

**THE DEVELOPMENT OF AUGMENTED
REALITY BASED TEACHING MODEL FOR
TVET INSTRUCTORS**

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THE DEVELOPMENT OF AUGMENTED REALITY BASED TEACHING MODEL FOR TVET INSTRUCTORS

by

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LIST OF ABBREVIATIONS

TVET	Technical and Vocational Education and Training
AR	Augmented Reality
NOSS	National Occupational Skill Standard
COPTPA	Code of Practice for TVET Programme Accreditation
ZPD	Zone of Proximal Development Learner
ISM	Interpretive Structural Modelling
NGT	Nominal Group Technique
FDM	Fuzzy Delphi Method
TPACK	Technological Pedagogical and Content Knowledge
SSIM	Structural Self-Interaction Matrix
SAMR	Substitution, Augmentation, Modification, and Redefinition

PEMBANGUNAN MODEL PENGAJARAN BERASASKAN REALITI TERIMBUH UNTUK PENGAJAR TVET

ABSTRAK

Penyelidikan ini bertujuan untuk membangunkan model pengajaran realiti terimbuhan untuk pengajar di institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Model pengajaran ini dicadangkan untuk mengatasi masalah kekurangan panduan untuk melaksanakan amalan pembelajaran berasaskan realiti terimbuhan dalam latihan kemahiran. Kaedah pengajaran sedia ada memberi tumpuan kepada pembelajaran teori di dalam bilik darjah dan latihan praktikal di makmal, mengakibatkan kurang pendedahan kepada teknologi baharu yang digunakan dalam industri. Kajian ini menggunakan pendekatan Penyelidikan Reka Bentuk dan Pembangunan yang diperkenalkan oleh Richey dan Klein, dimana ia dijalankan dalam tiga fasa, iaitu Fasa Analisis Keperluan, Fasa Reka Bentuk dan Pembangunan, dan Fasa Penilaian. Hasil kajian Fasa 1 telah mengenal pasti keperluan untuk menambah baik kaedah pengajaran semasa dengan mengintegrasikan teknologi ke dalam latihan kemahiran program TVET. Dalam Fasa 2, pendekatan Interpretive Structural Modelling (ISM) dan Nominal Group Technique (NGT) telah digunakan untuk membangunkan model dengan khidmat tujuh orang panel pakar. Kaedah pendekatan ini melibatkan kesepakatan pakar terhadap kedudukan elemen dalam setiap domain dari aspek kuasa memandu dan kuasa pergantungan. Hasil Fasa 2 adalah pembangunan model, yang terdiri daripada 24 aktiviti pengajaran yang dikenal pasti oleh kumpulan pakar. Aktiviti pengajaran boleh dikelaskan kepada tiga domain: Kandungan, Aktiviti dan Penilaian bagi memudahkan tafsiran peranan aktiviti pengajaran tersebut. Fasa terakhir kajian ini adalah untuk menilai model yang dibangunkan menggunakan

Kaedah Fuzzy Delphi (FDM) yang diubah suai, bagi menentukan pandangan dan pendapat konsensus pengguna model. Interpretasi data adalah berdasarkan penerimaan domain dan elemen model yang diterima oleh panel pakar. Nilai peratusan skor penerimaan dikira untuk menentukan kesesuaian kesemua domain dan elemen dalam model. Nilai peratusan skor penerimaan mestilah melebihi 70% bagi setiap komponen dan elemen dianggap sesuai dan boleh digunakan. Keputusan Fasa 3 menunjukkan bahawa pengguna bersetuju dengan empat aspek yang menyumbang kepada kebolegunaan model. Hasil kajian ini boleh digunakan oleh penggubal dasar, institusi TVET dan pengajar TVET kerana ia menyediakan garis panduan untuk menjalankan latihan kemahiran menggunakan teknologi realiti terimbuhan untuk mewujudkan persekitaran pembelajaran yang berkesan. Diharapkan model pengajaran realiti terimbuhan ini dapat menambahbaik pelaksanaan latihan kemahiran agar lebih berkesan dan menarik minat pelajar di institusi TVET.

THE DEVELOPMENT OF AUGMENTED REALITY BASED TEACHING MODEL FOR TVET INSTRUCTORS

ABSTRACT

This research aims to develop an augmented reality based teaching model for instructors in Technical and Vocational Training (TVET) institutions. The teaching model was proposed in response to the problem of the lack of guidance for implementing an augmented reality learning environment in skills training. Existing teaching methods focus on theoretical learning in the classroom and practical training in laboratories, shortening exposure to new technologies used in industry. This study adopted the Design and Development Research (DDR) approach introduced by Richey and Klein, which was conducted in three phases: the Needs Analysis Phase, the Design and Development Phase, and the Evaluation Phase. The results of Phase 1 identified the need to improve current teaching methods to enhance the integration of technology into skill training in TVET programs. In Phase 2, the Interpretative Structural Modelling (ISM) and Nominal Group Technique (NGT) approaches were applied to develop the model using the expertise of seven panels. This approach involves expert consensus on the position of elements within each domain in terms of driving power and dependence power. The results of Phase 2 are the outcome of the model's development, which consisted of 24 teaching activities identified by the expert group. The teaching activities could be classified into three domains: Content, Activity, and Assessment, facilitating the interpretation of their roles. The final phase of this study is to evaluate the developed model using a modified Fuzzy Delphi Method (FDM), to determine the consensus views and opinions of the users of the model. Data interpretation is based on the acceptance of the model's domains and elements by the

