ACCEPTANCE OF AUGMENTED REALITY IN THE MEDICAL PROFESSION

Navin Kumar
Faculty of Business Finance, Information Technology, and Hospitality
MAHSA University, Malaysia
Email: farhazafira@mahsa.edu.my

ABSTRACT

The research shed light on augmented reality as a new platform for the diagnosis of patients in medical facilities. In the current context, AR is a costly diagnostic tool that enhances the doctor's and nurse's ability to perform operations and give medications. This research is aimed at finding whether AR technology will be accepted in the medical field in the coming years or not. The research proposes the main problems with conventional research and the benefits of using AR in medical facilities. The acceptance of AR in the medical profession is highlighted by understanding the perception of users through various theories and models. The research methodology to complete the research proposal is also highlighted in this study. In addition, the limitations of the study and the activities of the research are all presented to encourage further research in this field.

Key Words*:* AR. Augmented Reality, Diagnosis of Patients, Malaysia, Medical Profession

1. Introduction

Augmented reality involves developing a real-world environment by using virtual reality to interactive experiences for enhancing the learning process based on the purpose of better understanding. Medical professionals have adopted augmented reality for providing training to the medical staff for a clear and better understanding of computer-based technology and virtual reality. This study will address different dimensions of augmented reality and its impact on medical professionals, respectively. Analysis and evaluation of augmented reality for the purposes of Medical Science development is important for understanding the level of innovations used by Health Care officials. Moreover, it is important to understand the contribution of AR features in providing better customer service in order to cure diseases.

The proposal is going to address problem statements, research questions, research objectives, scope and significance, research design, literature review, research methodology and limitation of the study. As per Rahi (2017), problem statements will help to understand important issues associated with the acceptance of augmented reality by medical professionals and their associated consequences. Research questions are going to highlight important research areas by developing questions for identifying functional areas and research limitations. Research objectives will focus on representing research deliveries and focus areas. It will involve developing quality results and findings for contributing towards understanding consequences of augmented reality. Scope and significance will represent key elements and contributions of this research work for developing new information and knowledge towards augmented reality.

The scope and significance of the research are necessary for representing in-depth analysis of research contributions on the future development of research areas for understanding the importance of augmented reality in medical professionals. As mentioned by Pratt *et al*. (2018), the research design is involved with representing selected philosophy, research approaches and types of research methods for discussion and analysis of various variables. A literature review is associated with addressing concepts and characteristics of dependent and independent variables of the research work based on augmented reality. Research methodology is associated with presenting data collection and analysis methods that will be used in this study for developing potential findings. In addition, the limitation of the study is going to represent loopholes and outline of the research work.

2. Problem Statement

As augmented reality is associated with creating a virtual real-world environment by medical practitioners for learning diagnosis, the procedure of performing surgery, deliveries and order treatment activities has some major risks. According to the view of SL and Madhavan, (2018), the gap between the real and virtual world in the medical professions is a major problem that will be addressed in this research work. New AR innovations greatly help doctors and surgeons to understand the procedure and be able to conduct diagnosis and surgery activities but at the same time, it fails to represent possibilities of real-life issues. According to the view of Rauschnabel and Ro, (2016), the significant problem area associated with the adoption of augmented reality is that AR innovations are *hardware issues, limitation of content, absence of regulations, and loopholes of physical safety.*

Augmented reality adaptation by medical professionals has higher possibilities of hardware issues including a computer system, electricity and projector for representing different medical concepts during the discussion process. According to the view of Rauschnabel and Ro, (2016), the arrangement of all the needed hardware for discussing a particular treatment issue during an emergency period is a significant problem associated with implementing augmented reality in medical professionals. This process can negatively affect medical practices and has high chances of health issues. According to the view of Mather *et al.* (2017), another problem associated with augmented reality adaptation by medical professionals is ***a limitation of content***. Creating medical content for using augmented reality for discussion, study and promotion of medicine and treatment methods are very complex and extremely expensive. According to the view of Rauschnabel *et al.* (2016), the maintenance of budget for developing appropriate modeling of a virtual representation of the diagnosis process is high. The surgery process and treatment process required time and human labour as compared to traditional methods of discussing and teaching in medical history.

Another significant problem associated with the acceptance of augmented reality by medical professionals is the lack of appropriateness; it is an obligation and regulations for its excising and utilization. According to the view of Hsu *et al.* (2017), lack of appropriate regulations has the highest chances of creating complications and conflict among different medical professionals for using innovative AR processes during diagnosis and treatment procedures. On the other hand, the misuse of different modelling and content related to medical practices can create health issues for patients. As opined by Plotzky *et al*. (2020), virtual reality is unable to incorporate the actual feelings and duration of the treatment process for enhancing the treatment and diagnosis skills of medical professionals. The absence of proper legislation has higher possibilities of creating confusion and decreasing the skills of medical professionals as compared to traditional practical learning methods. According to the view of Dey *et al*. (2018), making a proper physical safety for practicing augmented reality process for surgical and diagnosis tutorials are major problem statements that will be focused on in the study.

3. Research Questions

Question 1: What are the ways to analyze the interactive experiences of evaluating new drugs through medical devices interact with the help of augmented reality technology?

Question 2: How disruptive technology is engaging with healthcare professionals by accepting augmented reality?

Question 3: What are the major complications and limitations of augmented reality in medical practices for treatment, surgeries and diagnosis?

Question 4: What are the recommendations for the proper installation of innovative augmented reality Healthcare organizations for improving medical practices?

4. Research Objectives

- To analyze the interactive experiences of evaluating new drugs through medical device interaction with the help of augmented reality technology
- To evaluate disruptive technology engaging with healthcare professionals by accepting augmented reality
- To evaluate major complications and limitations of augmented reality in medical practices for treatment, surgeries and diagnosis
- To develop a recommendation for proper installation of innovative augmented reality Healthcare organizations for improving medical practices

5. Scope of the Study

The analysis and evaluation of multiple dimensions of augmented reality based on medical practices and professionals have a wide range of scope for future implications and development. The following will be the potential scope of a study:

Understanding digital health technologies: One of the potential scopes of investigating different dimensions of augmented reality understands digital health technologies appropriately. According to the view of Zafar and Zachar, (2020), the study will generate opportunities for conducting in-depth research on promising digital health technologies identifying the challenges and advantages. Development of findings regarding the benefit of considering and accepting augmented reality by medical professionals can help in developing and improving future strategies for health care practices by medical organizations. As argued by López Belmonte *et al.* (2019), the study will clearly help to understand required

infrastructure as hardware, software and innovative technologies for adopting augmented reality as modern digital health technologies.

Identification of potential benefit of augmented reality: Another significant scope of this research work is the identification of the potential benefit of augmented reality. Evaluating the benefit of augmented reality in improving the diagnosis process, reminding medications of different persons, treatment and surgeries guidelines will help to create a study area for further research work (Silva *et al.* 2017). Moreover, this research work will generate scope for conducting micro-level research work of implementing augmented reality for curing different types of diseases and improving nursing practices. According to the view of Barsom *et al.* (2016), these activities will help to bring new evaluations on medications and the treatment process of Health Care services and contribute towards human development to a great extent.

Understand the trends of Health Care development: This research work will develop a potential scope of understanding modern trends of Healthcare development by incorporating ***Artificial Intelligence*** and modern technologies. According to the view of Barsom *et al.* (2016), it will help to evaluate new techniques of interactive experiences regarding the impact of different drugs and interaction of medical devices on the human body. In addition, this will generate a new scope of conducting research on the impact of augmented reality in drug doses and medical devices' implications on different persons. As per the view of Pratt *et al.* (2018), evaluation of modern trends of developing disruptive technology for medical practices will help to update existing and traditional Healthcare methods for different organizations. It will also help to improve the learning process of medical staff by incorporating virtual reality process-based real environment experiences for improving medical practices.

Contribution of literature review: Conducting Research and Analysis on multiple dimensions of augmented reality acceptance by medical professionals can help in enhancing existing literature. According to the view of Pratt *et al.* (2018), the qualitative research findings of the study will help to represent a project conclusion of benefits and limitations regarding the topic and help to guide further research work appropriately. It will help to understand limitations and associated functional areas to the researcher and provide them clear and quality background information. On the other hand, this research work will help medical professionals in adopting innovative technologies for improving their Healthcare practices respectively (Chen *et al.* 2017).

6. Significance of the Study

Conducting authentic investigation and analysis of augmented reality is important for understanding its contribution to the developing health care services and practices of the medication process. As cited by Pratt *et al.* (2018), this study has several significances that include procedural guidance of modern technology, quality checking of Healthcare practices, accessible patient data and hospital navigation understanding.

Procedural guidance: One of the potentials said contributions and significance of this study will understand the procedural guidance of adopting modern technology by different Healthcare organizations. As pointed by Xue *et al*. (2019), the evaluation of the advantages and disadvantages of augmented reality will help to provide recommendations for healthcare organizations. It will help to focus on accepting modern technologies and develop appropriate procedural guidelines for ensuring safety and welfare. On the other hand, the development of procedural guidance will greatly help to understand the necessity of augmented reality for improving medical practices.

Quality checking of Healthcare practices: The development of quality checking procedures in health care practices is a major significance of the study. According to the view of Xue *et al*. (2019), the discussion and analysis will develop appropriate standards of quality checking implementing augmented reality in medical practitioners for ensuring improvement and development. This process will help in the decision-making process of installing augmented reality by different Health Organization for guiding diagnosis and surgery activities for doctors and surgeons. As per the perspective of Beckmann *et al.* (2017), it will also help for adopting an easy way of learning for hospital interns by learning different procedures of treatment through virtual reality activities along with real-life practices. Conducting research on the understanding adaptation procedure of augmented reality will help in developing potential quality checking methods in health care practices for future development.

