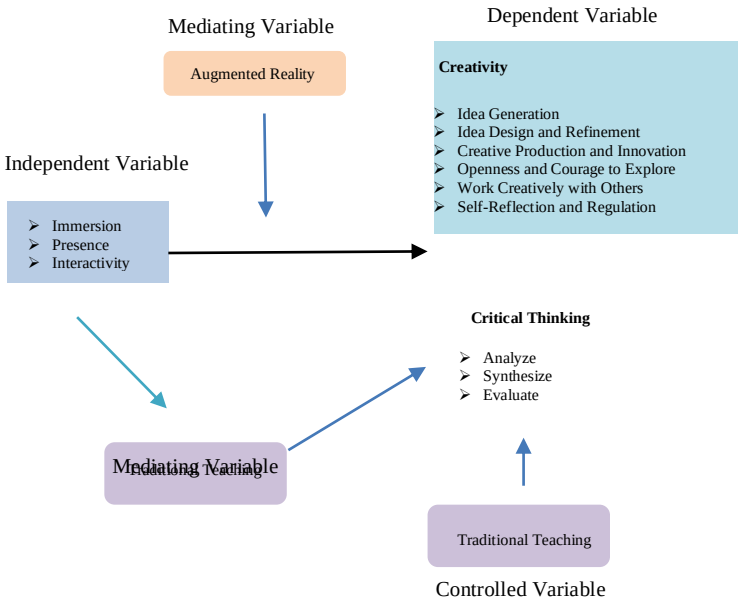

Fig.1 Conceptual Framework

Statement of the Problem

This study attempted to determine the impact of mixed reality as a learners training ground on enhancing creativity and critical thinking of Grade 9 students of Prudencia D. Fule Memorial National High School.

Specifically, it aimed to answer the following questions:

1. How do the respondents perceive the application of mixed reality as to:

1.1 immersion;

1.2 presence; and

1.3 interactivity?

2. What is the pretest and posttest level of students' creativity in the controlled and experimental group in terms of:

2.1 idea generation;

2.2 idea design and refinement;

2.3 creative production and innovation;

2.4 openness and courage to explore;

2.5 work creatively with others; and

2.6 self-regulation and reflection?

3. What is the pre-test and post-test level of students' critical thinking in the controlled and experimental group in terms of:

3.1 analyzing;

3.2 synthesizing; and

3.3 evaluating?

4. Is there any significant change between the pretest and posttest levels of creativity of the students in the controlled group?

5. Is there any significant change between the pretest and posttest levels of creativity of the students in the experimental group?

6. Is there any significant change between the pretest and posttest levels of critical thinking of the students in the controlled group?

7. Is there any significant change between the pretest and posttest levels of critical thinking of the students in the experimental group?

8. Is there any significant difference in the pretest levels of creativity and critical thinking between the students in the controlled and experimental groups?

9. Is there any significant difference in the posttest levels of creativity and critical thinking between the students in the controlled and experimental groups?

Research Hypotheses

The study posited the following hypotheses:

1. There is no significant change between the pretest and posttest levels of creativity of the students in the controlled group.

2. There is no significant change between the pretest and posttest levels of creativity of the students in the experimental group.

3. There is no significant change between the pretest and posttest levels of critical thinking of the students in the controlled group.

4. There is no significant change between the pretest and posttest levels of critical thinking of the students in the experimental group.

5. There is no significant difference between the pretest levels of creativity and critical thinking between the students in the controlled and experimental group.

6. There is no significant difference between the posttest levels of creativity and critical thinking between the students in the controlled and experimental group.

Significance of the study

The researcher hoped that the findings of the study would be beneficial for the following:

To the learning resource personnel. The study, if proven effective, could be used as an innovative tool and can be integrated into crafting localized materials intended to develop the 21st century learning skills specifically in creativity and critical thinking.

To the teachers. The study could be used as an instructional approach when classes are shifted to alternative delivery mode.

To the learners. The study would engage learners to develop their skills in computer assembly without the fear of any uncertain outcomes.

To future researchers. This study could be used as a basis for future researchers to craft new innovative tools that would enhance the teaching and learning process.

Scope and limitation of the Study

This study focused on creativity in terms of idea generation, idea design and refinement, creative production and innovation, openness and courage to explore, working creatively with others, self-regulation and reflection; and critical thinking in terms of analyzing, synthesizing, and evaluating.

This study was limited to Grade 9 learners of Prudencia D. Fule Memorial National High School who specialized in information and communications technology.

Definition of Terms

Creativity. The ability to create new ways with existing concepts under different modifications.

Creative Production. This refers to the ability of the learner to apply the flow of ideas into action.

Critical Thinking. The ability to think beyond, creates new ideas from existing knowledge.

Courage to Explore. This refers to the learners' ability to do a task new to them.

Immersion. This refers to the ability of mobile phone applications to engage learners.

Interactivity. This refers to the ability of mobile phone applications to interact with learners and engage them in a scenario where they could imagine they were being given instructions.

Idea Generation. This refers to generating creative ideas that are flexible and adoptive.

Idea Refinement. This refers to the ability to select generated creative ideas and hone its concept trimming it down to make it suitable for a certain scenario.

Idea Design. This refers to the ability to connect generated ideas, making a smooth flow of concept.

Innovation. This refers to new ideas/concepts that can be applied in education that could improve the learning process.

Mixed Reality. Refers to the use of mobile phone applications as an innovative tool in the learning process.

Openness. This refers to the ability of the learner to accept new ideas/concepts.

Presence. This refers to the ability of mobile phone applications to engage learners and imagine that they are in the virtual environment they engage in.

Self-Regulation. This refers to the learners' ability of not being afraid to make mistakes but learn from it.

LITERATURE REVIEW

Various related literature and studies on which this research is based will be reviewed. This chapter contains a collection of concepts and studies from which the research will be conducted, as well as insights that will keep this research project on track. This chapter emphasizes the diverse experience in using virtual reality, and the importance of creativity and critical thinking skills.

Mixed Reality

Virtual reality (VR) has become a major technical development that is transforming several industries, including training simulations, gaming, healthcare, and education.

The use of VR has been increasingly adopted in educational settings, where it offers immersive learning experiences. According to Mikropoulos and Natsis (2011), VR can simulate real-world scenarios, making complex subjects more accessible and engaging for students. For instance, medical students can practice surgical procedures in a risk-free environment, leading to better preparedness for real-life situations [80]. According to Burdea (2024) VR is a simulation by which it creates a new world that responds to the user's needs, this technology provides a three-dimensional experience with the use of different devices like head mounted displays (HMDs), headphones, and different navigational devices [10][54]. The use of different technological advancements in education is not a new concept [35]. Due to this concept, education together with technology develops together, and adapts to each other.

Mixed reality (MR) is defined by many authors. According to Gobettie & Scatenie (1998), virtual reality is not just the interaction in a computer-generated 3D world, it also needs presence to simulate, it allows users to perform tasks on a virtual environment[32]. Latta and Oberg (1994) defined VR as environments that are created and experienced, wherein its main goal is to immerse the participant in a setting that they would not normally experience[52]. This goal is achieved by establishing a connection between the user and the designed environment. According to Prothero (1994) VR can boost users' different senses, this technology can serve as a sensory stimulus that develops all other senses. With virtual environments, the technological advancement of VR far more stretches and continuously being developed[59].