expert panel. The percentage score of acceptance is calculated to determine the suitability of all domains and elements in the model. A percentage score of acceptance exceeding 70% for each component and element is considered suitable and acceptable for use. The results of Phase 3 showed that users agreed with four aspects that contribute to the usability of the model. The outcome of this study could be useful for policymakers, TVET institutions, and TVET instructors as it provides guidelines for conducting skills training using augmented reality technology to create an immersive learning environment. It is expected that the augmented reality teaching model will improve the implementation of skills training to be more effective and engaging for students in TVET institutions.

CHAPTER 1

INTRODUCTION

1.1 Overview

The development of knowledgeable and skilled human capital that can adapt to current and future technologies is important to produce competent, efficient, innovative, and competitive workers in the future job market. The Future of Jobs Report 2023 (Schwab & Zahidi, 2023) identifies several key technologies associated with Industry 4.0 that could lead to a significant impact on the job market in the coming years. Some technologies are expected to be job creators, and others will result in significant labour market disruptions (Chuang & Graham, 2018; Cukier, 2019). The report also suggests that skill training programs can help produce competent workers by providing them with the knowledge and skill competencies to succeed in the manufacturing industry.

Karabegović, Karabegović, Mahmić, and Husak (2020) describe Industry 4.0 as the concept of integrating new emerging technologies, including advanced robotics, artificial intelligence, the Internet of Things (IoT), big data analytics, cloud computing, augmented reality, and cybersecurity (Karnik et al., 2022; Suleiman et al., 2022), enabling smart production processes where machines are connected and can make autonomous decisions. Among these technologies, augmented reality has benefited manufacturing processes by improving product quality and shortening the cycle time thus reducing production costs (Chiew & Sung, 2022). Previous studies (Dey et al., 2018; Rusho et al., 2024; Stavropoulou et al., 2025) also concluded that augmented reality technology has a positive influence in the entertainment, medicine, tourism, and education fields.

Azuma (1997) defines augmented reality as a technology that has the capability to connect real-world objects with virtual elements and subsequently make both interact in the real-time. Schein & Rauschnabel (2022) added that augmented reality technology can display digital information on the users' view of the real world. These key characteristics make augmented reality technology valuable for immersive and engaging manufacturing training experiences. There are cases when the training using the real equipment needs higher cost and could be dangerous. In response to that, Ottogalli et al. (2019) built a simulation learning system with virtual reality and augmented reality technology to train workers to operate machines. They claimed that the use of these simulations contributes to lower production costs when it reduces training time and less misconduct of machinery.

Augmented reality technology supports an immersive and engaging training experience as it permits the interaction between virtual objects and real-world environments (López et al., 2020). These elements are useful for manufacturing skills training, where students can practise using virtual equipment and get real-time feedback (Ren et al., 2023) in a realistic and safe training environment (Wang et al., 2021). Therefore, students in skill training centres, as future workers in the manufacturing industry, need to have a combination of technical skills and knowledge of augmented reality technology to meet industry requirements.

Educational, Scientific, and Cultural Organization (UNESCO) plans a strategy to offer recognized and certified skills for school leavers and semi-skilled workers through Technical and Vocational Education and Training (TVET) programs (UNESCO-UNEVOC, 2020). The strategy aims to enhance collaborative efforts between governments, industries, and training institutions to provide education, skills,

and employment for up to one billion people by 2030. TVET has been implemented successfully in Germany and other European countries such as Sweden and Luxembourg through industry-education collaboration supported by their government policy to meet digital requirements in the new emerging Industry 4.0 era (*Innovation and Digitalisation in Vocational Education and Training*, 2020). The way they optimise their resources and investment towards the education system can be used as a guide to other countries in producing skilled workers.

In the global context, TVET has been established as a certified training institutions that provide Industry 4.0 related skills (Schröder, 2019). The United Kingdom, Germany, and the United States have become key players in the manufacturing industry (Omar et al., 2020) with their advanced technology-based education (*Future of TVET Teaching*, 2020). However, according to UNESCO (2021), the TVET program in ASEAN countries is not yet able to equip students with Industry 4.0 related skills and meet the needs of the industry. The report also highlighted challenges in implementing TVET programs in Malaysia, such as the lack of knowledge on new emerging technologies among instructors, and the lack of budget to cover the maintenance costs for high-tech equipment.

TVET programs in Malaysia are offered through a range of institutions, including polytechnics, vocational colleges, community colleges, and technical universities. These institutions are managed by different ministries and agencies, with the Ministry of Human Resources (MOHR) playing significant roles (Majlis TVET Negara, 2024). TVET in Malaysia covers a various of disciplines, including manufacturing, engineering, information technology, agriculture, hospitality, and health sciences. The demand for skilled workers is increasing, particularly in industries

such as manufacturing, construction, and technology. The government continues to invest in TVET to meet these demands and to ensure that the workforce is equipped with the skills needed for Industry 4.0.

