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Inquiry Practice Capability and Students' Learning Effectiveness Evaluation in Strategies of Integrating Virtual Reality into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice: A Case Study

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Abstract: VR has shown positive growth in the world in recent years, which is mainly due to projects such as learning, games, entertainment and experiential activities. VR has changed the way of life of users, providing users with more interesting interactions and immersive experiences. This study aims to investigate students' practical capabilities and learning effectiveness under the instruction strategy of integrating virtual reality into simulation games into the Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice curriculum for students of the Dept. of Auto Mechanics in a skills-based senior high school. Two student classes of the Dept. of Auto Mechanics major in Electrical Engineering featuring practical subjects in one skills-based senior high school in central Taiwan were chosen as the participants for this study. By way of pretest–post-test research design and heterogeneous grouping, an 8-week instruction experiment was conducted in which ZPD (zone of proximal development) instruction strategies were used in the experimental group (with 43 persons), while traditional didactic instruction strategies were used in the control group (with 36 persons). ZPD instructional strategies analyze and collect quantitative and qualitative data to investigate the instructional effectiveness and feasibility in developing ZPD as the research material in the practical curriculum for the study area of the Power Machinery in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services practice. According to the research objective, the results are concluded as follows. (1) Students achieved the best learning effectiveness when adopting ZPD (zone of proximal development) strategies in which virtual reality was integrated into the vehicle charging and starting system to investigate students' automotive diagnostic troubleshooting and fault-clearing capabilities. (2) Students attained the highest acceptance in learning phenomenon when adopting ZPD (zone of proximal development) strategies in which virtual reality was integrated into students' familiar practice factory environment and the tools and equipment operation process. (3) Students had a higher acceptance of learning effectiveness when using virtual reality simulation games in the disassembly and functional detection of vehicle charging and starting systems. (4) There is a positive effect when integrating virtual reality simulation games into ZPD instruction strategies in the knowledge, skills and attitude on students' overall inquiry practical capabilities and their learning effectiveness.

Keywords: skills-based senior high school; virtual reality; ZPD (zone of proximal development) instructional strategies; learning engagement; learning effectiveness

1. Introduction

In the past two years, the world has been affected by the new crown epidemic (COVID-19), which causes significant changes in human life and patterns. The supply–demand gap in global stock markets appears as a result of the coronavirus crisis and at the same time leads to the rise in international raw material prices, supply chain problems, and chip shortages. As a result, there are also wave-like changes in daily food, clothing, housing and transportation biotechnology [1]. According to the data released by the Ministry of Economic Affairs (MOEA) in Q1 2022, the demand for the Taiwanese auto parts market will be tightened in 2020 due to the COVID-19 epidemic and the disruption of the supply chain in many cities around the world, resulting in an annual decrease of 4.4% in output value; in 2021, with the continuation of the goods tax subsidy policy and the extension of the epidemic, the purchase of cars will emerge, and the gradual lifting of the seal in Europe and the United States will lead to a recovery in demand for auto parts. Taiwan's auto parts market will grow at an annual rate of 21.0% [2,3]. The global semiconductor supply chain is facing disruptions that affect operations, cause shutdowns in some countries, and at the same time, widen the gap between automotive electronics and consumer electronics components that reduce chip shortage. Nevertheless, due to the proper control of the epidemic in Taiwan, and also because Taiwan's geographical location is not within the scope of the US–China trade war, Taiwan has advanced process technology, as well as close and reliable industrial clusters, which help Taiwan stand out in the global automotive industry chain [4,5]. Taiwan's performance in the automobile industry has grown prosperously in the past five years against the trend in the context of poor sales in the global auto market, which is mainly due to the epidemic factor in that people are worried about the risk of infection in the public transportation system. Therefore, the new demand for "mobility and autonomy" has been spawned, which also drives the sales of new cars and second-hand cars to show a growth trend all the way, becoming a unique phenomenon in Taiwan [6]. Taiwan's vehicle industry is an extremely important industry in Taiwan, and the total output value of Taiwan's vehicle industry continues to grow with an increase of 7.22% from January to September in 2022 (NT$560.9 billion from January to September) that accounts for about 4.30% of the total output value of Taiwan's manufacturing industry [7]. Despite the global epidemic, the smart EV industry is still standing, which is largely due to "policy and regulatory oversight". As environmental awareness rises, carbon emission rules are becoming more stringent and zero-emissions vehicle purchase policies are accelerating. By the end of 2020, more than 20 countries around the world have announced bans on the sale of conventional fuel vehicles or require the latest batch of vehicles sold to be zero-emissions vehicles. At the same time, "tax and subsidy incentives" are being offered by most countries to meet their 2030 environmental policies, and governments are extending incentives to revive the smart EV market as the epidemic hits economic activity in many countries. International organizations and governments have been influenced by climate change and green economy thinking. From the Kyoto Protocol to the Paris Agreement to the United Nations Climate Change conference, the emphasis on climate issues continues to grow, and this has led to the development of the smart electric vehicle industry [8,9]. According to the data from the National Greenhouse