Due to different capabilities of virtual environment and other factors such as the cost of production, different

forms of virtual reality were created, such as these forms are extended reality (XR), augmented reality (AR) and mixed reality (MR) [10]. Mixed reality is the use of mobile phone applications that respond to real-world situations without the use of HMDs [32]. Mixed reality offers users to experience virtual environments without the risk of a higher cost, for it promotes the use of mobile phone applications [12].

A transformational technology that seems poised to revolutionize the education field is augmented reality. Change in Classroom Environment Numerous research have studied on the maturity of MR use within educational environment for many ways to equipped students, enhanced learning outcome and better immerse experience as it combines virtual elements with physical reality [82]. For example, one systematic mapping review has shown that the use of AR in STEM learning strand can improve students' perception about concepts as well as collaboration and communication, as well as problem-solving skills. [65]. The present review demonstrates the diverse benefits of AR for educational applications, but a closer examination indicates that many research questions are yet to be addressed.

Both reviews of the educational uses and benefits augmented reality in education point towards a growing recognition among educators about AR's potential to improve teaching and learning process across many subject areas. As an example, studies have shown AR-based learning materials to improve students' understandings of complex scientific concepts (MHGSCI), such as molecular structures and anatomical systems by providing the possibility to visualize and interact with three-dimensional digital models in real time. In addition, the general agreement among researchers is that AR has a unique fit in mathematics education [30] enable students to handle virtual shapes and manipulate mathematical elements through dynamic and interactive manner where they can have deeper understanding of mathematical topics [32]. Furthermore, AR can be used not only in the STEM disciplines but also, research shows that it is applicable across all other fields such as humanities and social sciences where students could experience ancient historical sites or archaeological excavations through an augmented reality environment [39].

The existing literature reveals a generally positive point of view for AR educational potentials, but it is essential to recognize the subtleties and dynamics present in AR-aid integration in learning spaces. While some works have warned that the mere integration of AR does not translate per se into better learning results, and critical dimensions should be taken into account regarding design and implementation considerations for the use of AR in educational contexts to guarantee their pedagogically effectiveness [82]. In addition, there are several challenges regarding the implementation of AR in a broadened context with schools' time and some strategic solutions to promote this type of technology adoption [31]. An example is about technological constraints, logistical problems or even teacher training/support can be mentioned as barriers not elucidated concerning an understanding.

Beyond that, to cultivate the growth of AR in education research limitations must be ameliorated and opportunities should be identified for drawing-out new potential applications. Through further investigating how AR affects student learning and engagement, scholars can develop derived evidence-based frameworks that report on the effective uses of this ground-breaking edtech across a range of educational contexts which will extend our understanding to facilitate optimal teaching opportunities for e-learning and blended learning education through noticing: Learning Process; Classroom Practice & Curriculum Implementation.

LaValle (2023) stated that the main goal of augmented reality is to create a new experience through presence, immersion, and interactivity. Users of virtual reality are far more likely to be engaged, and pay attention to details [33]. According to Chen (2009), using any form of virtual reality creates a tremendous experience for learners, for virtual reality renders a non-existing environment and immerses learners through it. This helps learners simulate and is used most of the time especially in practicing and mastering a skill [14]. Merchant et al. (2014) stated that virtual reality is an effective innovation in the teaching and learning process, this helps learners to improve their outputs [63]. The technological advancement of VR shows a positive outcome experience, especially in education [61]. In education, augmented reality has been making headlines for a while now because of the transformation it is bringing to the learning processes. Augmented Reality when incorporated in the education sector can offer a lot- starting from better visualization and understanding of difficult concepts, to enhanced motivation & engagement level amongst learners [1].

An important benefit of using AR in the education field is that it can provide better and interactive learning environments. Once digital content such as 3D models, animations or interactive simulations created over physical space it empowers the students to learn in a much profound way. This is especially useful for fields such as science where the ability to interact with prototypes of structures can greatly enhance a student's comprehension, or engineering which needs some degrees of solving dynamic and time-dependent problems [65].

Augmented reality could, furthermore, provide the setting for better spatial awareness and problem-solving abilities. Augmented reality allows students to manipulate virtual objects and interact with the space around them in novel ways, helping facilitate problem solving skills along with an increased aptitude for applying these concepts within real world environments. Augmented reality in education also leads to more active engagement and motivation levels among students.

The current review produces AR for learning in creating an interactive visual and attention capture environment besides student interaction [39], which explodes the teacher-student remote room confines to be indeed a holodeck.

While the introduction to augmented reality in education is exciting, there are also various hurdles and best practices that should be considered. To implement AR more successfully, careful planning is needed in terms of infrastructure development and the teacher education that needs a bit improvement or training for better integration on classroom level so as students could learn it with maximum benefit.

Augmented Reality has a variety of benefits in education that could be transformative for the students attending lessons. A key advantage of MR is to provide improved visualization for abstract topics as students can visualize and manipulate digital content in a more concrete way with an increased ability to interact [85]. These are very helpful, especially in fields like architecture, engineering and science where AR allows for interactive learning.

Augmented Reality can also promote shared learning experiences because students explore virtual objects and simulations with each other. This collaboration also nurtures important teamwork, conversational skills and problem-solving abilities which are primary to the development of their students. Over the years, AR has been deployed in multiple sectors under education proving its adaptable and powerful nature. In medical education, AR has been developed to improve the understanding of complex anatomy by visualizing digital 3D models that can be manipulated and viewed spatially via recorded images or a user-controlled display. In the field of sciences, AR can also be used to Creating little scientific experiments which yields a safer and dynamical learning experience [82].

One possible new application of AR in education is for learning in STEM [65]. AR has created tools to assist students in visualizing otherwise difficult scientific topics like the molecular structure, forces and energy systems. Hence, the capability of using mixed reality as an educational tool in enhancing certain skills of students are limitless and could be done across learning areas.

Creativity

Creativity is an important skill one must have, this will help them to adapt in the rapidly changing world of globalization, and technology, promoting digitalization [56]. According to Kulmaminov and Mukhtarova (2023), an individual with a creative mind develops different skills and performs tasks that even a machine cannot. Nurturing creative thinking helps us to be above and more important than an automated machine in doing a work [50]. According to Simonton (2012), creativity is the product of originality and appropriateness, if neither originality nor appropriateness is present, then there is no creativity [42]. According to Gafour & Gafour (2020), creativity is finding different solutions to a problem, meeting follow-up problems, and finding new ways to solve it, that implies acquiring new knowledge and overwriting it. The capability of developing creativity in oneself is limitless and boundless, helping us to adapt in a changing environment.

Creativity is a multidimensional, complex phenomenon that has been studied from multiple disciplinary

perspectives. Fundamentally, creativity consists of being able to conceptualize an idea and then bring that concept into reality through rendering art, enabling a scientific breakthrough or developing inventive solutions for the enchanting complexities in life. Of course, the function that creativity serves in how we develop as individuals is one thing, but then it also has a strong bearing on our professional and social lives too (Lucendo, 2009).

It is also human creativity that differentiates us, design tools and utilize them as well search for a solution every problem. Today, creativity and its output — innovation—rise to the top of lists as one of the most outstanding predictors for economic progress right next to or ahead investments. The earlier creative skills are developed in childhood because it helps to prepare the child for a world that continues to expand, complicate and globalize (Newton & Newton, 2014).