Accessibility of patient's data: Understanding the process of accessing patient's data easily through innovative augmented reality will be a potential significance of the study for the development of medical professional practices. As argued by Hettig *et al.* (2018), the study will greatly help to understand easy methods and techniques of accumulating medications and health issue data of patience easily. Moreover, it will help hospital staff in providing better services to the patient for advanced treatment.

Hospital Navigation: understanding hospital navigation processes that have been developed by incorporating innovative augmented reality will be a potential contribution of this research work. As per the view of Azuma, (2019), the understanding procedure of hospital navigation and its respective benefit will help different Healthcare organizations to understand the importance of adopting modern technologies. Moreover, it will also help to evaluate other important features of augmented reality for Healthcare professionals' development. According to the view of Lange *et al.* (2020), using the procedure of pain relief process and pain navigation process of the human body by automatic disease explaining process and surgery simulation process of augmented reality can be understood easily. The research work will also help to understand the importance of AR features for navigating the mental and emotional health status of different individuals.

7. Research Design

Significance

The research design refers to the overall strategy that is chosen to iterate the different components of the research in a coherent and logical way. As mentioned by Andrade (2018), choosing the appropriate research design is necessary to address the research problem as effectively and unambiguously as possible. In research projects, the design should be made in such a way that is able to test the theory with evidence, describe the variables and analyze the research objectives, properly. It is observed that without proper research design, the conclusions drawn from the study are weak and unconvincing, thereby, consequently leading to the failure of the project. Therefore, as argued by Rahi (2017), it is absolutely necessary to understand the length and complexity of the research and then come up with the best research methodology. The design of research explains the type of research that will be undertaken such as experimental, survey, correlation, case study and review.

In this research, a descriptive research design will be followed to gather insight into the variables. The descriptive design can be used in both qualitative and quantitative research methods. In this research a secondary qualitative method will be conducted; hence, a descriptive research design will be helpful in understanding the level of acceptance of AR previously and in the current scenario. Moreover, it can be argued that the medical field has undergone subtle new technological introductions within the past few years. Therefore, the

descriptive research design will be used to underpin the changes in augmented reality application in the medical field. For example, in the early phases of 2015, only 14% of medical care facilities utilized AR (Kobayashi *et al*., 2018). However, with the change in time and technology about 23% of the medical centres are using AR at present. These changes can be described easily with the help of a descriptive research design.

Characteristics

A research design is followed by data collection, measurement, and data analysis. The design phase of the research determines which tools and methods are appropriate for the study. In order to create an impactful research design, care should be taken to understand the purpose of the research, techniques to be implemented, timeline, measurement, methodological approach, and research objectives. As mentioned by Follmann *et al*. (2019), a successful research design elicits minimum bias in data collection and provides authentic data with the least marginal errors. There are four key characteristics of research design:

- ***Neutrality***- There are assumptions in a research project that alters the results in research. However, a descriptive research design that will be followed in this study is not affected by personal thoughts and maintains neutrality before coming to a conclusion.
- ***Reliability***- A research design that is based on timely evaluation in order to understand the changes is highly valued. Therefore, for this research, the data will be collected through descriptive design making it reliable and authentic (Andrade, 2018).
- ***Validity***- There are multiple measuring tools for a research project; however, only the correct tools help to make a project successful (Kobayashi *et al*., 2018). In the case of this study, a secondary thematic analysis will be conducted to understand the acceptance of augmented reality in the medical profession.
- ***Generalization***- The outcome needs to be applied to a whole population rather than a specific medical facility. This research will generalize the search for acceptance of augmented reality by taking journals from various locations and drawing conclusion for a wide population.

Types

Figure 1: Descriptive research design for qualitative data analysis

(Source: Avella, 2016)

There are many types of research designs that can be chosen based on the topic and variables of the study. In this research, a descriptive research design will be followed to answer the research questions and relate to the current phenomenon affecting the medical world. As mentioned by Avella (2016), a descriptive research design is highly effective in obtaining information about the newest trends in medical care and describing "*what exists*" with respect to the current conditions or situations. It can be observed that in the medical field, augmented reality is taking over the industry at a rapid pace (Rahi, 2017). This research will highlight the importance of augmented reality and its application in the medical profession. Unlike in other research designs, the descriptive research design goes with the flow and cannot be controlled, thus, reducing personal bias.

Implementation

There are many ways in which the descriptive research design can be conducted. The main aim of this research will be to address the acceptance of augmented reality in the medical profession. Therefore, the research design will include descriptive data collection from the existing literature to analyze the acceptance of augmented reality. Information is collected from literature sources on the same topic within the last 5 years. Then the data is compared with the current trends in views and perspectives of medical professionals. Ultimately, the research will

portray a normative understanding of both the existing literature and the current situational changes in the medical field. According to Rahi (2017), this would be helpful as a descriptive research design will be more explanatory than the exploratory or experimental research design. The main reasons for opting for descriptive research design will be:

- ***Defining subject characteristics***- Descriptive research design is effective in defining the variables and their characteristics in the research (Kobayashi *et al*., 2018). Information is gathered through existing articles for this study and the variables will be defined accordingly.
- ***Measurement of data trends***- As the changes that happened over time can be addressed by descriptive design; the research uses this method to measure the data trends.
- ***Comparison***- The descriptive research design is also beneficial in comparing the changes in the variable over time. The existing literature can be compared with the recent trends and changes in the medical profession (Avella, 2016). This helps to gather a better knowledge of the research variables and understand the level of acceptance with changing times.
- ***Validation of existing conditions***- Descriptive research design ascertains the underlying patterns of changes in acceptance of augmented reality in the medical profession. As stated by Andrade (2018), this helps to gather valid reliable results that are free from personal bias.
- ***Conducted overtime***- The data is collected for a certain time frame so that the changes occurring at each point of time can be included in the research. The higher the number of research is conducted, the more authentic the conclusion will be.

8. Literature Review

8.1. Conceptual framework

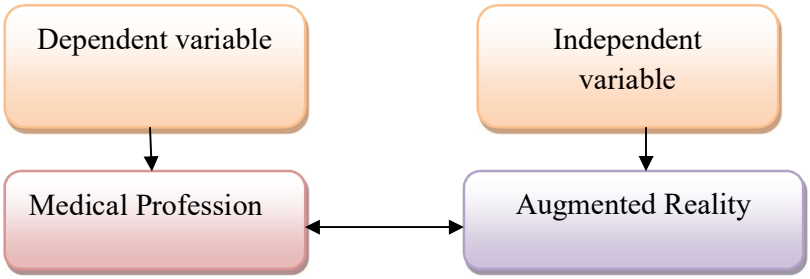

Figure 2: Conceptual framework

(Source: Learner)

8.2. Characteristics of Augmented Reality

Augmented reality or AR is the mixture of the virtual world and real-time elements combined into a symbiotic whole. As mentioned by Yeom *et al*. (2017), AR uses computer-generated sensory inputs such as pictures, sounds, videos and graphics to blend virtual reality with the physical world. AR is different from virtual reality, as the latter resembles a connection with the 3D world only. AR is a unique blend of technology in which the users do not lose sight of reality and yet experience a virtual world. As cited by Hettig *et al*. (2018), the key characteristics of AR are its ability to overlay real and physical worlds, real-time interaction, and alignment in the 3D world. In order to make a proper AR connection, there is some hardware such as processing devices, sensors, head-mounted displays, cameras, and eyeglasses.

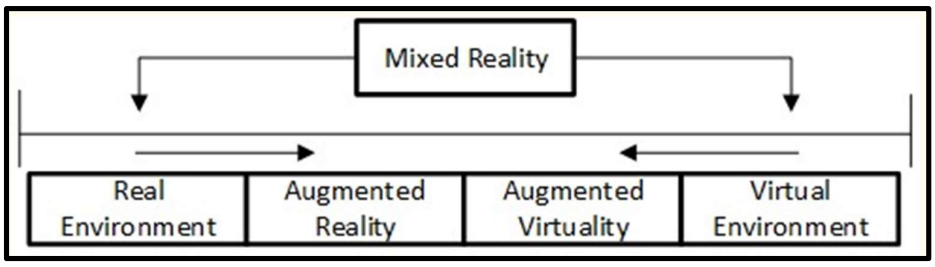

Figure 3: Overview of Augmented reality (Source: Beckmann *et al.*, 2019)

AR and VR are actually twins of digital evolution that help the users experience a new world. Augmented reality has its root in 1968 when an American scientist showed the world the application and benefits of computer-generated graphics (Beckmann *et al.*, 2019). Since then, AR has been developed steadily in various fields and is used extensively for training purposes. Countries such as Malaysia, the United States, Singapore, the United Kingdom, Germany, and Italy use AR to train pilots, educate students, and train surgeons. It is observed that within the last few years, the use of AR has grown significantly and the budget enrolled by the governments is increasing by 15% every year (Xue, Sharma & Wild, 2019). It is expected that industries such as medical and healthcare services will be completely relying on AR for training surgeons and medical practitioners.

Augmented reality is one of the most promising rising technologies that are affecting the medical field and everyday medicines. As per the opinion of Chen *et al*. (2017), AR has secured a place in the future of the healthcare system as it becomes more affordable and user-friendly. There are a plethora of benefits for AR application in healthcare such as education, communication, training and improving patient's expectancy. In the current context, the top organizations are bringing forth new AR therapies to combine the virtual and physical world. As argued by Pratt *et al*. (2018), the disruptive technology can be used in the form of glasses, headset monitor and digital contact lens. There are countless cases of using AR application in the medical field, such as describing symptoms through AR, showing defibrillators, and finding veins.