Gas Inventory in 2022 of the Environmental Protection Agency of the Executive Yuan, the International Energy Agency announced that Taiwan's fuel combustion emission carbon dioxide emission index has occupied 22nd place in the world, and among them, the transportation part accounted for 14.17%, which is enough to show that the automobile industry is booming. In addition, Taiwan has also successively launched new energy vehicle policies in the past two years to improve air pollution problems [10]. In the face of the international 2050 Net Zero Emissions target, electric vehicles have become one of the key projects for Taiwan to achieve this goal. Taiwan's global semiconductor industry is well positioned to meet the large demand for EV chips from automakers. With its electrical, electronic control, and battery technologies and component manufacturing capabilities, Taiwan is actively entering the global EV supply chain, and it has become a major focus for domestic universities to train industry talent [11,12]. Muzir et al. (2022) believes that in addition to new energy vehicles, good energy management is also an important factor improving the sustainable development of the industry [13]. With the substantial increase in the number of vehicles listed in Taiwan, which indirectly causes a serious talent shortage in the vehicle industry, "satisfying the thirst for talents" can be said to be imminent [14]. The rise of electric vehicles has changed the automotive industry from mechanical engineering (mechanical engines, drive shafts, brake discs) to relying on electrical and mechanical engineering (motors, batteries, power distribution panels, power converters) and information electronic engineering (onboard computers, networks, radar, sensors, display panels, etc.) technologies; whether it is electrical and mechanical engineering or information network electronic engineering, components or subsystems, especially in the IC chip manufacturing, design and other semiconductor industry areas, almost all are Taiwan's strengths [15]. As a consequence, Taiwan's auto industry is facing a rapid transformation, in which electrification and intelligent vehicles have become one of the hottest topics in Taiwanese society [16]. Therefore, for the process of future automotive technology development, it is necessary to carry out the revision of courses related to automotive electrical appliances, to add the course content of hybrid vehicle technology research activities, to plan innovative courses such as Electric Vehicles Theory and Practice, Electric Vehicle Theory and Core Competencies Practice and Related Issues in order to enhance Taiwan's automotive technology capabilities [17].

According to the educator Piaget, "the basic model of behaviour that human individuals use to adapt to their environment is primarily through the cognitive effects of balance, adaptation, accommodation, and assimilation to produce cognitive change and learning" [18,19]. The Organization for Economic Cooperation and Development (OECD) suggested "The Future of Education and Skills 2030" in 2018 to assist countries in education innovation [20]. The focus is on thinking about the competency-oriented nature of students and the appropriate teaching style for teachers to effectively guide students to learn the attitudes and knowledge needed for the future. According to Lan (2019), the implementation of the competence-oriented curriculum focuses on the design of learning experiences, including the "selection of contexts" and the "organization of contexts". Students explore in learning contexts through peer discussion, interaction with materials and equipment, so the choice of contexts determines what concepts students will learn, and then teachers organize and arrange the concepts in different learning contexts to facilitate the development of relationships between concepts [21]. The basic model of behavior can be applied to cooperative learning, allowing students to interact and cooperate to achieve common learning goals and build the ability to collaborate with others. Through a variety of learning styles, students can acquire rich learning connotations and problem-solving skills that use the function of education to transform the process of class [22]. The implementation of re-cognitive structures can sharpen students' potential learning outcomes of computational thinking to solve life and learning problems, which in turn can lead to a richer life [23]. Scaffolding learning provides students with learning resources that match their original abilities and significantly enhances learning motivation through mutual guidance and learning between teachers and students and peers [24]. Lin and Lin (2007) believe that the temporary scaffolding created by teachers can make learners focus on learning goals and control frustrations in the process, while providing demonstrations and giving successful experiences. Thus, through the teaching method of scaffolding theory, students can develop skills and problem-solving abilities so that technical learning can be most effective [25]. The traditional teaching method in our country tends to tell the teaching method of "teacher teaches directly while students concentrate on listening". This kind of teaching method focuses on the one-way imparting of knowledge, in which students cannot absorb concepts effectively and, as a consequence, students' new ideas and new knowledge created will be limited [26,27]. The most important thing in technical courses is to teach organized and systematic professional skills and to increase the familiarity of professional technical operations. Therefore, the teaching and learning sequence of technical courses should be taught and sequenced with great care with regard to the difficulty of the skills, and the consistency of the integration of different types of skills should be considered [28]. Today's society is in an era of rapid development of information technology that focuses on the understanding of students' knowledge, the multiple development of inspiring individual potential, and the promotion of collaborative learning among groups. It plays a very important role in the goal of cultivating scientific and technological talents in response to social needs in my country's current senior high schools [29]. Kao (2017) explored the impact of virtual reality on the future of education and found that virtual reality is a multi-wisdom learning approach that can increase students' desire to learn and efficiency. In the future, there will be many contexts in teaching not only through slides and whiteboards but also by allowing students to actually see, hear, and simulate live situations, which can deepen students' impressions and learning [30]. The goal of teaching is to guide and assist learners in constructing knowledge, and teachers' teaching methods and strategies will directly affect the effectiveness of digital technology learning [31]. The biggest advantage of the VR technology simulation system is that it can be practiced at any time as long as the host is turned on, which is highly convenient. It is possible to practice the operation skills repeatedly from various dangerous situations [32]. Lee (2021) showed how VR technology works with visualization simulation engine software to accurately represent the ship's six-degree-of-freedom acceleration response, the ship's trajectory, and marine environment interaction on the screen, enhancing the sense of immersion in the simulated operating environment [33]. VR teaching is significantly more effective in enhancing nursing expertise and anatomical knowledge than traditional teaching methods [34,35]. An et al. (2023) stated that VR can facilitate interaction between teachers and students through virtualization, regardless of location, to improve the teaching of practical knowledge, which is a weakness of current lecture-based teaching, especially in the COVID-19 era. VR teaching increases student motivation and satisfaction, especially in practical knowledge [36]. The adoption of new technologies such as virtual reality (VR) as a training method helps with teaching and learning compared to traditional methods, which have shown significant limitations in engaging young students growing up in a smartphone culture of constant entertainment. In addition, not all educational centers or organizations can integrate specialized labs or equipment for training and instruction. Using VR applications, it is possible to reproduce training procedures with a high degree of similarity to real procedures, filling in the gaps of traditional training. In addition, it reduces unnecessary investment, prevents economic loss, and avoids unnecessary damage to laboratory equipment [37]. This study mainly explores the subjects of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice with the main purpose of preparing students for future electric vehicle courses and allowing students to use scaffold-assisted VR virtual reality technology teaching to assist students with the intangible concepts of power and current to let students understand the problems of circuit faults, trouble-shooting strategies, so that talents are not wasted and technology is not hidden. This way not only finds a way to relieve the shortage of talents in the auto industry in the past one or two years but also provides an endless supply of talents and contributes a lot to the automotive industry service market for projects such as new energy vehicles, next-generation smart vehicles, smart high-level diagnosis and maintenance, etc.