Recent research has demonstrated the importance of creativity to all sorts of different cognitive and emotional abilities, like critical thinking, emotional intelligence, and problem-based skills (Kind & Kind, 2007). Creative activities that encourage children to observe, research and interact with their environment can foster the development of these skills which as well-established in scientific literature are the basis for success both at school and at work (Lucendo, 2009). Moreover, developing creativity is not just for the young; it serves an individual well throughout his/her life.

The role of creativity in personal growth is only part of the story, for it also pertains to our overall happiness and well-being — as human beings. Light: Research has shown that engaging in creative activities can alleviate stress, elevate mood, and heighten of feelings of accomplishment and self-worth so it makes sense to bring creativity while we are shut off from our usual routine. In a nutshell, creativity provides necessary capital to express oneself deeply, explore passions outwardly and comes with the possibility of indulging in existential derivatives that together feed into personal growth as well overall wellbeing (Glăveanu et al., 2013).

Creativity is considered an important skill in educational curriculum, and a notable academic talent in school (Craft, 2005). According to Moran 2010, creativity enhances learners' capability to think in multiple ways. With the different outcomes that could be produced with creativity, a way to teach it, and promote it is always hard for educators. Various creative theorists draft a way to promote and educate learners. This also includes various trainings and workshops, as well to evaluate the level of creativity of a learner, however in education, according to Kim (2011), there is still a crisis in the development of creative thinking exists (Kaplan, 2019).

Creativity is an important part of being human and one which school's need to master above all else. Since authorities understood that creativity could be developed and taught way back when, there has been an emphasis on the need to not just teach creatively but more importantly to teach for creative. Allowing creativity in the classroom will encourage students to be problem solvers, think differently and take risks with coming up with out of the box answers. Several studies have found that creativity is important across a wide range of spheres, from science to arts and that it can help us with everyday problem-solving. If teachers resort to innovative ways of teaching, then the results seen in student achievement will rise dramatically as well due to creative nimble thinking and more motivated students doing better [28]. On the other hand, teacher perspective can hinder creativity in teaching when teachers may be unwilling to break away from traditional ways of educating [79].

As the landscape of schooling changes and leaves one question burning in most educators' minds is how to teach creativity within an environment that only values productivity. This ability to innovate and grow personally (achieved by creativity) is one of the primary values that many hold in high regards, however; it has been difficult grasping this pillar — especially through an academic scope.

One of the main challenges for creativity and schools is the focus on standardized testing, convergent thinking. The high-stakes nature of these assessments may create a learning environment that tends to favor cramming and proficiency over creativity, which can be at odds with the more divergent thinking and calculated risks necessary for creative outlets. In addition, research indicates that most elementary-school teachers are not teaching creative practices [37]. In personal or professional growth, creativity and thinking outside of the box is a major leverage point verse challenges with fresh eyes. Although, majority of us do not really get to

enhance our crafting skills and talents as we might feel suffocated by life or may also believe that they are probably not creative.

The relationship between creativity and adversity is multifaceted [27], with some evidence suggesting that creative people are more vulnerable to emotional pain and trauma. Simultaneously, research suggests that creativity can be used as a powerful vehicle for making sense of and reshaping challenging experiences to generate personal growth and fortitude. Creative practices also, through helping the individual access traumatic memories to metabolize and release them, lead on retrospectively suggest facilitation of healing [84].

Creativity should be cultivated with a mindful and engaged way of life. This will lead you to be much more mindful, which is the practice of being present and aware in that moment quieting your inner critic while allowing yourself access to all different ideas already rooted within. Furthermore, "honing", or the act of intentionally training and refining a creative ability can sharpen an individual's craft to ensure creativity flourishes with exceptional skill [27].

A third consideration in the understanding of creativity is that environment also plays a part. Some research suggests creative people need a supportive, agentic culture characterized by diversity of thought and tolerance for risk taking, as well as collaboration [27]. Educational institutions and workplaces can empower people to develop their own creative potential, one answer might be by turning creativity into something that is possible for everyone; this would enable them to work in environments they are all destined to contribute with innovative answers through creating a creative ecosystem.

In the end, developing creativity is a combination of individual and systemic elements. Through practicing mindfulness, sharpening their creativity skills and surrounding themselves with the right ingredients for success, individuals can capture some of those fruits when they unleash their creative flame in either personal or professional settings.

With the recent results of the 2022 Programme for International Student Assessment (PISA), Philippines placed at the bottom of 64 countries when it comes to creative thinking abilities and with only an average score of 14 which does not even come close to the standard average of PISA which is 33 [15]. According to the survey conducted by the Organization for Economic Cooperation and Development (OECD) during the same year before learners took the test, various pedagogies and strategies were given by educators, a result of an average of 83 - 86% when it comes to teacher related pedagogies and strategies which comes higher to the OECD average of 63 – 70%. Students also has access to digital tools, art galleries, and computer programming, However, the survey also shows that 40% of Filipino learners spend more time on accessing digital tools due different leisure activities such as mobile games and other applications which is a little higher for the set OECD average of 35%. Spending more time with digital leisure activities decreases the learner’s ability in developing creative thinking skills [69].

The Department of Education addresses the problem with the rank of the Philippines with the use of the Matatag Curriculum. This curriculum highlighted the different areas in need of improvement, like reading, mathematical computations, science and computer literacy. This curriculum also highlights the development of learners’ 21st century skills especially in creative and critical thinking of learners (DePed Order no. 10, s. 2024).

Critical Thinking

Different studies argued that the application of critical thinking in education is in need, some government agencies stated that to establish a good nation is to produce citizens that is capable of making good decisions, and can think for themselves [72]. Though some contradicts that critical thinking skills require good decision making, Enciso et al. (2017), stated that the importance of such skills is in need in many aspects of life not only in education. This idea pushes educational institutions to promote and continually develop critical thinking skills among learners.

In this digitized global age where things are changing overnight, the need for critical thinking to learn and

flourish is high. Critical thinking is described as the ability to evaluate information objectively and think clearly on one side or it is an essential skill that supports both individual success and national performance.

Critical thinking is an essential part of education because it provides students with tools to solve complex problems, challenge assumptions and make decisions based on available evidence. A 1972 survey conducted by the American Council on Education (ACP) resulted in a report concerning student development which listed among its basic questions using the data gathered from over 40,000 faculty members, representing institutions of both lower and upper division-only enrollments, ninety-seven percent considered that the thinking ability is the most important outcome of undergraduate education for students [93]. This renewed focus on critical thinking combats the consensus that people who can think critically are more qualified to face the complexities of life in an age largely defined by globalization.

It is a central workshop for own betterment and the key to handling some of society's most urgent problems — because every person must make their self-interest subordinate. Increasingly, there is also a demand for the development of critical thinking tools in students as it aids them to address complex problems and think critically so that they can ask valid questions and take well-informed decisions.

Recent study reveals that most of the faculty believe critical thinking competency is one key goal in undergraduate education [71]. As they faced complex problems and the more, they think critically in their education, the better prepared kids of today are to become critical thinkers. As Kettler (2014) pointed out that "communications skill have been touted as paramount with the changing face of higher education" and elite liberal arts are no longer proving ground for desirable skills but imperative competence needed start living in this century [45].

Despite this, the development of critical thinking skills has not always been a priority in educational systems — especially under some cultural contexts. For instance, in China some have even claimed that a model of education fixated on memorization and exam-based learning compromises 'critical thinking' as well for university students. The slippage between how we educate students and our actual practices of fostering critical thinking speak to the inadequacy of education in preparing young adults for life after formal learning.