8.3. Impact of Augmented Reality in the Interactivities Medical Profession

Figure 4: Implementation of Augmented Reality in the medical healthcare system

(Source: Barsom, Graafland and Schijven, 2016)

AR has made a significant impact on the medical field by encouraging training and improving treatment methods. As mentioned by Barsom, Graafland and Schijven (2016), new therapies and educational training are brought into light by companies after accepting AR in the medical field. Augmented reality (AR) is adopted in medical facilities in order to train surgeons for real-life surgeries. In addition, as discussed by Silva *et al*. (2017), with the increasing development of AR in the medical field, surgeons can experience real-life problems prior to their actual surgery. This not only improves the decision-making ability of the surgeons but also helps in providing a real-time experience. It can be observed that AR helps to create rich and interactive experiences while understanding a process.

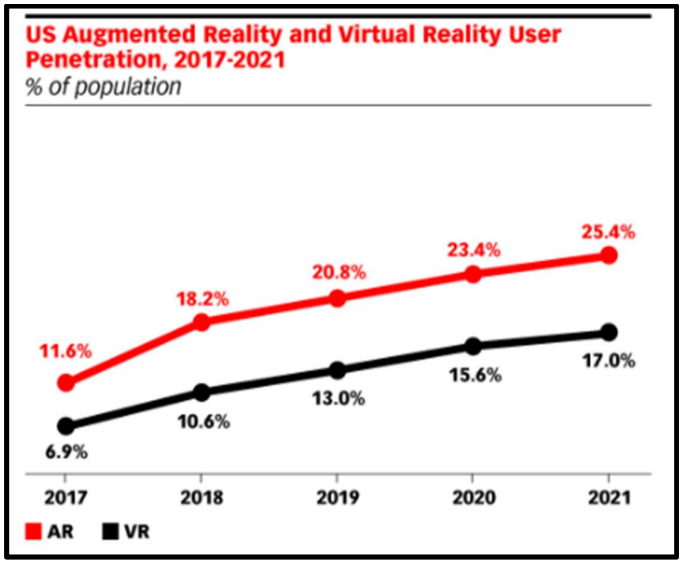

Figure 5: Penetration of Augmented Reality in medical field

(Source: López Belmonte *et al*., 2019)

As AR allows interaction in both the physical and virtual worlds, users can gain both theoretical and practical knowledge through this technology. In the current scenario, about 23.4% of the world's medical care facilities are using AR in the medical field (López Belmonte *et al*., 2019). Some of the greatest impacts of AR in the field of medicine include doctor education, disease simulation, surgical visualization, and enhanced patient treatments. The research indicates that the application of AR has increased greatly over the years and by 2050, more than 60% of the world's medical centre would be using AR.

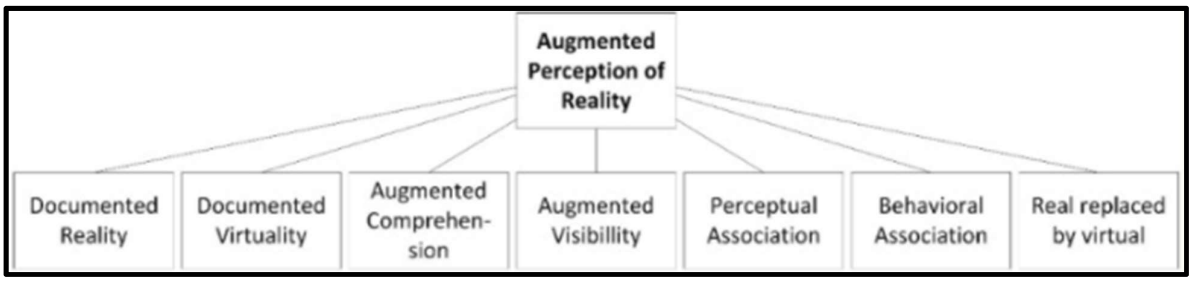

Figure 6: Perception of Augmented Reality in the medical field

(Source: Zafar and Zachar, 2020)

A good example of showing the impact of AR in the medical field is its applications in complex surgery. Tech giants such as Medsights Tech developed an AR system that can assist surgeons during the operation of tumours. As per the view of Lange *et al*. (2020), the 3D reconstruction of the complex tumour is reflected as a real-time image to empower the surgeons in operations. As the function constructs a 3D image of the tumour it becomes easier to operate and complete the stitches. Another example is the application of AR on the patient's body to view the veins. Nurses use this to locate the veins appropriately and reduce time wastage during surgery. The nurses have to wear an AR lens or eyeglasses to know the exact location of the vein and start the IV prior to surgery.

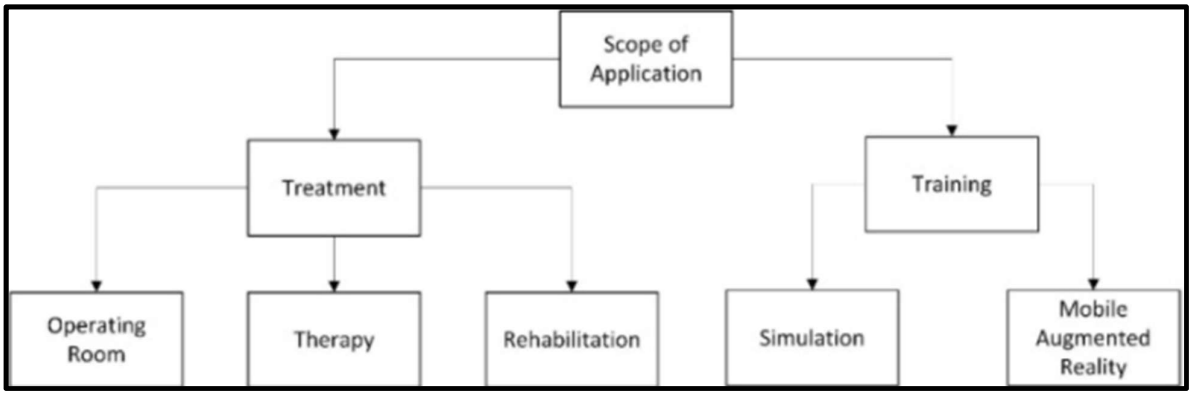

Figure 7: Scope of Augmented Reality

(Source: Created by learner)

The aim of this research will be to address the opportunities in the medical field as much as possible and draw out the conclusion of whether AR will be having a significant place in the

future of the medical profession. According to the existing literature, it is found that the impact of augmented reality has shown a positive effect on both training and treatment. As stated by Azuma, (2019), doctors and medical practitioners have constantly used augmented reality during operation, therapy, rehabilitation, simulation training and mobile AR. This research proposes that AR will become more popular with the passage of time and will be able to accommodate advanced clinical trials after a few years. As technology is improving day by day, with the improvement in hardware and software inputs, new opportunities will be created in this field.

8.4. Theory and Model

Diffusion of Innovation Theory (DOI)

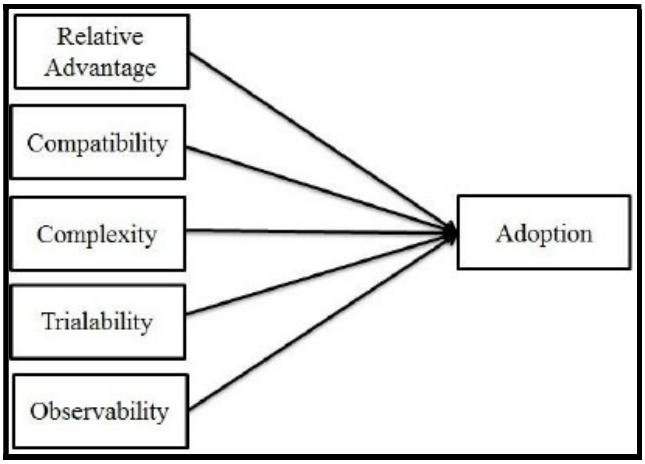

Figure 8: Diffusion of Innovation Theory

(Source: Min, So and Jeong, 2019)

According to this theory, there are cumbersome elements that determine the diffusion of innovation. As mentioned by Franceschinis *et al*. (2017), augmented reality is a complex innovation framework that is being slowly embraced into society. In order to capture the determinants and understand the complexity behind its diffusion, it is of paramount impedance to understand this innovation. Acknowledging the characteristics of AR, its impact on the medical field and its role in diagnosis, this theory can define the attributes of the variables. The DOI theory is mainly used in decision-making, to form an attitude towards innovation and

forecast whether to accept or reject the idea. Therefore, this theory will be an important asset to analyze the acceptance of AR in the medical field.

Disruptive Innovation Theory

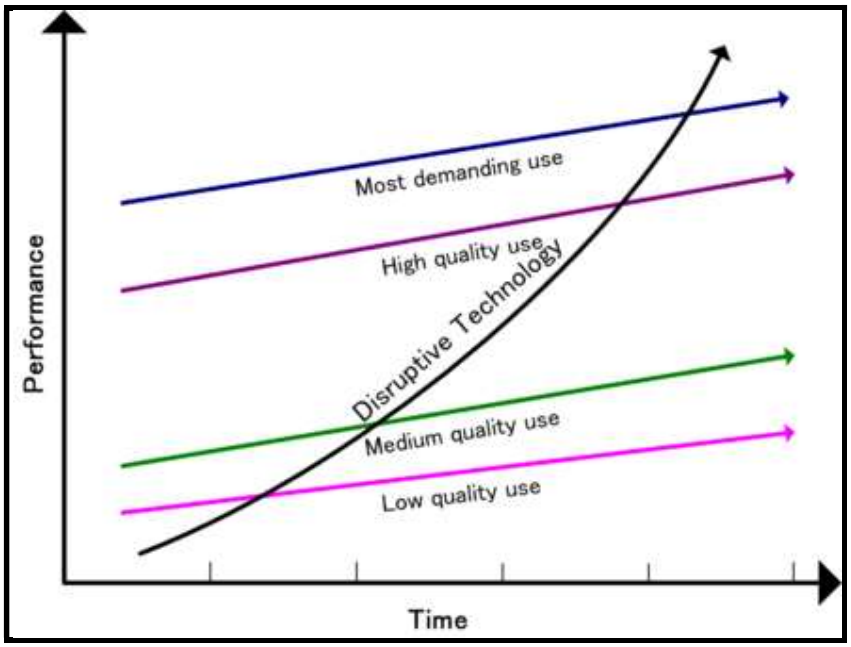

Figure 9: Disruptive Innovation Theory

(Source: Li, Porter and Suominen, 2018)

This theory is used when a new market is created that overrides the values of the existing market. As per the view of Makovhololo *et al*. (2017), AR technology is a new concept that is slowly penetrating the medical industry. This concept is bound to override the existing diagnostic techniques and introduce AR as a better and cost-effective diagnosis technique. The disruptive innovation theory can be used to analyze the perception of users' on how much the AR technology is influencing them. Therefore, this theory can be aligned with the research objective to address the acceptance of AR in medical facilities.