2. Literature Review

2.1. General Guidelines of Curriculum Guidelines of 12-Year Basic Education and Core Competencies

The 21st century is an era of rapid growth of Internet technology in which the year 2022 officially ushering in the era of Web 3.0. The miniaturization of electronic equipment, digitization of resource libraries, and all kinds of informatization have made learning resources available to teachers at their fingertips. The communication world of the Internet of Everything indeed shortens the distance between the worlds, and meanwhile, the cognitive gap between generations is also shortening rapidly. The talents needed by various industries in the future will also be different from those of yesterday [38]. To respond to the rapid change of the century, The Ministry of Education promulgated the Curriculum Guidelines of 12-Year Basic Education General Guidelines in 2014, which has been officially implemented in 2019. The new curriculum emphasizes "people" as the core and the concept of whole-person education with the focus on each student becoming a "whole person" and the demonstration of education in assisting the all-round development of "people" [39].

The positioning of core competencies in the Curriculum Guidelines of the 12-Year Basic Education takes part in the holistic perspective of the European Union and OECD in which "Competency" was defined as an individual's knowledge, abilities and attitudes that are indispensable for the healthy development of his or her needs of life situations [40], and the core competencies team proposed the 10 Core Competencies and core competencies of continuing the Grade 1–9 Curriculum in order to outline the image of the learner (autonomous action), the image of learning (communication and interaction) and the meaning and value of learning (social participation) in the hope of cultivating students' affection and attitude toward learning, being willing to learn and enjoy learning [41].

The Ministry of Education clearly defined in the "General Guidelines of Curriculum Guidelines of 12-Year Basic Education" announced in March 2014 that "core competencies" refers to the knowledge, ability and attitude that a person should possess in order to adapt to current life and face future challenges, and it emphasizes that learning should not be limited to subject knowledge and skills. Instead, we should pay attention to the combination of learning and life and demonstrate the whole-person development of learners through practice [42].

Based on the spirit of whole-person education and with the basic concepts of "Spontaneous", "Interactive", and "Common Good", students are emphasized and considered self-motivated learners. Therefore, school education should be good at arousing students' learning motivation and enthusiasm, and it also should guide students to properly develop various interactive abilities with themselves, with others, with society, and with nature, and to help students apply and practice what they have learned and experience the meaning of life, and as a consequence, they are willing to contribute to the sustainable development of society, nature and culture as well as to seek mutual benefit and common good together [42].

Looking at the historical development of education reform in my country, the "teaching quality", "educational philosophy" and "educational action" of school education are some of the most important keys to promoting the curriculum. Therefore, the newly added core competency in the 12-Year Basic Education General Guidelines was seemingly seen as new perspectives for skill-based high school group branches. However, there are many similarities between core competency and the functional connotation that has always been emphasized by the skill-based high school group branch in which both emphasize the cultivation of knowledge, ability and attitude related to real life or industry. In the implementation of education policy, it is necessary to train teachers to have the core competency of “Curriculum Design”, “Curriculum Instruction” and “Curriculum Evaluation” to carry out the 12-Year National Education Curriculum Guidelines [43].