Realizing the importance of critical thinking, educational institutions and policymakers are mandating to teach this skill in every curriculum [45]. The Partnership for 21st Century Skills, a key advocacy organization that has called for critical thinking and problem-solving skills to be integrated across all content areas. This move is suggestive of the recognition that critical thinking cannot be thought of as only a discrete skill but rather, it should be considered one among others in a developmental trajectory across disciplines.

Critical thinking is an essential part of education. In an increasingly messy world, it is no longer enough to follow directions, students of all ages face complex problems where they must think critically, challenge assumptions and decide rationally for themselves or society at large to succeed. Empowering students to make decisions and face real-world issues, as well being able to synthesize information from various sources equips them the necessary skill sets, they need not just in achieving a degree but also when becomes time for each one of us can contribute positively towards our communities and world at large.

Critical thinking skills are defined differently by many authors, this depends on how they use such skills in life [21]. McPeck (2016) defined critical thinking as thinking about something, for critical thinking has some unique behavior[62]. According to Butler (2024), enhanced critical thinking skills doesn’t mean having a good life full of wise decisions, or not being influenced by bad advice, but it does guarantee to save us in negative scenarios [11]. According to Lai (2011), critical thinking requires skills in analyzing, decision-making, judgement and evaluating, for critical thinking not only requires cognitive aspect but also character [51]. However, according to Anggraeni et al. (2023), critical thinking is a way one thinks rationally, deciding what to believe in and understanding the task to be done[4]. The way different studies define critical thinking depends on how they treat such skills. One may treat this skill deeper or not, this does not extinguish the importance of critical thinking skills and developing it through education [21].

In the face of a more complex world, people need to be able to take in information and analyze it for what the

arguments are worth as they make decisions [45].

The need for critical thinking is also recognized by pedagogues and policy makers as central to the skills required in education today [45]. These are skills which require the coordination of many cognitive functions: perception, analysis, logic, judgment and choice [19]. People who possess strong critical thinking skills are far more able to wade through the murk of modern life — from understanding thorny societal issues to making informed decisions about their personal and professional lives.

These studies support the view that critical thinking is proved crucial in the research conducted. A study by one group argues that students to be having these skills are going to deal with the increasing complex life and work environments of the 21st century [41]. This study further highlights the relationship between critical thinking skills and higher order cognitive functions that may have notable impact on economic and social outcomes [25].

Besides that, there is more than one way to develop critical thinking skills, and it is not limited to a formal set of education. One uses critical thinking when faced with a problem, evaluating an argument, or making a decision. Through the development of these skills, people can strengthen their capacity to think for themselves and question all assumptions to make good decisions by which we may live.

The development of critical thinking skills starts at home, and continues at any place, especially in educational institutions. However, there is such difficulty in teaching critical thinking skills because for such skills to prosper needs continues exposure, practice, and continuous feedback [36]. Alsaleh (2020) stated that there are several teaching strategies to enhance critical thinking skills of students such as collaborative learning, discussion method, and the use of technology [3]. Furthermore, with direct instruction given to learners, they can enhance their critical thinking with different instructions such as web-based teaching, computer simulation, and drills computer applications.

Raj et al (2022) stated that the inquiry, evaluation, interpretation, and synthesis of knowledge, as well as the application of creative thinking to problems and questions, are the greatest ways for students to develop their critical thinking abilities [75].

RESEARCH METHODOLOGY

This chapter discusses the methods and procedures to be used in this study. Specifically, this includes research design, subject of the study, and determination of sampling technique, research instrument, research procedure, and statistical treatment of data.

Research Design

This research used a quasi-experimental design. A quasi-experiment is a prospective or retrospective study in which groups are divided into controlled or experimental groups to compare the effectiveness of the tool. Quasi-experiments are observational studies that share many characteristics with randomized controlled trials (RCTs), with the main distinction being that respondents self-select into various treatments rather than being randomly assigned to them [58].

Respondents of the Study

This study focused on students in Grade 9 at Prudencia D. Fule Memorial National High School (PDFMNHS) in Brgy. San Nicolas, San Pablo City Laguna for school year 2023-2024. In this study, there were two sections, and each section consisted of forty (40) students since they are heterogeneous. Students at the said school were composed of different barangays because of the four catchment areas including Brgy. San Benito, Brgy. San Nicolas, Brgy. San Rafael, Brgy. Sta. Monica, and Brgy. San Roque exhibits diverse cultures. The sample size was chosen based on the availability of the class that is tackling ICT as their specialization in Grade 9. The respondents were chosen due to limited availability of respondents in the said specialization.

Sampling Technique

No sampling technique was used. All Grade 9 learners of Prudencia D. Fule Memorial National High School specialized in ICT had 2 sections having students come from different barangays since they were heterogenous sections.

Research Instrument

The researcher used a survey questionnaire, a pretest and posttest, and a performance activity. The researcher used an existing mobile application that focuses on the competency in the curriculum guide competencies for junior high school students which is relating to modifications of computer systems.

The pretest and post-test are research-made questionnaires that include the three domains of critical thinking skills, these include analyzing, synthesizing, and evaluating. The questionnaire is a 2-point questionnaire wherein it includes the best answer and reasoning. Creativity will be measured through a performance activity and will be scored thru a rubric that was adopted from Windyariani & Setiono (2024)[93].

The survey questionnaire is adapted from the works of different authors. The questionnaire would use a 7-point likert scale to rate the experience of the learner while engaged in the mobile phone application.

Validation of the Instruments

The researcher forwarded it to the thesis adviser for additional refinement and finalization to ensure the accuracy and quality of the instruments, including Master Teachers from the school, and test validators from Laguna State Polytechnic University – San Pablo City Campus.

Research Procedure

Conceptualization. After extensive discussions with the research adviser, an idea for the subject was developed and submitted to the dean's office for approval. For the manuscript's quality and relevance to our current circumstances, it was assessed by several panel specialists. Suggestions and other adjustments were generally incorporated before the study started.

Implementation. After the experts approved the research tools, the researcher wrote a letter to the panels and dean requesting permission to conduct the study. The researcher sent the school principal and public schools division supervisor with a request letter and consent to conduct the study. The researcher followed the necessary procedures after receiving the public school’s division supervisor and school principal's endorsement and approval.

Data Analysis. Upon completing the week intended for the study. All necessary information and resources were gathered by the researcher. The statistician received the researcher's condensed data and provided it for analysis. When the results were presented to the statistician for evaluation, the researcher organized the tables to help the statistician better comprehend the primary focus of the study.

Statistical Treatment of Data

Various statistical treatments of data were used to assess the impact of mixed reality on the creative and critical thinking skills of learners. Mean and standard deviation were used to identify the level of the learners’ interests before and after the traditional teaching in the controlled group and after the use of mixed reality in the experimental group. Frequency and percentage were employed to determine the level of mastery of creativity and critical thinking of the students in the controlled and experimental groups before and after the use of mixed reality. And independent t-test was used to determine the significant difference in the students’ level of creativity and critical thinking skills before and after the use of mixed reality.

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter shows the result of the study findings based on the respondents' response. The findings are presented in tables followed by interpretation and discussion according to the purpose of the study reflected on the specific questions under the problem statement.