Theory of Reasoned Action (TRA)

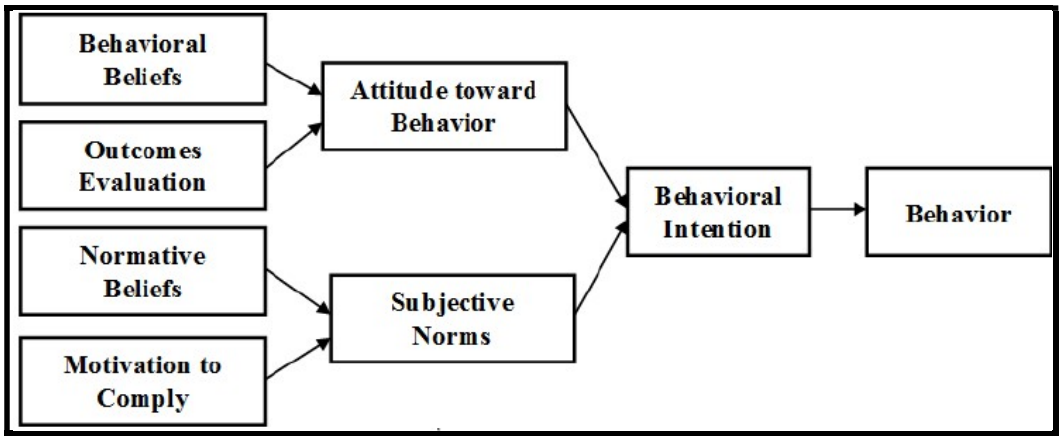

Figure 10: Theory of Reasoned Action

(Source: Procter *et al*., 2019)

The theory of reasoned action is used to explain the relationship between human attitude and behavior for any action. In this case, the theory will be beneficial to identify the perception of medical practitioners and patients for accepting AR technology in the medical field. As stated by Procter *et al*. (2019), the theory predicts the perception of individuals based on their pre-existing attitudes towards the subject. AR is an innovative concept that has been used for decades and many patients have been benefited from the technology. However, as argued by Kniazieva, Kolbushkin and Smerichevskiy (2017), there are some patients who are reluctant to such innovative technologies and prefer traditional diagnosis methods. Therefore, knowing these attitudes and behavior of the people, the theory can find whether AR is being accepted in the medical field or not.

Theory of Planned Behavior (TPB)

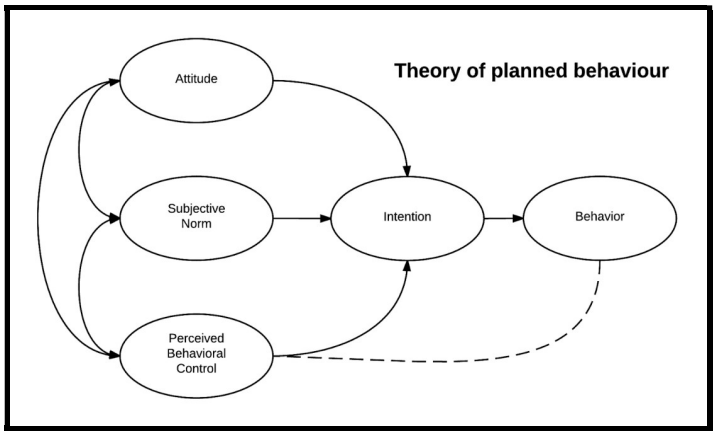

Figure 11: Theory of Planned Behavior

(Source: Paul, Modi and Patel, 2016)

The theory of planned behavior is a theory which links one's beliefs and behavior with the subject norms. In this case, this theory can be used to pin down the behavior of doctors, practitioners and patients to opt for AR technology. As cited by Paul, Modi and Patel (2016), the perceived behavioral control, behavioral intention and beliefs will be analyzed using this model. As there are still some patients that do not trust AR and long for traditional diagnosis methods, this theory will be able to forecast the reason behind their belief. After integrating the results, the research will be able to answer whether the AR technology will be viable for everyone in medical care.

Technology Acceptance Model (TAM)

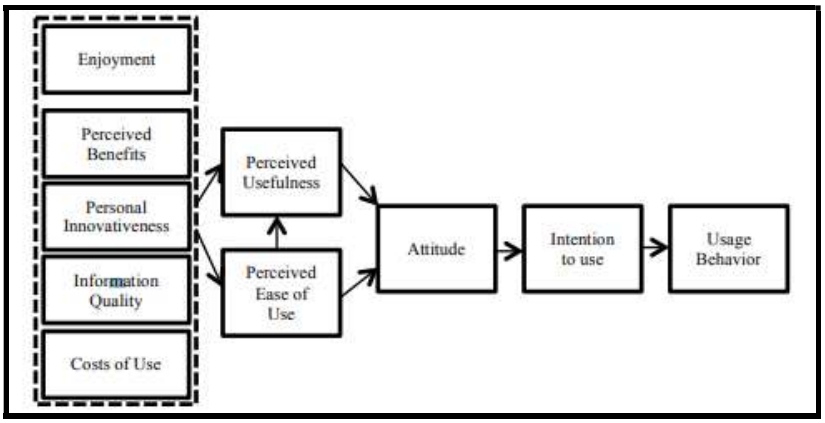

Figure 12: Technology Acceptance Model

(Source: Rahimi *et al.*, 2018)

TAM is considered as one of the most influential frameworks for addressing user acceptance, beliefs and behavior. It is important to understand the users' reasons to accept or reject a technology that can make wonders. AR is a great technology with limitless potential in improving the diagnosis process in medical facilities. However, as argued by Rahimi *et al.* (2018), some users reject the technology based on perceived ease of use and perceived usefulness of the technology. According to the literature, these people want to avoid any new methods that have even a slight chance of risk of failure. Therefore, the theory states that perceived benefits will be an important element to influence the users about the role of AR technology in the medical field. Therefore, according to the TAM model, the acceptance of AR in the medical field can be found by understanding the users' intention to use this technology.

Rational Choice Theory

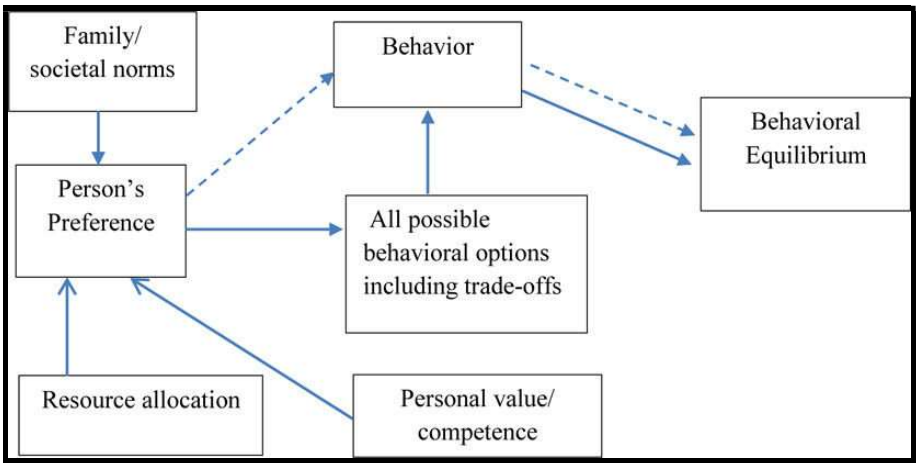

Figure 13: Rational Choice Theory

(Source: Paternoster, Jaynes and Wilson, 2017)

The rational choice theory is aligned with rational calculations, choices and outcomes along with personal objectives. According to this theory, people choose the outcome that will bring the greatest benefit and satisfaction to them (Paternoster, Jaynes and Wilson, 2017). Therefore, in this case, whether AR technology is able to bring that level of satisfaction can be evaluated. As rational choice theory actively measures the satisfaction level of the individuals, it can be used to find out the acceptance of AR in medical facilities.