In Chen’s opinion (2018), competence-oriented curriculum and instruction put forward five key points centered around the learner. The first circle is integration, which states that curriculum and teaching must integrate knowledge, attitudes and skills; the second circle is context, which emphasizes that curriculum and teaching need situational and contextualized learning; the third circle is procedural, in which teaching emphasizes the learning process, methods and strategies; the fourth circle is practical, which states that learning performance must be practiced; and the fifth circle is generative, which stands for the learning of any knowledge. No matter through contextualization, process, or practical practice, it is ultimately necessary to return to the learner’s own integration to generate new knowledge, new seeing and new self-knowledge [44], as shown in Figure 1.

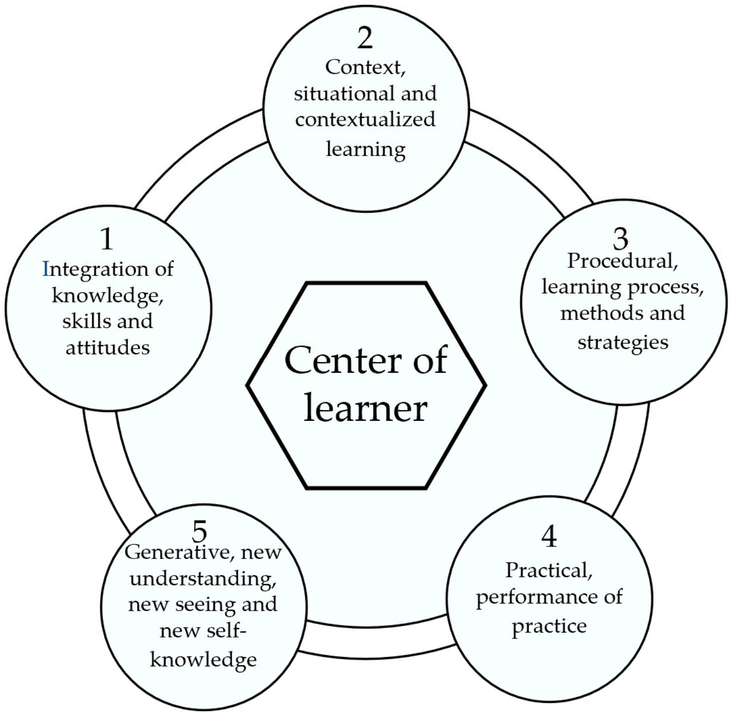

Figure 1. Learner-Centered Five Competence-Oriented Curriculum and Instructional Key Point.

Lu (2017) indicated that in the ideal of a multi-faceted and multi-assessment for core competency-oriented curriculum, teachers with literacy competency-related curriculum capabilities will be an important indicator [45]. Wu (2017) also mentioned that education field teachers need to grasp the pulse of the times and social trends as well as timely link with education reform, which will benefit students’ learning, and it can also cultivate students with the knowledge, skills, attitudes and values needed in the future [46].

In summary, when teachers in each field start to think about implementing competence-oriented instruction strategies by integrating the context of life situations into the course teaching, leading students to apply knowledge of life, and cumulating in-depth understanding, multi-level cognition and perceptual learning, students will start to learn independently in the future and to communicate and interact through learning activities toward an opportunity for social participation, which encourages students to become lifelong learners and better selves.

2.2. The Era of Competence-Oriented Instruction and Assessment

Our process is influenced by the competence-based education (CBE) movement in Taiwan that puts special emphasis on basic abilities, ability indicators, curriculum integration, and collaborative teaching when formulating the syllabus. At the same time, referring to the "key capabilities" framework of Australia and Canada, 10 Core Competencies were proposed to unify the curriculum objectives of each learning area [47]. When the Organization for Economic Cooperation and Development (OECD) completed the "Definition and Selection of Competencies, DeSeCo" project, the Ministry of Science and Technology immediately launched related plans [48] in which "Ability" was changed to "Competence", and at the same time, the name of "Key Competencies" was changed to "Core Competencies". Meanwhile, referring to the holistic view of the European Union and OECD, "Competence" was defined as "the knowledge, abilities and attitudes that are indispensable for the healthy development of individuals and the needs of life situations" [40].

Regarding competencies-oriented instruction, it is emphasized that competencies-oriented instruction has no fixed model and is not fixed in one model. It is an instruction that summarizes principles from its meaning. Therefore, Wang (2021) integrated the principles of competencies-oriented instruction, as shown in Figure 2 [49].