The use of augmented reality can significantly support skill training in environments where maintaining high-tech equipment is challenging due to resource constraints, high costs, or accessibility issues (Chiang et al., 2022). Augmented reality based training minimises the dependence on physical machinery by providing virtual simulations that replicate real-world tasks and equipment. This reduces the wear and tear on actual machines (Matsika & Zhou, 2021). Augmented reality applications can simulate the operation of complex technical devices like CNC machines, oscilloscopes, or robotic arms, allowing students to practice essential skills without needing constant access to high-tech equipment.

Augmented reality is being widely adopted in technical training across several countries, enhancing learning outcomes by making education more interactive and accessible. In Malaysia, augmented reality is used in subjects like current and voltage, welding, and CNC machine operations, where it improves user engagement and allows flexible learning (Adam et al., 2022; Rusli et al., 2019; Zuhairy et al., 2021). Researchers in Thailand integrates augmented reality into microcontroller training, where it has been found effective for hands-on learning (Pipattanasuk & Songsriwittaya, 2020). Similarly, in Chile, augmented reality success in digital current training highlights how the educational environment can influence students' attitudes toward emerging technologies (Álvarez-Marín et al., 2021). Akçayır et al. (2016) use augmented reality in physics laboratories to enhance laboratory skills and improve students' attitudes toward experiments in Turkey, while in Saudi Arabia AlNajdi et al.

(2020) apply AR in robotics training to enhance enjoyment and learning achievement. These examples demonstrate how augmented reality enhances technical education globally by providing immersive, flexible, and hands-on learning experiences tailored to each country's specific educational and technological needs.

Despite the growing integration of augmented reality in technical training, several research gaps remain in the context of teaching models that effectively support augmented reality usage. Many studies have demonstrated the benefits of augmented reality in enhancing engagement, motivation, and practical skills, yet research on the most effective instructional frameworks to optimize augmented reality integration is still limited (Bacca et al., 2019; Chen et al., 2020). While experiential and constructivist learning models are commonly suggested as suitable for augmented reality-based education, there is insufficient evidence on how to tailor these models to different technical fields, skill levels, and student's needs. This gap calls for more detailed studies to design and develop various teaching activities in maximizing augmented reality potential across diverse technical skill contexts.

Augmented reality also enhances maintenance and troubleshooting training by offering interactive overlays that guide students step-by-step through virtual repairs and diagnostics. This virtual assistance can help learners understand the internal mechanisms of high-tech equipment without dismantling real machines, thereby avoiding potential damage (Sakr & Abdullah, 2024). Additionally, augmented reality can support flexible and remote training by allowing students to engage with augmented reality content anytime, anywhere, thus overcoming the limitations posed by equipment shortages or malfunction (Sun et al., 2021). Augmented reality ensures that skill development continues even in settings where maintaining advanced

technical equipment is difficult by diversifying training options and reducing reliance on physical resources.

1.2 Background Study

Industry 4.0 is expected to give significant impact on the types of jobs and skills that will be in demand in the future. Industry 4.0 involves the combination of cutting-edge technologies such as the Internet of Things (IoT), artificial intelligence, augmented reality, virtual reality, and robotics into manufacturing processes (Ghobakhloo, 2020; Karnik et al., 2022). These advanced technologies require highly skilled workers to operate and maintain these complex systems. As Industry 4.0 is a continuous process, industry workers must learn new skills and keep up with new technologies (Longo et al., 2017). Therefore, skill training centres and instructors also need to adapt to this change and shift their focus to Industry 4.0 related skills to provide future workers with the necessary skills they need to succeed in the new working environment.

TVET is one of the initiatives under the Eleventh Malaysia Plan (Economic Planning Unit, 2015) to enhance the effectiveness of vocational training programs in preparing graduates to meet the evolving skill requirements of various industries and to improve their employability. The implementation of TVET programs in Malaysia is guided by the National Occupational Skill Standard (NOSS) issued by the Department of Skill Development (DSD). According to *NOSS TVET Instruction* (2021), instructors must have teaching competency, which combines expertise in technical subjects, pedagogical and digital knowledge to deliver effective training. Therefore, instructors should enhance current teaching competency by using appropriate instructional strategies, technology, tools and resources (Mohebi, 2021;

Pipattanasuk & Songsriwittaya, 2020) to create engaging and effective learning experiences to suit industry best practices.

The Department of Skill Development (DSD) plays a pivotal role in managing TVET programs in Malaysia and recognizing instructors' teaching competency through standard certification. DSD through the Centre for Instructor and Advanced Training (CIASST) are responsible for coordinating the instructors' training with the implementation of reskilling and upskilling programs (Department of Skills Development, 2021a). The recognition of CIASST as a Centre of Excellence (CoE) for TVET Instructors is very important to support the mission of developing instructors with world-class standard that equipped with competent knowledge, good discipline, and responsive to technological changes (*TVET Instructor EProfiling System*, 2022). The reskilling programs at CIASST focus on upgrading instructors' technical competencies, teaching methodologies, and their ability to integrate advanced technologies into the teaching process.