There will be a huge positive impact of augmented reality in the interactive medical profession which is listed below:

- The application of the technology of augmented reality has opened up new opportunities in the healthcare industry. In the opinion of SL and Madhavan, (2018), the concept helps and enhances surgeons and doctors the ability to treat, perform and diagnose surgery in an accurate way. This will help with real-time data and access patient information in a faster way.
- However, augmented reality brings huge value for practicing education and medicine and allows students and trainees to the better visualization of health issues and the appropriate treatment procedures. As per the views of Limbu *et al*, (2019), the concept of augmented surgery can use modern and emerging technology and save the life of patients. MRI and CT scans help to diagnose individual patient anatomy before going for surgery. Surgeons can forecast the muscles, bones and internal organs without having any cut to the body. As argued by Mather *et al,* (2017), the concept of virtual reality determines the exact incision and injection procedure to display life-saving information and offer first response during any kind of medical emergency.
- Augmented reality cannot be used in low-risk surgeries and high-risk surgeries; it saves the time of doctors and provides better visualization of the entire process. As opined by Rauschnabel and Ro, (2016), the use of augmented reality systems helps individual doctors to find major blood vessels accurately and display three-dimensional images of individual patients for conducting surgery. Virtual reality provides individual doctors with knowledge about new products, procedures and increases retention. The use of cloud-based systems in the medical profession helps to connect individual students and surgeons anywhere in the world. In the views of Basoglu *et al,* (2018), medical training products have helped augmented reality and focus on the learning procedure to achieve functional and non-functional requirements of the surgery process.
- Another major impact of augmented reality is to make it possible for individual doctors to diagnose symptoms and provide accurate treatment to individual patients. Virtual reality in the medical profession can encourage individual patients to better know the problems of individual patients. As per the views of Rauschnabel *et al,* (2016), AR technology improves the process of an augmented scanner and accusing to enhance system formation and make them visualize during the time of patients' visit. 3D visualization platforms help to encourage the doctor and provide a clinical reference for higher productivity of the medical profession.

8.5. Role of Augmented Reality in Fiction Simplicity of the Medical Profession

The future of augmented reality has been widely adopted in the healthcare industry that helps to create business opportunities for individual healthcare organizations with the expertise of AR. In the views of Limbu *et al,* (2018), the concept of AR has been used to display sensors, cameras and overlay digital information in the real world. This is the current trend in medical education and uses the virtual environment and user's immersion and focuses on the interaction between doctors and patients in a realistic manner. As stated by Plotzky *et al,* (2020), the use of advanced technology such as force feedback capabilities and advanced haptic devices provide audio-visual effects and detect motion of individual patients.

The use of emerging technology provides zero latency to facilitate proper dimension in the medical profession. In recent times, most life-sciences companies have used the concept of AR and brought new therapies that help to combine physical as well as virtual life. As per the views of Janßen and Prilla, (2018), this enhances the forecast of how new drugs and medical devices have interacted with the body. The use of disruptive technology provides better engagement to individual healthcare professionals and explains the concept of a new treatment to patients. The main roles of AR are listed below:

Procedural guidance and Quality Check: The AR encourages professionals of healthcare to make accurate decisions from the first stage of the diagnosis process. In the views of Azuma (2019), this mainly requires skill but the skill has come up with practices and AR has guaranteed correct procedure performance to enable medical professions. AR applications show the exact layout of individual patients such as veins and provide proper guidance to the diagnosis process. Experienced healthcare professionals can also benefit from the AR treatment for performing rare procedures and providing a better diagnosis. According to the author Zafar and Zachar, (2020), however, individual nurses can be benefitted from the treatment process but AR helps for a quality check-up of the patients and improve the diagnosis.

Figure 14: Advantage of Augmented Reality in Healthcare

(Source: Zafar and Zachar, 2020)

Easily Accessible Patient Data: AR technology enhances the diagnosis process to easily access patients' information with the help of a mobile application. In the views of Iserson, (2018), healthcare professionals can see clinical records and focus on the latest lab result which has been displayed on smart glass or tablet at the beginning of the appointment. The use of hospital wristbands helps to scan QR codes and barcode images that help to gather relevant information about patients. Easy access to patient information provides enough and sufficient knowledge to doctors about their history and past treatment process. As commented by Ro *et al,* (2018), AR enhances effective communication with individual patients and provides more time for quality diagnosis processes.

Figure 15: Advantage of Augmented Reality in Healthcare

(Source: López Belmonte *et al,* 2019)

Explaining Diseases Process and Surgery Simulations: Healthcare professionals many times are unable to talk with patients in plain terms hence; there is a chance of miscommunication

that may result in serious diseases. In the views of López Belmonte *et al,* (2019), inappropriate communication not only focuses on complex details but also degrades information flow between doctors and patient parties. AR can encourage doctors to explain patients' health problems with the help of live simulation and make them understand with simple language. As mentioned by Simão and Bernardino, (2017), the interactive nature of AR can tailor the simulation of individual patients and create different scenarios for maintaining surgical procedures. This provides a clear image to individual patients and makes the surgery process rationale and flexible.

Figure 16: Advantage of Augmented Reality in Healthcare

(Source: Rauschnabel and Ro, 2018)

Navigation in Hospitals: AR can serve a structured GPS for both the visitors and patients and the process comes up with providing user inputs to the destination and the system automatically demonstrates the lab or room number where certain procedures have been performed. As suggested by Rauschnabel and Ro, (2018), the application then calculates the route which is captured by the lens of the camera and navigates arrows to the exact location. These features help unknown visitors to find the exact location of a patient on hospital premises and improve customer satisfaction levels.

Gamification for Kids and Mental Ill People: Hospital premises can be stressful for mental patients and kids. In critical conditions, patients can develop depression hence the application of AR easily distracts patients from stressful thoughts. According to the author Chen *et al,* (2017), however, kids are suffering from the mentally ill or autism spectrum and can have panic attacks and anxiety. The use of mobile devices and AR applications explore hospital grounds and are beneficial for virtual companions. As per the views of Xue *et al,* (2019), the features

of AR can improve the mental state of people and reduce their stress level and manage for a successful realization of the concept.

Figure 17: Advantage of Augmented Reality in Healthcare

(Source: Xue *et al*, 2019)

Pain Relief: As per the current situation of the opioid epidemic both patients and doctors are looking for a better perspective to relieve pain. In the views of Yeom *et al,* (2017), technology provides enhancement and demonstrates destructive therapy for the betterment of health. AR app is used for burn pain relief and the name of the application is SnowWorld that has proved to be the most effective way to reduce pain. As stated by Tezer *et al,* (2019), mobile AR applications provide more realistic ways to bandage burn and the use of smart glass enhances the diagnosis process.

Training and Development: Skilled and competent medical staff is the main assets of the healthcare industry and there will be a need to train medical professionals. In the opinion of Hettig *et al*, (2018), the application of AR comes with an effective way for engaging highly experienced professionals with different types of sensory input. The application encourages the retention of medical professionals and enhances knowledge and competency based on the current development in the medical field. As opined by Chang *et al,* (2019), the learning tool of AR helps to provide an immersive educational experience and clarify complex concepts for experienced professionals.

Assisting Practice: From aiding the diagnosis process and assisting the medical professionals to get training for the medical team. In the opinion of Bursali and Yilmaz, (2019), this tool encourages individual professionals to complete day-to-day tasks logically and coherently. Various real-time applications of AR help for 3D visualization of internal organs hence; this can assist the doctors for the appropriate diagnosis process. The incorporation of electronic

restorative records encourages the doctors for proper counselling of patients for better treatment and procedures (Rauschnabel *et al.* 2016).

Engaging Patients: The utilization of AR improves and increases proactive roles for managing welfare and health. 3D anatomical testing and representation encourage the diagnosis process and maintain the appropriate structure efficiently. As per the views of Zabel and Telkmann, (2020), AR helps to enhance the healthcare industry and mitigate the demands of patients in a modern way. Technological advancement enables AR to visualize the patient's upcoming health condition and provide medicine accordingly.

9. Proposed Methodology

The proposed methodology will be based on data analysis and data collection for analysing whether augmented reality would be accepted in the medical profession or not. In this section, the progress of research and the purpose of methodology is defined. The main purpose of methodology will be to understand the chosen tools, techniques and methods for the research. The data collection method and the data analysis tools used for the evaluation will also be highlighted in this section. As the study will follow a secondary qualitative method, ethical guidelines will be presented to generalize validity and reliability of the research proposal. Secondary journals will be selected from authentic websites, journal articles and blogs to state the authenticity of the research.

9.1 Research Philosophy

In this research proposal, a positivist philosophy will be chosen to state the acceptance of augmented reality in the medical profession. As mentioned by Kennedy (2017), the positivist philosophy has an inherent advantage of analysing the natural phenomena for finding information. As scientific research and technology acceptance is deeply related with augmented reality, positivism philosophy would be beneficial to define the different variables associated with augmented reality. In addition, this philosophy provides information about the scientific facts related to the variables so it would be easier to conduct research on a topic such as augmented reality. It can be argued that using this philosophy, the research can correctly display the factual knowledge related to the independent and dependent variables (Žukauskas,

Vveinhardt and Andriukaitienė, 2018). Therefore, positivist philosophy will be selected for this study to develop a strong research base.

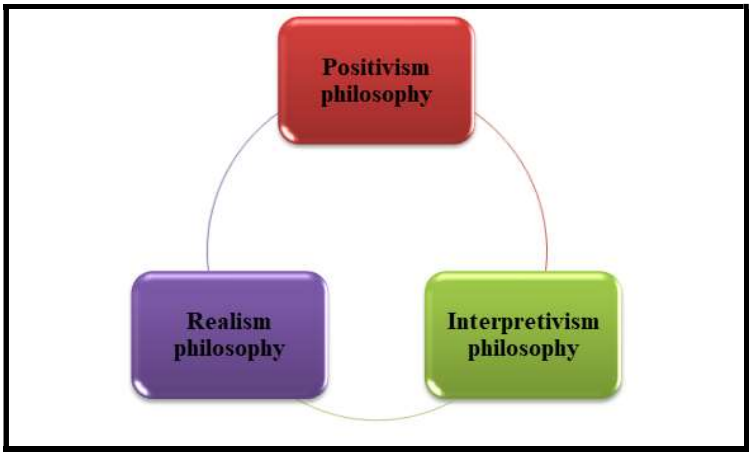

Figure 18: Proposed research philosophy

(Source: Žukauskas, Vveinhardt and Andriukaitienė, 2018)

The research will not be using realism or interpretive philosophy due to their disadvantage of collecting scientific data. In the realism philosophy, scientific data can be collected similar to the positivism philosophy. However, as the data would be based on real-time interpretation of augmented reality, it would be difficult to assess such data. As argued by Alase, (2017), due to its nature of generating such complexities in the research, realism philosophy will be avoided for this study. On the other hand, the interpretive philosophy will fail to generate a strong prediction of the impact of augmented reality due to its limitation in collecting scientific data (Tuffour, 2017). This would be contradicting the main purpose of the research, and therefore, interpretive philosophy will also be neglected in this research. Hence, positivism philosophy will be the best to find real-time information at a minimal timeframe.