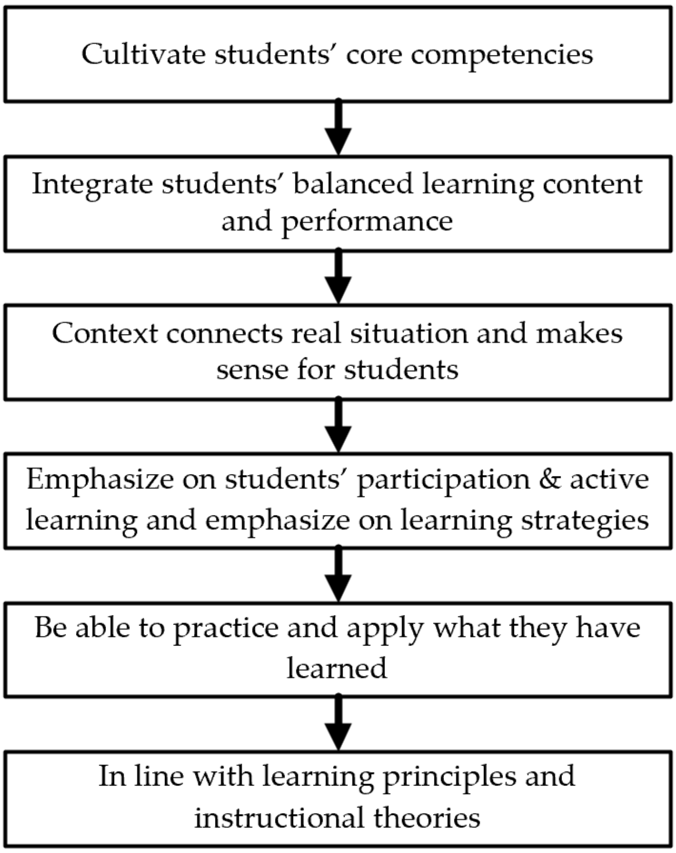

Figure 2. Competence-oriented instructional principles.

The General Guidelines of Curriculum Guidelines of 12-Year Basic Education takes "core competencies" as the main axis of curriculum development and the policy of teaching practice, and "assessment" aims to check students' learning effectiveness and learning development. Therefore, "competence-oriented assessment" has naturally become an important medium for transforming learning between teaching and learning. Wu (2018) indicated that competence-oriented education has the value of guiding teacher training and development, and the connotation of competence-oriented teacher education includes three dimensions: knowledge, skills and attitude [50]. Therefore, how to effectively cultivate students' ability to learn the knowledge, skills and attitudes needed in the future through teacher training has become the direction of efforts for teachers in every field to teach innovative thinking. "Assessment" aims to check students' learning effectiveness and learning development, so "competence-oriented assessment" has naturally become an important medium for transforming learning between teaching and learning.

The competence-oriented assessment mentioned in the international test focuses more on "scientific literacy", "mathematical literacy" and "reading literacy". What is a literacy proposition? Taking the connotation of "scientific literacy" of PISA as an example, the content includes testing the subjects' scientific proof ability, scientific issue ability and ability to explain scientific phenomena, etc., which is different from the connotation of the science achievement test. Gardner (1992) believed that good teaching evaluation should fully reflect the actual situation of students' important abilities and development to assist teachers to have a more sensitive understanding of individual differences [51]. Ho (2017) suggested that assessment methods should match the nature of teaching and learning content, and the assessment content should include multiple assessments [52]. It was also recommended by Wu and Lin in 2012 that teachers design a "standards-based assessment" for assessing learning content during the assessment process [53].

The General Guidelines of Curriculum Guidelines of 12-Year Basic Education have been fully launched, and the competence-oriented assessment test has been officially included in important examinations such as General Scholastic Ability Test, Subject Tests, TVE Joint College Entrance Exam, and Comprehensive Assessment Program for Junior High School Students, etc. in 2022 in order to evaluate the effectiveness of competence-oriented instructional strategies through assessment implementation. At the same time, through the competence-oriented assessment, teachers are guided to assist students in completing the transformation of the learning process. In summary, the proposition and implementation of competence-oriented assessment are the key work items of this study, looking forward to using the research results to provide on-site teachers of education to conduct professional teacher communities and to deepen competence-oriented instruction and assessment work. This study also hopes to help teachers transform from the traditional teaching mode to quality-oriented professional teachers from design, measurement, implementation, reflection to practice in order to enhance students' learning effectiveness.