Instructors must execute their instructional teaching plans by employing presentation skills and pedagogical approaches that align with available educational technology tools. During 2022, CIASST implemented a series of skills enhancement programs to improve the knowledge and expertise of TVET instructors, industry workers and the public in technical courses, Industry 4.0, and emerging technologies. They also offer short-term courses in ICT and Multimedia. This program offers various courses to develop skills in multimedia content development. All the courses offered are designed to impart understanding about new emerging technologies necessary for students as future workers in the manufacturing industry. There are 38 courses were successfully conducted as part of this program and 607 participants were trained

(*Laporan Tahunan 2022, 2023*). The participants came from various sectors of public and private TVET institutions and industries. The courses were delivered in various teaching delivery, such as face-to-face, hybrid and online courses.

Previous studies show that augmented reality technology can help facilitate the delivery of technical skills content for various subjects (AlNajdi et al., 2020; Chiang et al., 2022; Wang et al., 2018). CIIAST acknowledges this imperative by offering comprehensive courses in augmented reality technology. These courses provide instructors with the knowledge, expertise and tools required to integrate augmented reality technology seamlessly into their teaching methods and materials. CIIAST has planned several courses on leveraging augmented reality technology to empower technical skill delivery, particularly in the fields of mechatronics, welding, mechanical, computer, electronics and automotive. Among the courses are Fundamental Augmented Reality and Virtual Reality for TVET Instructors and Augmented Reality and Virtual Reality Developer. Augmented Reality Application Development Course has been offered as a modular course twice a year for instructors in Malaysia.

Compared to Virtual Reality (VR) and Artificial Intelligence (AI), augmented reality offers distinct advantages in technical teaching. Augmented reality overlays digital information onto the physical world, allowing students to visualize complex technical concepts in real-time without leaving their environment (Wang et al., 2021). This contextual learning aids in better comprehension and retention. Furthermore augmented reality applications can be accessed via smartphones or tablets, making them more affordable and easier to implement than VR setups, which often require specialized equipment (Zuhairy et al., 2021). This accessibility facilitates broader

adoption in educational settings .In term of hands-on practical, augmented reality enhances real-world environments by overlaying pertinent information, allowing students to practice technical skills within their actual workspaces.

The digital transformation from manual systems to computerised automation systems in the manufacturing industry requires knowledge of advanced technologies and specific skills to operate the equipment. Malaysia has taken a step forward with the launch of the National Industrial Master Plan 2030 (NIMP 2030) on 1 September 2023 to increase manufacturing value by 6.5 percent to RM587.5 billion by 2030 (Ministry of Investment Trade and Industry, 2030). This new industrial policy will focus on high-impact sectors such as aerospace, electricity and electronics, medical devices, machinery and equipment, and renewable energy. TVET and Industry 4.0 are important elements of the NIMP 2030, as they will help enhance the workers' skills and competencies (Adnan et al., 2021; Nurjanah & Ana, 2022), improve productivity and innovation, and create more high-value jobs.

Industry 4.0 was introduced in Germany as a concept of a production model that utilised a set of technologies that optimise the devices and processes with minimal dependent of human labour (Bakhtari et al., 2020). Although a minimum of labour is required to produce a product using automated machines, thus reducing labour costs (Ching et al., 2022), advanced manufacturing techniques and processes require more highly skilled and certified workers to perform the task efficiently. As the industry evolves and new technologies emerge, skill training students as future workers must enhance their employability to be compliant and relevant to the dynamic changing in work environment (Beer & Mulder, 2020). Therefore, instructors in TVET institutions

need to keep abreast of the latest technological developments in their respective fields so that they can impart the knowledge and skills required by industry.

TVET programs can offer a more effective and engaging learning ecosystem that prepares them for a real work environment by leveraging the power of augmented reality technology (Hincapie et al., 2021). However, it is important to consider infrastructure requirements, top management support (Masood & Egger, 2019), content development, and instructor training (Alzahrani, 2020) to ensure successful implementation. Jafar et al. (2020) and Mohd Ishar et al. (2020) emphasise the need for technical innovation, new training facilities, relevant policies, and enhanced instructors' competencies to use augmented reality technology in TVET. Therefore, augmented reality technology should be integrated thoughtfully into the curriculum, considering the specific needs of TVET programs and the DSDs' certification requirements.

Current studies emphasize short-term benefits, such as increased engagement, immediate learning gains, and reduced cognitive load, but there is limited understanding of how augmented reality teaching methods impact long-term skill retention, transfer to real-world tasks, and professional performance (Chiang et al., 2022). Another significant gap lies in the lack of research on long-term learning outcomes associated with augmented reality-based teaching models. Additionally, the sustainability and scalability of augmented-supported instructional methods in TVET have not been thoroughly explored. Questions remain about how well augmented reality-based teaching models can be adapted for different learning environments, including resource-limited institutions, and how they affect the broader educational ecosystem.