Table 1 Respondents Perception On The Application Of Mixed Reality In Terms Of Immersion

	Mean	**SD**	**Verbal Interpretation**
To what extent did the game hold your attention?	6.22	0.73	Extremely Experienced
To what extent did you feel you were focused on the game?	6.38	0.71	Extremely Experienced
To what extent did you lose track of time?	6.38	0.67	Extremely Experienced
To what extent did you feel consciously aware of being in the real world whilst playing?	6.40	0.59	Extremely Experienced
To what extent did you forget about your everyday concerns?	6.30	0.76	Extremely Experienced
To what extent did you notice events taking place around you?	6.38	0.71	Extremely Experienced
To what extent did you feel that you were interacting with the game environment?	6.30	0.79	Extremely Experienced
To what extent did you feel as though you were separated from your real-world environment?	6.30	0.72	Extremely Experienced
To what extent did you feel that the game was something you were experiencing, rather than something you were just doing?	6.45	0.68	Extremely Experienced
To what extent was your sense of being in the game environment stronger than your sense of being in the real world?	6.38	0.67	Extremely Experienced
Overall	6.35	0.22	Extremely Experienced

Legend: 1.00-1.85 Not experienced at all, 1.86-2.71 Minimally experienced, 2.72-3.57 Slightly experienced, 3.58-4.43 Moderately experienced, 4.44-5.29 Experienced, 5.30-6.15 Highly Experienced, 6.16-7.00 Extremely Experienced

Table 1 shows the perception of the respondents in the experimental group on the use of Augmented Reality(AR) as a training ground in terms of immersion. The application got an overall mean score of 6.35 indicating most of the respondents extremely experienced immersive quality of MR. This suggests that the respondents perceive MR as highly engaging.

Table 2 Respondents Perception On The Application Of Mixed Reality In Terms Of Presence

	Mean	**SD**	**Verbal Interpretation**
How much were you able to control events?	6.40	0.63	Extremely Experienced
How responsive was the environment to actions that you initiated?	6.33	0.73	Extremely

			Experienced
How did the visual aspects of the environment involve you?	6.33	0.76	Extremely Experienced
How natural was the mechanism which controlled movement through the environment?	6.38	0.63	Extremely Experienced
How natural was your sense of objects moving through space?	6.38	0.63	Extremely Experienced
How compelling was your sense of objects moving through space?	6.58	0.55	Extremely Experienced
How much did your experiences in the virtual environment seem consistent with your real-world experiences?	6.53	0.55	Extremely Experienced
How closely were you able to examine objects?	6.50	0.51	Extremely Experienced
How involved were you in the virtual environment experience?	6.50	0.60	Extremely Experienced
How quickly did you adjust to the virtual environment experience?	6.38	0.67	Extremely Experienced
Overall	6.43	0.20	Extremely Experienced

Legend: 1.00-1.85 Not experienced at all, 1.86-2.71 Minimally experienced, 2.72-3.57 Slightly experienced, 3.58-4.43 Moderately experienced, 4.44-5.29 Experienced, 5.30-6.15 Highly Experienced, 6.16-7.00 Extremely Experienced

Table 2 shows the respondents perception in the experimental group on the use of Mixed Reality(MR) as a training ground in terms of presence. The application got an overall mean score of 6.43 indicating that most of the respondents extremely experienced the presence quality of MR by which majority of the learners in the experimental group perceived, in terms of presence, that MR is highly engaging and easy to be involved in the virtual environment.

Table 3 Respondents Perception On The Application Of Mixed Reality In Terms Of Interactivity

	Mean	**SD**	**Verbal Interpretation**
I felt that I had a lot of control over my game experience.	6.50	0.56	Extremely Experienced
I decided the kind of experience I get	6.47	0.51	Extremely Experienced
The game gives me the opportunity to respond in more than one way	6.55	0.50	Extremely Experienced
I feel attracted by the game and enjoy seeing the game	6.53	0.51	Extremely Experienced
The game provides an opportunity for me to give feedback	6.60	0.50	Extremely Experienced
Overall	6.53	0.22	Extremely Experienced

Legend: 1.00-1.85 Not experienced at all, 1.86-2.71 Minimally experienced, 2.72-3.57 Slightly experienced, 3.58-4.43 Moderately experienced, 4.44-5.29 Experienced, 5.30-6.15 Highly Experienced, 6.16-7.00 Extremely Experienced

Table 3 shows the perception of the respondents in the experimental group on the use of Mixed Reality(MR) as a training ground in terms of interactivity. The application got an overall mean score of 6.53 indicating most of the respondents extremely experienced the interactive feature of using MR. This suggests that majority of the respondents found MR as easy to navigate and very much user-friendly.

Table 4 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Creativity In Terms Of Idea Generation.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	1	2.5	-	-	9	22.5	Highly Mastered
7-8	2	5	7	17.5	4	10	14	35	Mastered
5-6	23	57.5	26	65	17	42.5	17	42.5	Nearly Mastered
3-4	14	35	6	15	14	35	-	-	Least Mastered
1-2	1	2.5	-	-	5	12.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 4 shows the pre-test and post-test scores of the respondents in the controlled and experimental group. In the controlled group, the data presented indicates that after being exposed to traditional teaching method, there is a slight increase in the post-test levels of the learners in creativity in terms of idea generation, but still majority of the respondents remain at nearly mastered category, hence, no increase in the overall mastery of the learner's creativity in terms of idea generation. While in the experimental group, the data shows that there is an increase in the posttest levels of the learners, and majority of the learner's showed mastery of the lesson in terms of generating ideas and concepts in the performance task. This also shows that majority of the learners in the experimental group managed to increase their mastery levels, while the learners in the controlled group cannot.

Table 5 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Creativity In Terms Of Idea Design And Refinement.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	7	17.5	Highly Mastered
7-8	3	7.5	7	17.5	4	10	16	40	Mastered
5-6	20	50	22	55	17	42.5	17	42.5	Nearly Mastered
3-4	14	35	11	27.5	14	35	-	-	Least Mastered
1-2	3	7.5	-	-	5	12.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 5 shows the pretest and posttest scores of the learners in the controlled and experimental group in creativity in terms of idea design and refinement. The data presented shows a 10% increase of the learners in the controlled group moved to mastered category and a decrease of 7.5% in the no mastery category, this shows that upon being exposed to traditional teaching, some of the learners in the controlled group managed to combine their ideas and strengthen it upon presentation, while majority of the learners still needs a little more time to enhance and combine their thoughts. While in experimental group, though 42.5% of the learners in the experimental group still need some time to practice combining their thoughts and presenting it fluently during performance task, still majority of the learners managed to combine their ideas into one and further strengthen their concepts upon presentation during the performance task.

Table 6 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Creativity In Terms Of Creative Production And Innovation.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	1	2.5	-	-	9	22.5	Highly Mastered
7-8	3	7.5	3	7.5	5	12.5	19	47.5	Mastered
5-6	17	42.5	21	52.5	20	50	11	27.5	Nearly Mastered
3-4	18	45	15	37.5	14	35	1	2.5	Least Mastered
1-2	2	5	-	-	1	2.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 6 shows the pretest and posttest scores of the learners in the controlled and experimental groups in terms of creative production and innovation. In the controlled group, though there is a slight increase in the learner's posttest scores, majority of the learners remained at nearly mastered category in creativity in terms of creative production measured through the way the learners performed in assembling and disassembling computers and innovation by executing new ways in performing assembling and disassembling computers. The learners in the controlled group normally sticked to the discussions provided by the teacher, while the learners in the experimental group, an increase in the learners' posttest scores and an increase in the mastery levels of the group could be noticed. The learners in the experimental group performed better in creativity in terms of creative production and trying new ways to perform the task given. The learners in the experimental group continued to try new ways to make the task given be performed easily and in an organized manner. Though few of the learners need a little more time to master creativity in terms of creative production and innovation, still majority of the learners belonging in the experimental group reached mastery or high mastery of creativity in terms of creative production and innovation.