2.3. Zone of Proximal Development (ZPD) and Scaffolding Theory

Vygotsky elaborates on the theory of individual cognitive development from a socio-cultural point of view, arguing that the high level of human psychological development originates from actual human activities and that the external environment has a decisive influence on human behavior. Vygotsky also emphasizes that in the process of social interaction, using the cultural symbol system as a mediating psychological tool, individuals apply the activities of others to themselves and gradually internalize them to form a new way of action and develop higher mental functions. Therefore, the concept of zone of proximal development (ZPD) was proposed. Vygotsky defines the zone of proximal development as "the distance between the level of development in which the individual solves problems alone and the level of potential development formed through the interaction of other people or psychological tools" [54]. Doolittle (1998) proposed the dynamic nature of the "zone of proximal development" based on the connotation of "zone of proximal development". He believed that learners are stimulated to learn in the "zone of proximal development" through the assistance of peers or instructors in the learning process, and that the "zone of proximal development" is an evolving and forward-moving process in the interaction between teachers and students and peers [55]. Vygotsky's perspective suggests that teachers should understand the needs of children before interacting with students and use their cognitive abilities as a starting point to guide social interaction. Interactions with students should be with more knowledgeable or skilled individuals, such as parent–child interactions, mentoring, or collaborative interactions with more capable peers. Through such social interactions, Vygotsky believes that students not only participate in the joint problem-solving process but also grow cognitively. Vygotsky's theory of "zone of proximal development" is applied to teaching with a focus on learning support or the "scaffolding of learning. "The term "scaffolding" was first coined by Wood, Bruner and Ross (1976) and is close to the spirit of Vygotsky's ZPD [56]. Wood et al. argue that scaffolding is the process of reducing the freedom of the learner to figure out what to do, and that the instructor prompts the important features of the learning task and demonstrates them appropriately, and that by guiding the learner's learning through these supports, the learner will be able to accomplish a higher level of learning than if they were studying alone [57]. Bruner (1985) proposed Scaffolding Instruction, in which teachers provide a scaffolding that supports student learning and allows students to climb from spontaneous concepts to scientific concepts so that they remain in their immediate zone of proximal development and progress upward [58].

2.4. Virtual Reality (VR)

The term virtual reality (VR) was mentioned in the English book *The Theater and its Double* published in 1958; however, it was not until the 1990s that more people invested in relevant research in academic and practical circles [59]. After 2000, research literature was published, and after 2010, due to the maturity of related technologies, there was substantial growth in both academic literature and patented technologies. Sin (2020) indicated that throughout the development of VR and with the advancement of technology and the decline of prices, in recent years, VR has shown positive growth globally, which is partly due to the rapid acceptance of VR by the consumer market [60]. The main demand comes from projects such as games, entertainment and experience activities, and more importantly, VR has changed the way of consuming content, providing users with more interesting interactions and immersive experiences.

Syamimi (2020) indicated that VR is often used for training and learning because it allows learners to experience actual situations in an immersive and safe environment, while traditional teaching methods usually require the assistance of physical equipment and learning space, and it may even be necessary to suspend machinery operating hours to cope. In this case, trainees or learners may face problems such as environmental safety or danger due to improper preparation measures. Therefore, with the help of the characteristics, VR training can be carried out anywhere and at any time; creating a reduction in the resource costs and trainers' waiting times. In addition, trainers can also define the VR environment by themselves, train staff or learners for different situations, and provide learners with a richer source of knowledge to solve various problems [61].

Literally speaking, virtual reality refers to a virtual environment that is close to reality, which uses computer technology to simulate a three-dimensional, highly realistic 3D space, lets users experience the situation, and creates an experience just like in real life. Using VR in a situational learning environment not only allows students to have sensory immersion, directional navigation, and immediate signs of manipulating perception, it can also act as a promoter of positive emotions, and it can create effective and better learning outcomes. Chang (2020) believes that the construction of VR technology through virtual reality and simulated environments allows students to interact in real situations, and at the same time it increases students' learning motivation by using their positive attitude to improve learning efficiency [62].

This study focuses on the application of virtual reality in teaching and learning. The following are examples of successful applications of virtual reality in teaching and learning in recent years. Kumar et al. (2023) showed that virtual reality simulators can increase the motivation of medical students to learn. They found that the use of virtual reality simulators increased students' motivation to learn and developed motivation through indicators such as attention, relevance, satisfaction and confidence [63]. Ryu et al. (2021) showed that virtual reality could reduce anxiety levels and improve procedural efficiency in children undergoing chest radiography [64]. They conducted a randomized clinical trial and showed that the VR experience appeared to reduce children's anxiety levels and increase the efficiency of the procedure compared to the same content on a tablet. Kuna et al. (2023) found that virtual reality has potential applications in vocational education and training. Their study shows that virtual reality systems can be used for education and training in secondary vocational school apprenticeships and have good potential for application [65]. Gómez-Cambronero et al. (2023) validated that the gamification process can facilitate hands-on practice by designing, developing and evaluating a virtual environment gamification experience for aircraft maintenance [66]. Their study showed that the ease of use of the gaming experience facilitated the learning of aircraft maintenance skills and that the use of the VR experience did not cause dizziness to the user.

Taken together, this literature shows that VR technology can be used to increase students' motivation to learn and reduce children's anxiety levels, and it has potential for use in vocational education and training. In addition, the use of virtual reality technology can enhance students' practical skills and abilities and create a better learning experience. Therefore, the application of virtual reality technology in education is very promising and is expected to bring more innovations and advances in various fields of learning and training in the future.