9.2 Research Approach

A research approach is usually selected based on the nature of the research and data analysis. It is observed that understanding the research approach can help to identify the variables of the study logically and coherently. As mentioned by Dougherty, Slevc and Grand (2019), there are mainly three types of research approaches that involve a deductive approach, inductive approach and an abductive approach. As discussed by Tuffour (2017), each of the approaches

has separate benefits and disadvantages, hence, it is essential to choose the approach carefully that would go hand-in-hand with the research. In this study, a deductive approach will be followed to define the relationship between the two variables. This approach would highlight whether augmented reality is getting appreciated by medical facilities or not.

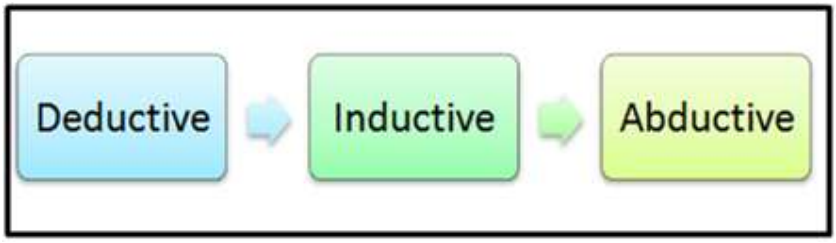

Figure 19: Proposed research approach

(Source: Peterson *et al*., 2019)

In other approaches such as the inductive and abductive approach, the data collection process is very limited. Inductive approaches cannot distinguish between the same variables such as virtual reality and augmented reality. Therefore, the findings drawn from the inductive approach would not be truly authentic. Due to such interference in fair analysis, an inductive approach will not be selected for this research topic. As per Peterson *et al*. (2019), unlike the inductive approach, the abductive approach has a strong connection with scientific data collection and innovativeness. However, the data collected with an abductive approach cannot be used to positively verify the variables. This contradicts the main purpose of the research to understand whether augmented reality will be accepted or not. Therefore, abductive reasoning will not be used for this research proposal.

9.3 Sampling

Sampling refers to the selection of the data from authentic sources to propose a bias-free work. As commented by Sharma (2017), highlighting the sampling size and technique will enable the readers to understand which sources will be used to collect data. There are two types of sampling techniques that are used in research works which include probability sampling and non-probability sampling (Chang *et al,* 2019). Each of these techniques can be further divided into different sampling methods that are selected based on the research topic. In the case of this research, a non-probability sampling will be chosen to select the sources. A purposive sampling

technique will be followed to be selective and subjective when choosing the resources for this study. As the samples will be hand-picked by the researcher, the purposive sampling method holds the advantage of being cost and time-effective (Etikan, Musa & Alkassim, 2016). The researcher can choose the samples based on their personal opinion and which are easy to find.

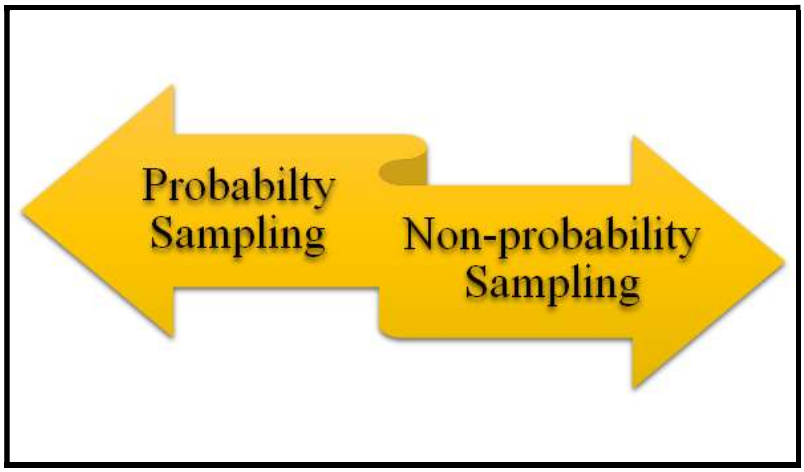

Figure 20: Proposed sampling technique

(Source: Etikan, Musa and Alkassim, 2016)

In previous literature, it can be found that research did not separate the two elements, augmented reality and virtual reality. However, with this sampling technique, the research will be able to portray the acceptance of augmented reality in medical facilities. According to Etikan and Bala (2017), purposive sampling increases the simplicity of finding data and collecting evidence for the research. Thus, the research can be completed at a faster pace with purposive sampling than any other sampling method. Moreover, the probability method is absolutely shunned in this research to avoid mixing conceptual knowledge. With the help of purposive research, around 30 journals will be selected from authentic library sources such as ProQuest and Google Scholar. The PRISMA model will be used to filter the journals and develop appropriate themes for the study.

9.4 Data Collection Method

Data collection method is an important element in methodology as it defines how the information will be gathered and integrated. As stated by Rinderknecht *et al.* (2017), there are

two types of data collection methods namely; primary data collection method and secondary data collection method. In this research, a secondary data collection method will be followed to gather data from existing literary sources. As per Jentoft and Olsen (2019), secondary qualitative data can be collected from both internal and external sources, thereby, making the data collection more reliable.

Internal sources such as industrial records, financial statements, sales reports, and magazines can be used to understand whether augmented reality has made an impact in medical healthcare. On the other hand, external sources such as journals, government reports, library sources and the internet will be used to gather evidence on acceptance of augmented reality in medical facilities (Fauzi & Pradipta, 2018).

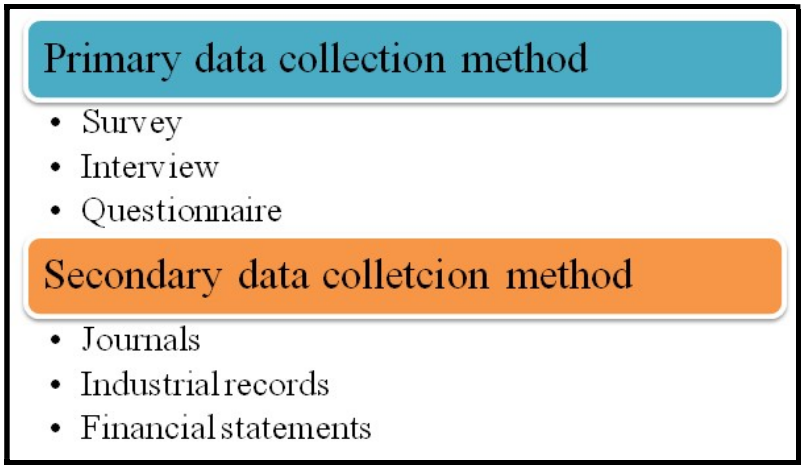

Figure 21: Proposed data collection method

(Source: Fauzi and Pradipta, 2018)

As augmented reality is a trending topic, the research aims to present relative information on its evolution in medical care. Starting from the first time usage to the current state, all information can be gathered from existing literature. Moreover, as discussed by Farouk and Zhen (2019), it is easier to search for secondary literature sources than to conduct a primary survey. Secondary data collection not only saves time but also is more economic than primary data collection. In addition, due to the current COVID 19 restrictions, it will be difficult to gather direct communication with the participants. Hence, a secondary data collection method will be the best way to study augmented reality evolution in the medical field and provide

records of its acceptance. The research will progress with a thematic analysis in which data will be taken from several journals.

9.5 Data Analysis Tool

Data analysis is the process of transforming and modeling useful information for research decision making. As per the opinion of Peterson *et al.* (2019), the main purpose of data analysis is to make a decision based on the information to be extracted. There are mainly two types of data analysis techniques that include qualitative data analysis and quantitative data analysis. In the case of this research, a qualitative data analysis technique will be followed to generalize the search for information. In qualitative data analysis, researchers can probe deep into the past and gather useful information about the evolution of the variable. It is estimated that medical healthcare facilities could be the first industry to embrace augmented reality in the working framework. However, this statement needs to be proved with evidence and solid findings that portray the acceptance of AR in the medical field.

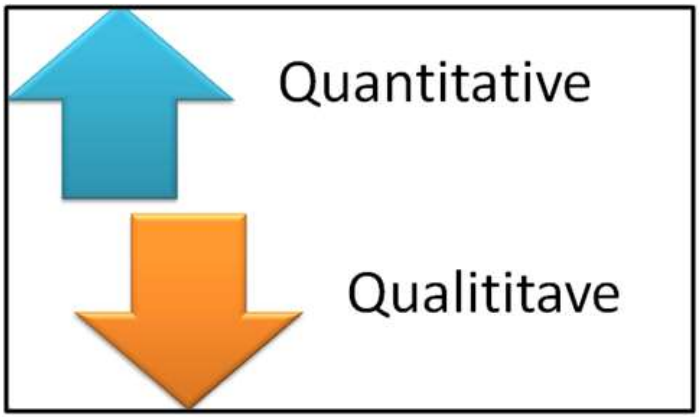

Figure 22: Proposed data analysis technique

(Source: Farouk and Zhen, 2019)

The qualitative method involves a descriptive search of information from existing literature sources. These sources will be beneficial to address how AR came into the medical field, how people reacted to augmented reality and their changing perceptions over time. As data can be analyzed by collecting information from different periods, secondary qualitative research can answer all the research questions and stay true to the research aim. As cited by Rinderknecht

et al. (2017), quantitative data analysis needs mathematical interpretation of data gathered from direct interviews and surveys. However, due to limited movement and social distancing policies in this pandemic state, it would be difficult to interpret data in such a way. Moreover, the time and money requirement in the quantitative method will be more compared to qualitative research. Therefore, the qualitative data analysis technique will be the best option to understand the role of AR and analyze its acceptance level in the field.