1.3 Problem Statement

Technical skills are crucial for TVET students to thrive in the manufacturing industry. According to Minghat et al. (2020), vocational schools must teach the technical skills required by Industry 4.0 so students can operate advanced machinery. Additionally, innovative pedagogical practices in classrooms are essential to ensure effective teaching and enhance the student learning experience (Harris & de Bruin, 2018). However, students have problems visualizing complex skill content because traditional learning materials do not convey the entire curriculum well (Fernández-Enríquez & Delgado-Martín, 2020). According to (De Moraes et al., 2023) augmented reality technology offers new methods and approaches to learning, revolutionizing conventional teaching methods. Augmented reality technology is able to offer interactive and immersive learning experiences, facilitating skill development in dynamic and realistic environments (Onu et al., 2023). Consequently, the use of augmented reality is essential in the design and development of immersive learning environments.

Most research in augmented reality technology aimed at developing and evaluating applications for specific topics using specialized software (Blanco-Novoa et al., 2018; Quintero et al., 2019). In contrast, Czerkawski & Berti (2021) emphasized the role of instructors in dealing with augmented reality technology in terms of hardware and software before it is introduced in the classroom. They recommended implementing augmented reality technology in instructional design in both theoretical and practical training to facilitate future learning experiences. Furthermore, Laviola et al. (2022) and Marino et al. (2021) asserted that instructors should be familiarised with the technology used in the industry to remove barriers between current teaching

approaches and advanced technology that can enhance the training quality and avoid human errors while completing the task to achieve learning objectives.

Adam et al. (2022) proposed an augmented reality mobile application aimed at guiding workers in the operation of CNC machines and enabling remote system control from a mobile device. This innovative mobile application has significantly enhanced the efficiency of CNC machine operation and reduced the risk of hazards and accidents, hence improving machining performance while decreasing completion time. Blanco-Novoa et al. (2018) conducted an evaluation of automated and computerized operations in Industry 4.0 shipyard and concluded that the integration of augmented reality technology in the experiment enabled better operator performance.

However, some instructors may resist the introduction of new technologies because they do not have guidance on how to seamlessly integrate them into their curriculum, resulting in less use of these innovative technologies (Akçayır & Akçayır, 2017). Limited familiarity with augmented reality technology, inadequate training opportunities, lack of integration of augmented reality technology into the curriculum, and resistance to adapting to technology are among the factors that contribute to instructors' reluctance to use augmented reality technology to teach skills in TVET changes (Alzahrani, 2020; Romano et al., 2020; Salleh et al., 2021). Additionally, Matsika & Zhou (2021) claimed that a lack of guidance for instructors to use augmented reality technology in teaching could be a barrier to the provision of virtual learning environments in the TVET context. Not only that, but a more important aspect to consider is how to utilise it to enhance the student learning experience (Garzón et al., 2019). This shows a significant gap between the current teaching methodology and the appropriate teaching models to effectively guide the deployment of augmented

reality technology. Therefore, a new teaching model with the integration of augmented reality technology to conduct skill training is needed for TVET instructors.

There is a need to identify the possible method where augmented reality technology can be fully utilised in the TVET teaching and learning process to ensure that the implemented measures provide tangible and meaningful benefits to both instructors and students, thereby enhancing the overall learning experience. An effective augmented reality-based teaching model for TVET should provide a guide to create immersive and interactive learning environments (Saif et al., 2021). This includes an augmented reality environment that allows students to explore real-world scenarios and tasks within a safe, controlled digital space (Onu et al., 2023). The learning environments should be modelled on actual work environments so that students can gain practical experience (Solmaz et al., 2021). Therefore, several essential elements need to be incorporated into the current TVET teaching methodology to create a new augmented reality teaching model.

Augmented reality can display 3D models, animations and simulations that demonstrate complex technical concepts and processes in a visual (Arnay et al., 2017; Hamel & Ryan-Jones, 1997). These elements help students grasp and apply theoretical knowledge during hands-on practical training, promoting a deeper understanding of technical subjects. The teaching model must provide adaptive learning pathways and real-time feedback to students. Continuous training and easy access to augmented reality technology facilities are crucial to ensure successful integration and ongoing support for instructors and students. The augmented reality teaching model for TVET can potentially improve student engagement, motivation, and retention, as well as support the development of practical skills and enhance the learning experience (Gong

et al., 2024). However, like any educational approach, it should be carefully designed and integrated into the curriculum to align with learning objectives and instructional goals and ensure that it enhances the overall learning experience for the students (Takrouiri et al., 2022). Proper guidelines and support for instructors are needed to assist them in implementing augmented reality technology efficiently in skill training for TVET programs. This research aims to develop a new TVET teaching model as needed in conducting skill training using augmented reality.

1.4 Research Objectives

This research aims to develop an augmented reality teaching model for TVET instructors to conduct skill training for TVET programs in TVET institutions. This study are conducted to achieve these research objectives:

1. To identify the need to develop a teaching model with augmented reality technology to conduct skill training program in TVET institutions.
2. To design and develop an augmented reality teaching model for skill training based on expert views.
3. To evaluate the usability of augmented reality teaching model in TVET institutions.

1.5 Research Questions

Refer to the research objectives, research questions have been formulated for every phase of this study. They are as follows:

1. The need to develop an augmented reality teaching model.

- a. What is the knowledge of augmented reality technology among TVET instructors?
 - b. What are the perceptions of using augmented reality technology in TVET program?
 - c. Is there a need to develop an augmented reality teaching model for TVET instructors?
2. The design and development of an augmented reality teaching model based on expert view.
 - a. What elements need to be included in the teaching model?
 - b. What are the relationships between elements in the teaching model?
 - c. How should the elements be classified in the teaching model?
3. What is the TVET instructors' agreement on the usability of the augmented reality teaching model for skill training?