2.5. VR Practical Curriculum Integrating into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice

This study aims to develop the competence-oriented instructional strategy of integrating virtual reality VR into the curriculum guidelines of the 12-Year Basic Education for automobile Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice, in which the adopted curriculum standards were announced by the Ministry of Education in 2019 and are applicable to first-year freshmen in 2019. The following describes the core competencies for the study area of power machinery as well as the learning performance and learning content of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice. The study area of power machinery mainly cultivates six core competencies of students. First of all, students must cultivate the core competencies and capabilities of self-specialization and the spirit of maintaining professional ability in order to have the capabilities to understand systematic thinking, technology application, symbol recognition, problem solving and the use of various professional equipment and instruments. Through the integrated use of the above-mentioned competencies capabilities, the different fields of expertise, and the skills in making good use of various strategies, students can achieve the ultimate goal of technical services [67].

Students in the study area of power machinery mainly focus on technical services in which students should put more emphasis on the quality of communication and coordination with customers and the ability of teamwork while demonstrating their professional capabilities. Among them, communication and interaction with customers or car owners is the source of information needed by students in the study area of the power machinery to improve the quality of technical services. Moreover, it is an indispensable basic connotation for students in the study area of power machinery to cultivate civic awareness of occupational safety and health, professional ethics, environmental protection, labor laws, professional regulations, etc.

The VR practical curriculum of students in the Dept. of Auto Mechanics in a skills-based senior high school is based on the learning priorities of the Ministry and practical subjects, in which the group's core competencies are integrated with the goal of achieving the whole-person development of learners through instruction and utilization. Moreover, among them, in the core competencies corresponding to professional practice subjects, the following are the more important basic subjects: Applied Mechanics, Principle of Machinery, Principles of Engine, Principles of Chassis, and Basic Electricity. By possessing this basic background knowledge, students will be able to help themselves face and solve various problems in the workplace in the future and at the same time quickly understand and find feasible solutions. Among them, students in the Dept. of Auto Mechanics must be familiar with electronic testing-related equipment, such as professional languages and tools, which echoes the future in the practical technical curriculum in that students must have a quick understanding of machinery, vehicles, robotic bicycles, hydraulics, pneumatics, power machinery skills and other fields.

In this study, students in the Dept. of Auto Mechanics in a skills-based senior high school are investigating participants in VR practical curriculum integrating into Vehicle

Body Electrical System Comprehensive Maintenance and Repair Services Practice. In summary, the core competencies of the whole group correspond to the corresponding project of the professional practical curriculum content. The details are shown in Table 1.

Table 1. Corresponding items of group core competencies to professional practice curriculum content.

Professional Practice Curriculum Content	Specific Connotation
Vehicle skills field: 1. Maintenance and Repair Services practice of automobile chassis. 2. Maintenance and Repair Services practice of automotive air conditioning. 3. Comprehensive Maintenance and Repair Services Practice of vehicle body electrical system.	1. Make use of professional technical data written in Mandarin and foreign languages. 2. Make use of tools, measuring tools, electrical testing instruments and equipment. 3. Systematic thinking, analysis, and exploratory competency.
	1. Have systematic thinking capabilities. 2. Check, adjust and change car engines, automobile chassis and electromechanical appliance and equipment components. 3. Make good use of every strategy to execute technical services. 4. Communicate with clients.
	1. With understanding and utilization of occupational safety and hygiene knowledge. 2. Explore the basic competencies of work ethics and environmental protection. 3. Develop individual potential, have a positive attitude toward self-values and be good at career planning.
	1. Have competencies in professional and labor laws and regulations and have competencies in relevant issues, speculation and conversation. 2. Cultivate civic consciousness and social responsibility.

Source: The Center for Study Area of the Power Machinery of Ministry of Education (2019).

2.6. The Investigation and Practical Skills of Scaffold-Assisted Virtual Reality Integrating into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice

A total of 108 new curriculum guidelines [68] consider "ZPD" and "Inquiry and Practice Curriculum" as curriculum development targets as well as guidelines for instructional utilization which aim to investigate whether practical curriculum could be appropriately developed and precisely implemented in instruction. If what is mentioned above could be achieved, then instruction effectiveness would be extended, students' science learning motivation would be promoted and, meanwhile, students' science conceptual comprehension and confidence in practical capabilities would be increased under the way of instruction complying with instructional materials core concepts. The instruction development of "Science Inquiry and Practice" should be based on the Curriculum Guidelines of 12-Year Basic Education-General Guidelines (CIRN) in the philosophy of "spontaneous, interactive, and common good" and also consider core competencies as the target of curriculum development [19]. The following are the explanations of the viewpoints and vertical literature in "Inquiry and Practice Instruction", "Vygotsky's Scaffolding Theories Integrated into Instruction" and "Units Analysis of Inquiry and Practice Instruction" in sequence.

2.6.1. Inquiry and Practice Instruction

Concerning Inquiry and Practice Instruction, which emphasize that curriculum content should comply with contemporary science knowledge development, curriculum design should be implemented following the spirit of inquiry and practice, and at the same time, student's learning performance should be evaluated by practical assessments in order to expand their existing conceptual structure and promote scientific knowledge construction and development [69]. Therefore, the integration of science inquiry as well as practical curriculum in investigation experiment, argumentation, and writing would be beneficial to students for their development in the core competencies of science investigation capabilities and science concepts. Science inquiry is the process of a person who solves scientific questions by making use of logic and interpretation capabilities, including forming a problem, proposing a hypothesis, designing solving plans and choosing reasonable explanation, which are considered effective methods to cultivate students' science competencies [70].