9.6 Validity and Reliability

Reliability and validity are the flip sides of the same coin that helps to evaluate the quality of research. According to Östman and Turtiainen (2016), reliability refers to the consistency in the use of authentic sources and proper citations to display the result. In order to have reliable research, the data gathered will be cross-checked and any kind of contradicting statements will be avoided. The research will be using the same data collection methods under similar circumstances to forecast reliable findings. The acceptance of AR and its implementation with changing time is forecasted in this study to understand its evolution over the years. As secondary data collection uses existing literature to find evidence of AR acceptance, it will be usually more reliable and accurate.

In contrast to the concept of reliability, validity refers to the degree of accuracy for collecting data and proposing a suitable research finding. If research has high validity, it means that the results are obtained from a thorough analysis of real-time properties (Jentoft and Olsen, 2019). In this case, the use of AR in the medical field and how it has been affecting the medical world will be taken into account. Analyzing different sources such as venerated journals, the internet, industrial records and financial records, it would be easier to acknowledge the rising use of AR in the medical field. At present, about 10 million people in the world are diagnosed with the help of AR which portrays a stable acceptance rate of the technology in the medical field.

9.7 Ethical Considerations

In order to maintain proper authentic research, it will be essential to maintain work ethics. As mentioned by Rüdiger and Dayter (2017), ethical considerations will be able to state the authenticity and integrity of the work. It is necessary to take the content and follow proper guidelines to produce authentic work. This research will consider the ethics to propose

authentic results highlighting the assumptions taken for this study. Data manipulation and personal bias are highly despised and the research will cut no corners to collect and present data free from manipulations. The research would also abide by the Data Protection Act to use sources fairly and lawfully.

In addition, ethics helps to value the sources from which the data will be collected. The research would properly cite and mention the respective authors when data would be collected. This will be done to reduce personal bias in the work and give credit to the original source from where the data would be collected. As cited by Östman and Turtiainen (2016), ethical consideration greatly enhances the quality of the research and will be essential for avoiding problems for future research. Furthermore, ethics will promote the aim of the research and expand the knowledge of readers by pointing out all the relevant sources used in the study. Lastly, research ethics state whether there will be any contradiction of this topic with other research or not.

9.8 Summary

The main purpose of methodology will be to analyze the specific processes, information and techniques on how the research will progress. The research methodology is estimated to draw out the progress and states the validity and reliability of the findings. It is expected that this section will answer the research questions and describe how the data will be collected. In addition, it can be observed that this research will follow a positivist philosophy with a deductive approach and descriptive research design. The reason for the selection of these processes and their benefits would have been highlighted in this study. In addition, the data collection method and tools would have been chosen according to the research objective and questions. It is assumed that the sampling frame and techniques will be addressed to understand from where the data is collected. It is expected that the research methodology would contain a section for ethical consideration, validity and reliability to present that the study will be free from bias and would be authentic in nature.

10. Limitation of the Study

The study will focus on technological adoption; however, there will be some limitations of research such as inflexibility and improper assumption about the observation of results. Human interference will be another major limitation of positivism philosophy that will not depict the

current scenario of AR in medical professions. In the opinion of SL and Madhavan, (2018), another drawback of research philosophy is improper assumption and results of the respondents based on the inappropriate conclusion. The research will be focused on understanding the issues and challenges of AR in the healthcare industry however, there will be certain limitations of descriptive research. As commented by Limbu *et al,* (2019), a descriptive analysis will not test or verify research problems statistically and will create a certain level of bias due to the improper absence of statistical data. The weak observational nature cannot predict the aim and objective of research hence; it cannot measure the impact of AR in the medical profession in future times. For description analysis, this is unable to test hypotheses in this research that provide biased results to the observers.

The deductive research approach will be used for analyzing research data and focused on the observation and knowledge of researchers. In the opinion of Mather *et al,* (2017), if one observation will be wrong then the overall conclusion will falsify the reducing the accuracy and authenticity of the research problem. Based on the observation the conclusion can be valid or invalid which will be based on the concept of augmented reality application indefinite medical profession. As per the views of Rauschnabel and Ro, (2016), another major limitation of the descriptive study is that this will not focus on the recommendation but will encourage the researchers to adapt knowledge regarding challenges.

Secondary data collection methods will be used here that can provide vague and general results about augmented reality and cannot help the researcher to make appropriate decisions. As stated by Basoglu *et al,* (2018), the information or data will not be accurate since it will be based on the previous or existing study and knowledge. Secondary data will be outdated and old which will produce biased results about augmented reality in healthcare professions. The use of outdated data may not be used in the future because of assumptions and the advancement in technology of augmented reality.

Qualitative thematic analysis will be utilized here to analyze the individual concept and theme based on augmented reality and its application in the medical profession. In the views of Rauschnabel *et al,* (2016), though there are certain limitations of qualitative analysis such as it will be a time-consuming process and fail to verify the result of research. A casualty of study cannot be investigated hence, the positive and negative outcomes cannot be judged with the help of qualitative data analysis. As opined by Plotzky *et al,* (2020), however, the data cannot be represented statistically which will lower accuracy and authenticity and reduce the

performance of the study. Another major drawback of qualitative study is such as insufficient methodological knowledge that can misinterpret data.

Probability sampling will be used in this study but there will be higher complexity in this research method. In the views of Janßen and Prilla, (2018), additionally, the sampling method will be more time-consuming and more expensive compared to the non-probability sampling method. Another limitation of probability sampling will the themes or articles which will be selected for qualitative analysis are not homogenous. As per the views of Azuma, (2019), this sampling method lowers the generalizibility of research and enhances unnecessary bias that can reduce the performance of the study and cannot visualize the advantages of AR in the medical profession.

11. Structure of a Research Report

Augmented reality mainly involves the development of real-world scenarios that have a connection with virtual reality and enhance the learning process based on the assumptions of the researchers. Health professionals have adopted the concept of AR for a clear understanding of patient diseases and to address the effective diagnosis process. The report aims to illustrate the individual dimension of AR in medical professions.

The first part of this study is focused on the problem statement that higher the possibilities of software and hardware issues including electricity and projector to represent individual medical concepts. As argued by Zafar and Zachar, (2020), the study aims to analyze and evaluate concepts of augmented reality in medical professions and to evaluate major complications and challenges of AR. The study helps to generate opportunities and provide digital health technologies to manage the issues of AR. The findings are based on accepting augmented reality and helping medical professionals to develop future strategies.

The study has forecasted a review of literature that will be based on the concept of AR and the positive impact of augmented reality in medical professions. The technology acceptance model is used here to analyze technological adaptation and evaluate the issues and challenges of AR in recent times. In the views of Iserson, (2018), the study depicts the role of AR in medical professions and focuses on in-depth analysis about the research topic and how AR can improve direct communication between doctors and patients. The study will focus on descriptive research analysis to measure the aim and objective of the research. As opined by Ro *et al,*

(2018), positivism research philosophy is used here to analyze the challenges of AR in the medical profession and encourage researchers to gather information about the future implication of AR in the healthcare industry.

Secondary data collection methods are used to collect data from existing data sources and previous knowledge of researchers. In the views of Simão and Bernardino, (2017), qualitative data analysis is used for enhancing the theme and concept of AR implementation in the medical industry. Non-probability sampling methods are used here to choose the articles and journals based on the chosen themes about the concept of AR in the medical profession and how it accurately diagnoses each patient.

12. Research Activities

Activities	Duration	Start Date	End Date	1 days	1 days	2 adys	2 days	2 days	1 days	2 days
Problem Statement	1	5.12.20	5.12.20							
Aim and Objective	1	6.12.20	6.12.20							
Scope of study	2	7.12.20	9.12.20							
Significance of Study	2	10.12.20	12.12.20							
Literaure Review	2	13.12.20	15.12.20							
Proposed Methodology	1	16.12.20	16.12.20							
Research Activities	2	17.12.20	19.12.20							

Figure 23: Gantt chart

(Source: Created by author)

Research problems help to explain the aim and objective of research based on the current assumption and observation. In the views of Rauschnabel *et al,* (2018), the scope of study helps to analyze the importance of AR and its application in the medical professions. Additionally, this motivates researchers to analyze the advantages and benefits of AR in the future medical industries. A review of literature is analyzed based on the impact of AR in the medical profession and the issues of AR.

A literature review helps to analyze the role of AR in medical professions including navigation, technological advancement and detailed study about the concept and themes. As per the views of Chen *et al,* (2017), the proposed methodology takes one day for the completion of thematic

analysis based on the description of AR in healthcare and analyzes the non-probability sampling method to choose the selected articles and journals. The methodology focuses on the description of the concept AR and its impact on the healthcare industry. Research activities are based on the proposed methodology and the timeline encourages the measurement of research. In this way, the overall research has been carried out to gain positive outcomes in return.

Acknowledgement

I am very much grateful to the professor and mentor of the project, Prof.Syed for giving me this opportunity to research on "***ACCEPTANCE OF AUGMENTED REALITY IN MEDICAL PROFESSION***" I also thank my mentor for helping me to collect the data regarding the research and encourage me to complete it within time. I also want to thank my friends and family members for supporting me in this research.

References

Alase, A., 2017. The Interpretative Phenomenological Analysis (IPA): A Guide to a Good Qualitative Research Approach. *International Journal of Education and Literacy Studies*, *5*(2), pp.9-19.

Andrade, C., 2018. Internal, external, and ecological validity in research design, conduct, and evaluation. *Indian journal of psychological medicine*, *40*(5), pp.498-499.