1.6 Theoretical Framework

This theoretical framework describes the relationship between the concept of skill training and the elements of augmented reality technology that can help improve the training process and achieve learning outcomes. The theoretical foundation chosen for this study is Zone of Proximal Development (ZPD), developed by Vygotsky. The Technological Pedagogical and Content Knowledge (TPACK) that focuses on the intersection of content, technology and pedagogy will be used as a reference to select suitable teaching activities as the elements of the model. Meanwhile, the Substitution, Augmentation, Modification, and Redefinition (SAMR) model, which explains how instructors can effectively integrate technology into the classroom and guide the

development of a teaching model to promote meaningful skills, knowledge and experience through an immersive learning environment.

1.6.1 Zone of Proximal Development (ZPD)

Zone of Proximal Development (ZPD) is identified as a constructivist learning theory to guide the elements of problem solving, guided instruction and peer interaction in the model (Conole et al., 2004). This theory emphasizes the interactive (Sellberg et al., 2022) and dynamic nature of learning, especially when it comes to acquiring new skills. ZPD theory plays a crucial role in education, especially in skill training where it represents the gap between what a student can do on their own and what they can accomplish with the assistance of a more experienced classmate or instructor as shown in Figure 1.1. In this study, instructors can use this theory to design lessons that challenge students within their ZPD and improve their skills. It highlights the necessity to decompose complicated skills into small scale manageable steps that are based on students' current abilities and allow for incremental skill improvement.

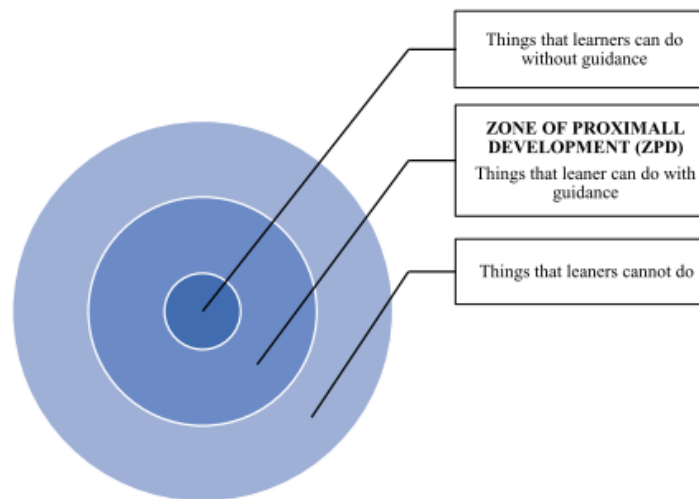


Figure 1.1 Zone of Proximal Development (ZPD)

Source: Vygotsky (1978)

In a skill training context, the success of technology-enhanced instruction depends on the right combination of technology, pedagogy and content for specific lessons (Krüger & Bodemer, 2022). The concept of instructors' knowledge of the subject matter they teach is often referred to as content knowledge, as described in the standard practice of TVET teaching competency (Department of Skills Development, 2021b). Therefore, it is imperative to combine the right pedagogical, content and technology for effective training.

1.6.2 Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is a framework that describes the interrelated knowledge that instructors need to effectively integrate technology into their teaching (Mishra & Koehler, 2006). The three key areas of the TPACK model are content, pedagogy and technology as shown in Figure 1.2.

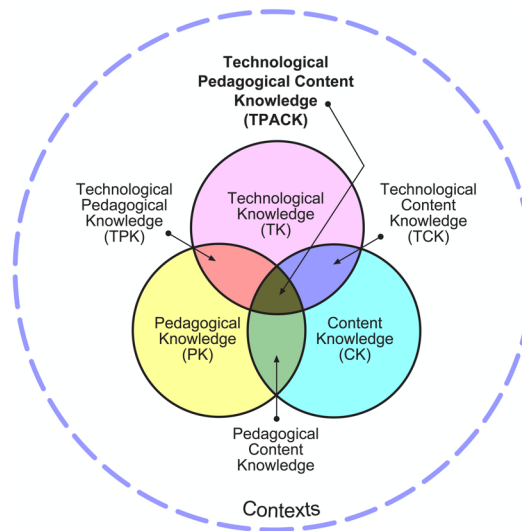


Figure 1.2 TPACK Framework

Source: Mishra & Koehler (2006)

The relationships between them are defined by Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). The TPACK model offers a valuable framework for effectively integrating augmented reality technology into skill training. Instructors need to start by developing a deep understanding of the technical skill content and specific learning goals, which is the Content Knowledge (CK). This is crucial because skill training involves particular skills, knowledge, and attitudes that must be effectively conveyed to students (Department of Skills Development, 2021c).