Table 7 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Creativity In Terms Of Openness And Courage To Explore.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	2	5	2	5	1	2.5	14	35	Highly Mastered
7-8	1	2.5	8	20	5	12.5	18	45	Mastered
5-6	19	47.5	22	55	25	62.5	8	20	Nearly Mastered
3-4	18	45	8	20	9	22.5	-	-	Least Mastered
1-2	-	-	-	-	-	-	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 7 reveals an improvement in the learner's performance in both controlled and experimental groups in terms of openness and courage to explore. The learner's performance was measured through the way they communicate within their own group and courage to explore through the way each member of the group explores new things and not being afraid of trying. The learners in the controlled group showed an increase in their posttest scores in creativity in terms of openness and courage to explore, and an increase in their mastery levels, though an increase occurred on some learners, still majority of the learners in the controlled group

needed more time to master creativity in terms of openness and courage to explore since most of the learners nearly mastered or has less mastery of the lesson. While in the experimental group, an increase on both posttest scores and mastery levels could be observed. The learners in the experimental group portrayed better in communicating with each member of the group as reflected by their posttest scores. The learners also were not afraid to suggest and perform new ways for better organization and completeness of the task.

Table 8 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Creativity In Terms Of Working Creatively With Others.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	8	20	Highly Mastered
7-8	3	7.5	5	12.5	10	25	24	60	Mastered
5-6	18	45	23	57.5	16	40	6	15	Nearly Mastered
3-4	16	40	12	30	13	32.5	2	5	Least Mastered
1-2	3	7.5	-	-	1	2.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 8 shows the comparison between the pretest and posttest scores of the learners in the controlled and experimental groups in creativity in terms of working creatively with others. The learner's performance scores in creativity in terms of working creatively with others were measured through the way the learner contributes as a member of the group. In the controlled group, though a slight increase in the posttest scores could be observed, majority of the learners still were categorized as nearly mastered and least mastered, which suggests that learners need more time to contribute and work creatively as a member of the group. While in the experimental group, an increase in the posttest scores and level of mastery could be observed. The learners in the experimental group contribute as members of the group by suggesting creative ways that aid the group to complete the task easily. The learners also were engaged during the performance and keeps on cooperating within the group.

Table 9 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled Group In Creativity In Terms Of Self-Regulation And Reflection.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	6	15	Highly Mastered
7-8	2	5	3	7.5	8	20	19	47.5	Mastered
5-6	13	32.5	20	50	13	32.5	15	37.5	Nearly Mastered
3-4	17	42.5	17	42.5	16	40	-	-	Least Mastered
1-2	8	20	-	-	3	7.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 9 shows the comparison between the pretest and posttest scores of the learners in the controlled and the experimental group in creativity in terms of self-regulation and reflection. In the controlled group, the data showed an improvement, as all learners moved beyond the "No Mastery" level, with an increase in those

reaching the nearly mastered category (from 32.5% to 50%). The mastered category showed a slight increase of 2.5%. Although an improvement in the scores was observed, majority of the respondents were categorized as nearly mastered and least mastered. The learner's performance in creativity in terms of self-regulation and reflection were assessed through learners' behavior and the way they handled outcomes of their ideas. The learners in the controlled group, though some were able to increase their posttest scores, majority still need more time to adapt with the outcome of their ideas. While in the experimental group, learners were able to adapt to the outcome of their ideas as well as revised it to produce a better outcome.

Table 10 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Critical Thinking In Terms Of Analyzing.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	6	15	Highly Mastered
7-8	-	-	4	10	1	2.5	20	50	Mastered
5-6	19	47.5	19	47.5	18	45	11	27.5	Nearly Mastered
3-4	13	32.5	16	40	12	30	3	7.5	Least Mastered
1-2	8	20	1	2.5	9	22.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 10 shows the pretest and posttest scores and mastery level of the learners in the controlled and experimental group in critical thinking in terms of analyzing. The learners were assessed through a researcher-made test and the scores they provided by answering each item. In the controlled group, a minimal improvement in learners score could be observed, as the highly mastered category remains at 0% and a slight increase of 10% in mastered category. Majority of the respondents remained at nearly mastered category at 47.5%, and the least mastered category increased from 32.5% to 40%. This suggests that some learners improved their critical thinking skills in terms of analyzing, but most of the learners still consume more time to analyze. While learners in the experimental group showed an improvement on both of their posttest scores and mastery levels. The learners in the experimental group were able to analyze the questions and choose the answer that is best suited for the situation.

Table 11 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Critical Thinking In Terms Of Synthesizing.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	2	5	Highly Mastered
7-8	-	-	2	5	-	-	16	40	Mastered
5-6	9	22.5	12	30	10	25	18	45	Nearly Mastered
3-4	20	50	20	50	17	42.5	4	10	Least Mastered
1-2	11	27.5	6	15	13	32.5	-	-	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 11 shows the pretest and posttest scores of the learners in the controlled and experimental group in

critical thinking in terms of synthesizing. The learners were assessed through a researcher-made test in which some items need synthesis to get the correct answer. In the controlled group, there was a slight improvement in the learner's posttest scores, with 5% achieving the mastered level and an increase from 22.5% to 30% of nearly mastered level. However, majority of the respondents remained at least mastered and nearly mastered category indicating that more than half of the respondents are still struggling to synthesize the situation. While the learners in the experimental group showed an increase on both of their posttest scores and mastery levels in critical thinking in terms of synthesizing. Some of the learners were able to synthesize effectively the situation provided in the test. Though half of the class needs more time to synthesize situations as shown on their posttest mastery level, still an improvement could be observed since learners that belonged to no mastery was eliminated, and a decrease in the number of learners in the least mastered level, this suggests that even though learners could not master synthesizing, they were able to improve.

Table 12 Distribution Of Pre-Test And Post-Test Scores Of Respondents In The Controlled And Experimental Group In Critical Thinking In Terms Of Evaluating.

Scores	**Controlled**				**Experimental**				
	Pretest		**Posttest**		**Pretest**		**Posttest**		
	F	%	F	%	F	%	F	%	**Interpretation**
9-10	-	-	-	-	-	-	-	-	Highly Mastered
7-8	-	-	-	-	-	-	6	15	Mastered
5-6	-	-	3	7.5	-	-	22	55	Nearly Mastered
3-4	12	30	18	45	14	35	11	27.5	Least Mastered
1-2	28	70	19	47.5	26	65	1	2.5	No Mastery
Total	40	100	40	100	40	100	40	100	

Table 12 shows the pretest and posttest scores of the learners in the controlled and experimental group in critical thinking in terms of evaluating. The learners were assessed through a researcher-made test were some items need evaluating factor of critical thinking for the learners to answer. In the controlled group, no learners were able to achieve high mastery or mastery levels in their pretest and posttest scores. Though there was a slight increase of 7.5% in the nearly mastered category, majority of the respondent remained in the least mastered and no mastery category, with 47.5% still doesn't achieve improve their evaluating skills. While in the experimental group, six (6) of the learners were able to reach mastery levels of evaluating and majority of the learners still need more time to process the questions in terms of evaluating. Even though majority of the learners reached nearly mastered, or least mastered levels of proficiency, with having one (1) learner remained at no mastery, an improvement in the learners mastery level could be observed as shown by the huge decrease in the number of learners in the no and least mastery levels.