Avella, J.R., 2016. Delphi panels: Research design, procedures, advantages, and challenges. *International Journal of Doctoral Studies*, *11*(1), pp.305-321.

Azuma, R.T., 2019. The road to ubiquitous consumer augmented reality systems. *Human Behavior and Emerging Technologies*, *1*(1), pp.26-32.

Barsom, E.Z., Graafland, M. and Schijven, M.P., 2016. Systematic review on the effectiveness of augmented reality applications in medical training. *Surgical endoscopy*, *30*(10), pp.4174-4183.

Beckmann, J., Menke, K., Weber, P., Chova, L.G., Martínez, A.L. and Torres, I.C., 2019. Holistic Evaluation of AR/VR-Trainings in the ARSuL-Project. *INTED2019 Proceedings*, pp.4317-4327.

Chen, L., Day, T.W., Tang, W. and John, N.W., 2017, October. Recent developments and future challenges in medical mixed reality. In *2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)* (pp. 123-135). IEEE.

Dey, A., Billinghurst, M., Lindeman, R.W. and Swan, J., 2018. A systematic review of 10 years of augmented reality usability studies: 2005 to 2014. *Frontiers in Robotics and AI*, *5*, p.37.

Dougherty, M.R., Slevc, L.R. and Grand, J.A., 2019. Making research evaluation more transparent: Aligning research philosophy, institutional values, and reporting. *Perspectives on Psychological Science*, *14*(3), pp.361-375.

Etikan, I., Musa, S.A. and Alkassim, R.S., 2016. Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, *5*(1), pp.1-4.

Farouk, A. and Zhen, D., 2019. Big data analysis techniques for intelligent systems. *Journal of Intelligent & Fuzzy Systems*, *37*(3), pp.3067-3071.

Fauzi, A. and Pradipta, I.W., 2018. Research methods and data analysis techniques in education articles published by Indonesian biology educational journals. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(2), pp.123-134.

Follmann, A., Ohligs, M., Hochhausen, N., Beckers, S.K., Rossaint, R. and Czaplik, M., 2019. Technical support by smart glasses during a mass casualty incident: a randomized controlled simulation trial on technically assisted triage and telemedical app use in disaster medicine. *Journal of medical Internet research*, *21*(1), p.e11939.

Franceschinis, C., Thiene, M., Scarpa, R., Rose, J., Moretto, M. and Cavalli, R., 2017. Adoption of renewable heating systems: An empirical test of the diffusion of innovation theory. *Energy*, *125*, pp.313-326.

Hettig, J., Engelhardt, S., Hansen, C. and Mistelbauer, G., 2018. AR in VR: Assessing surgical augmented reality visualizations in a steerable virtual reality environment. *International journal of computer assisted radiology and surgery*, *13*(11), pp.1717-1725.

Hsu, Y.S., Lin, Y.H. and Yang, B., 2017. Impact of augmented reality lessons on students' STEM interest. *Research and Practice in Technology Enhanced Learning*, *12*(1), p.2.

Jentoft, N. and Olsen, T.S., 2019. Against the flow in data collection: How data triangulation combined with a 'slow'interview technique enriches data. *Qualitative Social Work*, *18*(2), pp.179-193.

Kennedy, A.M., 2017. Macro-social marketing research: Philosophy, methodology and methods. *Journal of Macromarketing*, *37*(4), pp.347-355.

Kniazieva, T., Kolbushkin, Y. and Smerichevskiy, S., 2017. Method of strategic planning and management decision-making considering the life cycle theory. *Baltic Journal of Economic Studies*, *3*(5), pp.175-182.

Kobayashi, L., Zhang, X.C., Collins, S.A., Karim, N. and Merck, D.L., 2018. Exploratory application of augmented reality/mixed reality devices for acute care procedure training. *Western Journal of Emergency Medicine*, *19*(1), p.158.

Lange, A.K., Koch, J., Beck, A., Neugebauer, T., Watzema, F., Wrona, K.J. and Dockweiler, C., 2020. Learning With Virtual Reality in Nursing Education: Qualitative Interview Study Among Nursing Students Using the Unified Theory of Acceptance and Use of Technology Model. *JMIR Nursing*, *3*(1), p.e20249.

Li, M., Porter, A.L. and Suominen, A., 2018. Insights into relationships between disruptive technology/innovation and emerging technology: A bibliometric perspective. *Technological Forecasting and Social Change*, *129*, pp.285-296.

López Belmonte, J., Moreno-Guerrero, A.J., López Núñez, J.A. and Pozo Sánchez, S., 2019. Analysis of the Productive, Structural, and Dynamic Development of Augmented Reality in Higher Education Research on the Web of Science. *Applied Sciences*, *9*(24), p.5306.

Makovhololo, P., Batyashe, N., Sekgweleo, T. and Iyamu, T., 2017. Diffusion of innovation theory for information technology decision making in organisational strategy. *Journal of Contemporary Management*, *14*(1), pp.461-481.

Mather, C.A., Barnett, T., Broucek, V., Saunders, A., Grattidge, D. and Huang, W., 2017. Helping hands: using augmented reality to provide remote guidance to health professionals. *Studies in health technology and informatics*, *241*, pp.57-62.

Min, S., So, K.K.F. and Jeong, M., 2019. Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. *Journal of Travel & Tourism Marketing*, *36*(7), pp.770-783.

Östman, S. and Turtiainen, R., 2016. From research ethics to researching ethics in an online specific context. *Media and Communication*, *4*(4), pp.66-74.

Paternoster, R., Jaynes, C.M. and Wilson, T., 2017. Rational choice theory and interest in the "fortune of others". *Journal of research in crime and delinquency*, *54*(6), pp.847-868.

Paul, J., Modi, A. and Patel, J., 2016. Predicting green product consumption using theory of planned behavior and reasoned action. *Journal of retailing and consumer services*, *29*, pp.123-134.

Peterson, L.E., Fang, B., Phillips, R.L., Avant, R. and Puffer, J.C., 2019. The American Board of Family Medicine's data collection method for tracking their specialty. *The Journal of the American Board of Family Medicine*, *32*(1), pp.89-95.

Plotzky, C., Lindwedel-Reime, U., Bejan, A., König, P. and Kunze, C., 2020. Virtual Reality in Health Care Education: A Study about the Effects of Presence on Acceptance and Knowledge Improvement among Health Care Students. *DELFI 2020–Die 18. Fachtagung Bildungstechnologien der Gesellschaft für Informatik eV*.

Pratt, P., Ives, M., Lawton, G., Simmons, J., Radev, N., Spyropoulou, L. and Amiras, D., 2018. Through the HoloLens™ looking glass: augmented reality for extremity reconstruction surgery using 3D vascular models with perforating vessels. *European radiology experimental*, *2*(1), p.2.

Procter, L., Angus, D.J., Blaszczynski, A. and Gainsbury, S.M., 2019. Understanding use of consumer protection tools among Internet gambling customers: Utility of the Theory of Planned Behavior and Theory of Reasoned Action. *Addictive behaviors*, *99*, p.106050.

Rahi, S., 2017. Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics & Management Sciences*, *6*(2), pp.1-5.

Rahimi, B., Nadri, H., Afshar, H.L. and Timpka, T., 2018. A systematic review of the technology acceptance model in health informatics. *Applied clinical informatics*, *9*(3), p.604.

Rauschnabel, P.A. and Ro, Y.K., 2016. Augmented reality smart glasses: An investigation of technology acceptance drivers. *International Journal of Technology Marketing*, *11*(2), pp.123-148.

Rauschnabel, P.A., Hein, D.W., He, J., Ro, Y.K., Rawashdeh, S. and Krulikowski, B., 2016. Fashion or technology? A fashnology perspective on the perception and adoption of augmented reality smart glasses. *i-com*, *15*(2), pp.179-194.

Rinderknecht, A.S., Dyas, J.R., Kerrey, B.T., Geis, G.L., Ho, M.H. and Mittiga, M.R., 2017. Studying the safety and performance of rapid sequence intubation: data collection method matters. *Academic Emergency Medicine*, *24*(4), pp.411-421.

Rüdiger, S. and Dayter, D., 2017. The ethics of researching unlikeable subjects: Language in an online community. *Applied Linguistics Review*, *8*(2-3), pp.251-269.

Sharma, G., 2017. Pros and cons of different sampling techniques. *International journal of applied research*, *3*(7), pp.749-752.

Silva, R.D.D.C., Albuquerque, S.G., Muniz, A.D.V., Ribeiro, S., Pinheiro, P.R. and Albuquerque, V.H.C., 2017. Reducing the schizophrenia stigma: a new approach based on augmented reality. *Computational intelligence and neuroscience*, *2017*.

SL, S. and Madhavan, V., 2018. Acceptance of Augmented Reality as a Method of Training in the Medical Field. *International Journal of Pure and Applied Mathematics*, *118*(5), pp.603-607.

Tuffour, I., 2017. A critical overview of interpretative phenomenological analysis: a contemporary qualitative research approach. *Journal of Healthcare Communications*, *2*(4), p.52.

Xue, H., Sharma, P. and Wild, F., 2019. User satisfaction in augmented reality-based training using microsoft HoloLens. *Computers*, *8*(1), p.9.

Yeom, S., Choi-Lundberg, D.L., Fluck, A.E. and Sale, A., 2017. Factors influencing undergraduate students' acceptance of a haptic interface for learning gross anatomy. *Interactive Technology and Smart Education*.

Zafar, S. and Zachar, J.J., 2020. Evaluation of HoloHuman augmented reality application as a novel educational tool in dentistry. *European Journal of Dental Education*, *24*(2), pp.259-265.

Žukauskas, P., Vveinhardt, J. and Andriukaitienė, R., 2018. Philosophy and paradigm of scientific research. *Management Culture and Corporate Social Responsibility*, p.121.