TPACK highlights the critical role of integrating these components to create effective and engaging learning experiences. In this study, the TPACK serves as a reference for the selection of suitable teaching activities to be included as an element in the model. For the first component, Content Knowledge (CK), instructors need to understand the complexities of augmented reality technology itself, including its functions and limitations. Second, instructors need to focus on the Pedagogical

Knowledge (PK) component of the TPACK model. This involves determining the most appropriate pedagogical approaches and teaching strategies. When integrating augmented reality technology, instructors refer to Technical Knowledge (TK) to identify how augmented reality can enhance the learning process, promote active engagement, and improve skill acquisition. This could include the development of interactive augmented reality simulations, virtual workplace scenarios or hands-on augmented reality-guided activities that are aligned with the content and learning objectives.

Finally, the integration of augmented reality technology should be a harmonious blend of CK, PK and TK. Instructors should create a balanced TPACK model by effectively blending their understanding of technical content, augmented reality technology and instructional strategies (Salleh et al., 2022). This can be done by creating detailed augmented reality-based lesson plans, aligning learning objectives, and continuously evaluating the efficiency of augmented reality-based instructional material in achieving training objectives.

1.6.3 Substitution, Augmentation, Modification, and Redefinition (SAMR)

Figure 1.3 shows the four levels of the SAMR model, namely substitution, augmentation, modification, and redefinition. The levels can be divided into two subgroups: enhancement and transformation (Tunjera & Chigona, 2020).

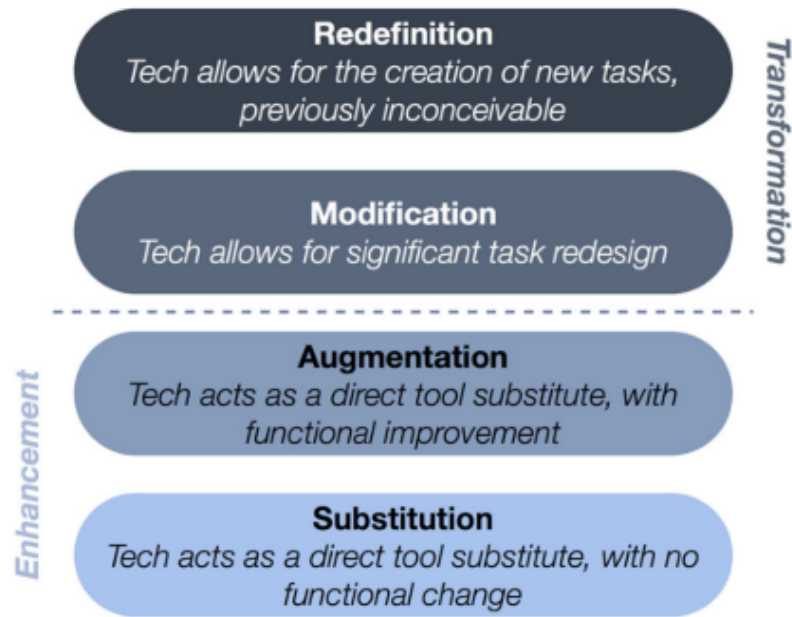


Figure 1.3 SAMR Model

Source: Hamilton et al. (2016)

The SAMR model provides a structured approach the integration of augmented reality into technical education, starting from simple substitution of traditional methods to redefining the learning experience through advanced technological integration. In the context of this study, SAMR model serves as a guide for developing augmented reality environments that are both effective and engaging for students. The integration of Zone of Proximal Development (ZPD), Technological Pedagogical Content Knowledge (TPACK), and SAMR models within augmented reality teaching provides a powerful framework for designing effective, engaging, and developmentally appropriate learning experiences.

These three theories/models interconnect in the context of augmented reality-based instruction as shown in Table 1.1

Table 1.1 Theories and Models Interconnection

Model	Role in Augmented Reality Teaching	Interconnection
ZPD	Ensures augmented reality content is developmentally appropriate and scaffolded	Augmented reality must help students perform tasks just beyond their current abilities
TPACK	Guides teachers in integrating augmented reality in ways that balance content, pedagogy, and tech	Strong TPACK enables the creation of augmented reality experiences that target ZPD
SAMR	Helps evaluate how augmented reality transforms learning	Higher SAMR levels promote engagement within ZPD, when grounded in TPACK

1.7 Conceptual Framework

Augmented reality technology involves superimposing digital content like images, videos, or virtual information onto the physical world, developing an immersive and interactive learning experience (Azuma, 1997; Sereno et al., 2022; Wu et al., 2013). The augmented reality teaching model is a pedagogical approach that incorporates augmented reality technology into skill training delivery. In the augmented reality learning environment, students use devices such as tablets, smartphones, or headsets to view and interact with virtual content that is superimposed onto their physical surroundings (Boboc et al., 2020; Strzys et al., 2018). This encourage students to engage in immersive and interactive learning experience where

they can visualise abstract concepts, manipulate virtual objects (El Kabtane et al., 2018), and explore virtual environments in real time (Matsutomo et al., 2012).