Table 13.Significant Change Between The Pre-Test And Post-Test Levels Of Creativity Of The Students In The Controlled Group.

Students' Creativity	**Pretest**		**Posttest**		**t-value**	**df**	**p-value**
	Mean	SD	Mean	SD			
Idea Generation	4.8	1.26	5.63	1.27	-7.33	39	< .001
Idea Design	4.65	1.49	5.42	1.26	-5.89	39	< .001
Creative Production	4.53	1.41	5.08	1.31	-4.87	39	< .001
Openness	4.75	1.45	5.58	1.45	-6.18	39	< .001

Work Creatively	4.55	1.47	5.1	1.17	-3.97	39	< .001
Self Regulation	3.73	1.58	4.78	1.29	-9.3	39	< .001

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 13 showed an improvement in all aspects of students' creativity, as shown by the higher post-test mean scores compared to pre-test scores across all categories. The t-values and p-values (< .001) suggest that improvements were significant and unlikely due to chance. Among the six (6) dimensions of creativity, self-regulation showed the most increase, while working creatively had the smallest improvement. After the pretest was conducted, the controlled group was exposed to traditional teaching methods and been exposed to an actual computer. Students in the group showed interest in the lesson, but depleted over time since there was lack of materials before and during the performance.

Table 14.Significant Change Between The Pre-Test And Post-Test Levels Of Creativity Of The Respondents In The Experimental Group.

students' creativity	**Pretest**		**Posttest**		**t-value**	**df**	**p-value**
	Mean	SD	Mean	SD			
Idea Generation	4.65	1.61	7.33	1.54	-14.02	39	< .001
Idea Design	4.67	1.61	7.08	1.38	-11.53	39	< .001
Creative Production	4.9	1.26	7.35	1.37	-12.11	39	< .001
Openness	5.42	1.34	7.8	1.34	-11.97	39	< .001
Work Creatively	5.33	1.53	7.45	1.41	-9.36	39	< .001
Self-Regulation	4.8	1.62	7.03	1.35	-11.25	39	< .001

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 14 presents significant improvement in students' creativity, as post-test mean scores are notably higher across all dimensions compared to pre-test scores. The negative t-values and p-values (< .001) suggest that the improvements observed are significant and not due to chance. Among the six (6) dimensions, openness and courage to explore has the highest post-test mean of 7.8. The students in the experimental group showed interest in the lesson that does not depleted over time, and has high levels of engagement The students were introduced to concepts and then exposed to mixed reality. The students also experienced seeing the actual computer parts.

Table 15significant Change Between The Pre-Test And Post-Test Levels Of Critical Thinking Of The Respondents In The Controlled Group.

critical thinking	**Pretest**		**Posttest**		**t-value**	**df**	**p-value**
	Mean	SD	Mean	SD			
Analyzing	4.55	1.57	5.3	1.4	-4.39	39	< .001

Synthesizing	3.85	1.53	4.5	1.55	-3.13	39	0.003
Evaluating	1.95	1.6	3.1	1.43	-5.72	39	< .001

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 15 shows improvement in students' critical thinking skills. The negative t-values and low p-values (< .05) indicate that the changes are significant. Among these three (3) dimensions, evaluating shows great improvement, while synthesizing showed the least, suggesting variations in the levels of progress in different critical thinking dimensions. The students took time to review the concepts introduced to them before taking up the posttest. Some students experienced confusion to some items specially in evaluating, and took most of the time in answering the posttest.

Table 16 significant Change Between The Pre-Test And Post-Test Levels Of Critical Thinking Of The Respondents In The Experimental Group.

critical thinking	**Pretest**		**Posttest**		**t-value**	**df**	**p-value**
	Mean	SD	Mean	SD			
Analyzing	4.55	1.69	7.45	1.63	-12.2	39	< .001
Synthesizing	3.85	1.53	6.8	1.49	-10.3	39	< .001
Evaluating	2.15	1.59	5.65	1.42	-11.9	39	< .001

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 16 reveals a notable improvement in students' critical thinking skills, with post-test scores higher than pre-test scores across all dimensions. The negative t-values and p-values (< .001) indicate that these gains are statistically significant. Among the three (3) dimensions, analyzing showed the highest post-test score of 7.45, while evaluating demonstrated remarkable growth. These data indicate an overall improvement in critical thinking skills in all dimensions. The students took time to review the concepts. The students in the experimental group showed lesser confusions in taking up the posttest. The students also finished the posttest in a much lesser time.

Table 17 Significant Difference Between The Pre-Test Levels Of Creativity And Critical Thinking Of The Respondents Between The Controlled And Experimental Group.

		Controlled		**Experimental**		**t-value**	**df**	**p-value**
		Mean	SD	Mean	SD			
Creativity	Idea Generation	4.8	1.26	4.65	1.61	0.463	78	0.644
	Idea Design	4.65	1.49	4.67	1.61	-0.072	78	0.943
	Creative Production	4.53	1.41	4.9	1.26	-1.254	78	0.214
	Openness	4.75	1.45	5.42	1.34	-2.168	78	0.033
	Work Creatively	4.55	1.47	5.33	1.53	-2.316	78	0.023
	Self-Regulation	3.73	1.58	4.8	1.62	-3.000	78	0.004

	Critical Thinking	Analyze	4.55	1.57	4.55	1.69	0	78	1
		Synthesize	3.85	1.53	3.85	1.53	0	78	1
		Evaluate	1.95	1.6	2.15	1.59	-0.560	78	0.577

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 17 shows the comparison of the pre-test scores in creativity and critical thinking skills between the controlled and experimental groups. Both groups scored equally in analyze and synthesize, while evaluate showed a slight but insignificant increase in the experimental group. In creativity, majority of the dimensions did not show significant differences except for openness and courage to explore (p = 0.033), work creatively (p = 0.023), and self-regulation (p = 0.004), where the experimental group performed better. The students in the controlled and experimental group showed no significant differences in the pretest levels in critical thinking, however in the three (3) dimensions of creativity specifically in openness and courage to explore, working creatively with others, and self-regulation and reflection, there is a significant difference. The students in the controlled group were composed of 40 students, by which some were newly transferred, while the students in the experimental group were composed of old students. The three (3) dimensions of creativity were anchored on socialization and team effort by which some students in the controlled group lacked due to new faces in the classroom.

Table 18 Significant Difference Between The Post-Test Levels Of Creativity And Critical Thinking Of The Respondents Between The Controlled And Experimental Group

		Controlled		**Experimental**		**t-value**	**df**	**p-value**
		Mean	SD	Mean	SD			
Creativity	Idea Generation	5.63	1.27	7.33	1.54	-5.37	78	< .001
	Idea Design	5.42	1.26	7.08	1.38	-5.58	78	< .001
	Creative Production	5.08	1.31	7.35	1.37	-7.6	78	< .001
	Openness	5.58	1.45	7.8	1.34	-7.12	78	< .001
	Work Creatively	5.1	1.17	7.45	1.41	-8.09	78	< .001
	Self-Regulation	4.78	1.29	7.03	1.35	-7.62	78	< .001
Critical Thinking	Analyze	5.3	1.4	7.45	1.63	-6.32	78	< .001
	Synthesize	4.5	1.55	6.8	1.49	-6.76	78	< .001
	Evaluate	3.1	1.43	5.65	1.42	-7.99	78	< .001

Legend:

p-value < 0.05 – Significant difference

p-value > 0.05 – No significant difference

Table 18 presents a comparison of the post-test scores between the controlled and experimental groups. Notable improvements in both creativity and critical thinking skills for the experimental group were observed. The negative t-values and p-values (< .001) across all dimensions suggest that the differences between the two groups are statistically significant and not by chance. In critical thinking, the experimental group achieved higher mean scores in terms of analyze (7.45 vs. 5.3), synthesize (6.8 vs. 4.5), and evaluate (5.65 vs. 3.1) in comparison with the mean scores of the controlled group, suggesting enhanced rational thinking and decision-making skills. Likewise, creativity performance scores were substantially greater in the experimental group in

all dimensions, with work creatively (7.45 vs. 5.1) and openness (7.8 vs. 5.58) with large improvements. The experimental group also excelled in self-regulation (7.03 vs. 4.78), indicating better control over their creative and critical thinking skills. The students in the controlled after being exposed to traditional teaching and experimental group after been exposed to mixed reality, showed significant differences in their posttest levels in all dimensions of creativity and critical thinking. Improvements on both creativity and critical thinking skills of the experimental group were observed, also the students have better central over their creative and critical thinking skills. Both the controlled and experimental group were a heterogeneous class of 40 students each with diverse cultures.

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the consolidation and summary of the conduct study, the conclusion formulated, and the recommendation offered based on the findings of the study.

Summary

This study dealt with using mixed reality as a learners' training ground in enhancing creativity and critical thinking skills.

This study aimed to answer the following questions: (1) How do the respondents perceive the application of mixed reality as to: immersion, presence, and interactivity? (2) What is the pretest and posttest level of students' creativity in the controlled and experimental group in terms of: idea generation, idea design and refinement, creative production and innovation, openness and courage to explore, work creatively with others, and self-regulation and reflection? (3) What is the pretest and posttest level of students' critical thinking in the controlled and experimental group in terms of: analyzing, synthesizing, and evaluating? (4) Is there any significant change between the pretest and posttest levels of creativity of the students in the controlled group? (5) Is there any significant difference between the pretest and posttest levels of creativity of the students in the experimental group? (6) Is there any significant difference between the pretest and posttest levels of critical thinking of the students in the controlled group? (7) Is there any significant difference between the pretest and posttest levels of critical thinking of the students in the experimental group? (8) Is there any significant difference in the pretest levels of creativity and critical thinking between the students in the controlled and experimental groups? and (9) Is there any significant difference in the posttest levels of creativity and critical thinking between the students in the controlled and experimental groups.

The study focused on the effectiveness of using mixed reality to improve creativity and critical thinking of the students. The research is Quasi – experimental research design.

The respondents consisted of 80 students that came from two Grade 9 classes (classified as controlled and experimental groups) with TLE specialization in ICT at Prudencia D. Fule Memorial National High School, Brgy. San Nicolas, San Pablo City, Laguna.

The instruments used were adapted from different authors, and a researcher-made test.

The study aimed to find out if there is a difference between the posttest scores of creativity and critical thinking between the students in the two groups, after exposing the experimental group in mixed reality.

Summary of Findings

1. Based on the data gathered, the students in the experimental group perceived the use of mixed reality in education as an application that would help them practice and enhance their creativity and critical thinking skills due to its immersive, presence, and interactive traits.

2. The results on the post-test levels of creativity in the controlled group compared with their pre-test levels, showed that after exposing the class in traditional teaching methods, only a few students improved their performance levels and majority of the class achieved a nearly mastered level in all dimensions of creativity. This suggests that further and more enhanced innovation is highly considered.

While the post-test levels of creativity in the experimental group showed that majority of the students achieved mastery and high mastery in their creative skills in all dimensions. The data also showed that students categorized in the least mastered and no mastery significantly improved.

3. The comparison between the pre-test and post-test levels of students critical thinking in the controlled group showed that though an increase in the proficiency level was observed, still majority of the students are categorized as least mastered, especially in terms of synthesizing and evaluating. This indicates that the method used was effective to a certain degree and still needed further intervention. While the post-test levels of the students critical thinking skills in the experimental group showed a large improvement in their proficiency levels. Even though the students critical thinking skills in terms of evaluating was categorized as nearly mastered, the improvement of the students in all dimensions could be greatly observed. This suggest that the intervention done by the experimental group affects their level of critical thinking skills.

4. There is a slight difference between the pre-test and post-test levels of creativity of the students in the controlled group. The highest increase in the average mean scores could be observed in self-regulation and reflection and at a slight increase in other dimensions of creativity. This suggests that even though an increase could be observed in the pre-test and post-test scores, further intervention could be given.

5. There is a significant change that could be observed in the pre-test and post-test levels of creativity of the students in the experimental group. There is a huge difference between the mean scores of the pre-test and post-test levels in all dimensions range between 2 to 3 mean scores, indicating that the intervention given to the students gave a huge impact to the students in enhancing their creativity skills.

6. There is a slight increase in the mean scores of the students critical thinking skills between their pre-test and post-test scores. This suggests that the intervention given to the students gave an improvement in a few students thus, making the increase in the mean scores between the pre-test and post-test significant.

7. There is a significant change between the pre-test and post-test level of critical thinking of the students in the experimental group that could be observed. Though the average mean score in evaluating is lower than other dimensions of critical thinking, it has a relatively high difference in comparison with its pre-test scores.

8. There is no significant difference in the pre-test levels of creativity and critical thinking between the students in the controlled and experimental groups. The data showed that though a difference could be observed in some dimensions of creativity, specifically in working creatively with others, Openness, and self-regulation. The significant change on those three(3) dimensions were due to some circumstances like number of transferred in students, strength of socialization in the classroom, and the length that they've been classmates.

9. There is a significant difference in the post-test levels of creativity and critical thinking between the students in the controlled and experimental groups, that could be seen in all dimensions. The relatively high difference between the post-test scores of the two groups suggests that the intervention given to the experimental group is much more effective than the controlled group.

Conclusions

With the summary of findings, the following hypotheses were concluded:

1. There is no significant change between the pre-test and post-test levels of creativity of the students in the controlled group, was not sustained.

2. There is no significant change between the pre-test and post-test levels of critical thinking of the students in the controlled group, was not sustained.

3. There is no significant change between the pre-test and post-test levels of creativity of the students in

the experimental group, was not sustained.

4. There is no significant change between the pre-test and post-test levels of critical thinking of the students in the experimental group, was not sustained.

5. There is no significant difference in the pre-test levels of creativity and critical thinking between the students in the controlled and experimental groups, was sustained.

6. There is no significant difference in the post-test levels of creativity and critical thinking between the students in the controlled and experimental group, was not sustained.

Recommendations

With the findings of the study, the following recommendations were perceived:

1. The use of mixed reality may be implemented in other grade levels since the respondents of the study is limited only to Grade 9 ICT students of Prudencia D. Fule Memorial National High School. Incorporating the use of mixed reality on other subjects and grade levels is highly recommended to test the effectiveness of mixed reality and further strengthen the study.

2. Teachers may try using their own developed application since the study only used an existing application created by Kingston.

3. This study may be used by future researchers to determine the extent of using mixed reality in education.

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