The knowledge transfer is improved by technology. Instructors must not only interpret the material for the student and create examples that are specific to the subject matter, but they must also comprehend the relevant classroom technology and modify their methods accordingly (Yian & Park, 2017). Augmented reality technology can be applied in various educational settings, from preschools to higher education, and across different subjects, including science, mathematics, history, art, and more (Lai & Cheong, 2022; Saltan & Arslan, 2017). This study focus on how augmented reality technology can be used to enrich the training delivery process in TVET programs. The augmented reality teaching model will be used by TVET instructors to develop interactive learning content using augmented reality technology to support immersive learning environment. Therefore, students can use augmented reality technology to explore and manipulate virtual 3D models of machines and equipment, providing a hands-on experience that enhances their understanding of complex concepts.

The important aspect is the teaching model should consider the skill training concepts as stated in policy, guidelines, TVET curriculum, content delivery, practical activity, and competency assessment. The augmented reality teaching model for TVET is a set of guidelines or principles that can be referred to begin the creation of augmented reality-based training materials and technical skills activities. It utilised the interactive features of augmented reality technology to improve the effectiveness of technical skills training.

The design and development practice of the augmented reality teaching model for TVET should include several key elements to ensure is effective and meets the

needs of students and instructors. From the elements derived from the literature review, this study selects six elements: i) Interactivity, ii) Simulation, iii) Performance feedback, iv) Remote expert assistance, v) Annotation and vi) Practice assessment to be considered in the design and development process as presented in a conceptual framework in Figure 1.4.

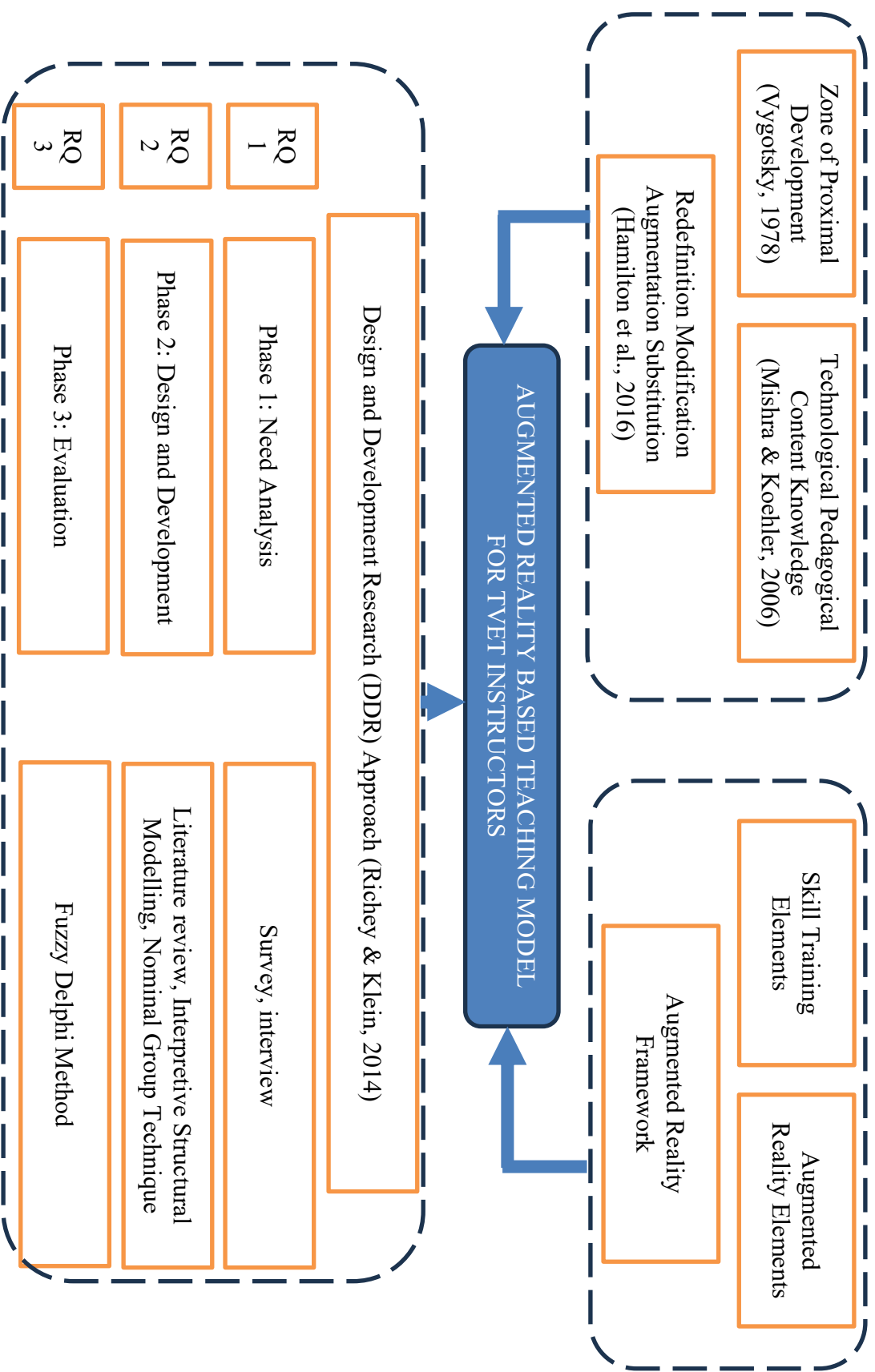


Figure 1.4: Conceptual Framework