Science Inquiry focuses on students' investigation into science phenomena or questions through their thinking and practice, and, as a result, it develops their science knowledge and understanding of scientific concepts [71]. National Science Education Standards in the United States indicate that inquiry capabilities include students' forming appropriate investigation questions through background concepts, explaining their own investigation design, applying various application technology methods to transfer the investigation results, building a scientific model, etc. [72]. By way of ZPD-type guiding and teamwork, students' science active investigation and studying, practical operation, design, research and development, analysis and expression capabilities would be stimulated and improved and, as a consequence, science education would be more comprehensive, complete and pioneering.

Unlike traditional teaching that majorly focuses on knowledge and practice, Inquiry Practice Instruction strengthens the connotation of investigation and practice subject, emphasizes students' spontaneous observation and exploration and aims to improve their scientific comprehension in the process of experimental building process from scratch, among which "Inquiry Learning" is the most indispensable part with a focus on the scientific investigation process, including four main items as follows: (1) finding problems, (2) planning and studying, (3) argumentation and modeling, and (4) expression and sharing. Scientific issues are used to guide them and help develop their critical thinking skills, and meanwhile, in order to help equip students with core knowledge as well as develop their ability to inquire and practice their scientific argumentation communication skills, each exploration and experimental operation with the foundation of existing experiences is required [73].

Inquiry Practice is a way for students to actively construct knowledge of which teachers play supporting, supervisory and guiding roles in the process. Systematic design curriculum units guide students to actively find and investigate situational problems, among which systematic thinking capabilities are the most indispensable part. Systematic thinking emphasizes that so-called "Systems" are the relevance formed by a series of high-level thinking operations and the interaction of different factors, Moreover, it also means for the various effects formed in the promotion of overall operational system power and furtherly, the systemic development was deduced under time variables with the aim to achieve systemic targets for solving system problems [74].

Gharajedaghi (2011) indicated that one of the basic capabilities in systematic thinking is the ability to develop holistic thinking [75]. This kind of thinking ability can provide students with a broad perspective and is used in systematic thinking to group and classify events with the focus on process, making it convenient to separately reflect and show the value of the corresponding event and create the impact of related events. Jacobson's (2001) empirical research shows that there is a different focus in mental models between those developed through the holistic lens of systematic thinking and those of traditional models [76]. The differences in mental models produced by holistic focus are associated with differences in decision making. A holistic systematic thinking approach helps in overall risk evaluation.

2.6.2. Inquiry Practice Capability Integrated into Vygotsky's Scaffolding Theories

Vygotsky's scaffolding theories are used in this study to guide students' development and the building of new skills in which teachers and students could integrate virtual reality as supporting equipment in their interaction strategy and, at the same time, it helps relieve students' learning burdens and assists their simulation demonstration and guiding process before their practical operation [77]. Chen (2021) indicated that there would be an obvious difference under the condition that students have basic science knowledge first and then start the interdisciplinary investigation [78]. In addition, teachers could observe teachers and students' interaction in a hierarchical way through the instruction process and positively and quickly improve the instruction problems and alternative instruction plans or solutions to the deficiency.

The design of the Inquiry Practical Curriculum integrated Vygotsky's scaffolding theories as basic architecture with layered supporting brackets to include situational learning topics in which the situational simulation of real skills was built through virtual reality. Then, students learn by joining the situation and independently exploring the simulation environment of virtual reality as well as through the recording and analyzing of peers about the participants' situational and virtual environment in order to reach the target of cooperative and negotiating learning with peers. These kinds of instructional strategies not only make students able to use scaffolding methods to develop cross-science and creative learning directions but also improve their learning effectiveness as well as learning motivation [79]. There are various models for scaffolding methods. Reigosa indicated that scaffolding support makes it easier for teachers, students and peers to learn and investigate through the ZPD (zone of proximal development) in which students could complete the missions through teachers' supporting tools to find solutions to the problems they are able to or are not able to solve [80]. Therefore, this study used the conceptual model of ZPD to a design a strategy model that meets the study's requirement of virtual reality presenting in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice practical capability investigation, as shown in Figure 3. The abbreviation of the zone of proximal development is ZPD in this study and the modeling concepts were used to input virtual reality as a supporting tool and then to use investigation practice as guidance for students to actively investigate situational problems and at the same time to cultivate their systematic thinking, problem-solving, and self-directed learning capabilities. In this model, orange lines and green lines focus on supporting learning through virtual reality, and meanwhile, the difficulty levels were added in three periods so that students could observe the problems in the practical curriculum first and then correctly assume and find the solutions to the fault causes through maintenance and repair and ways of detection.

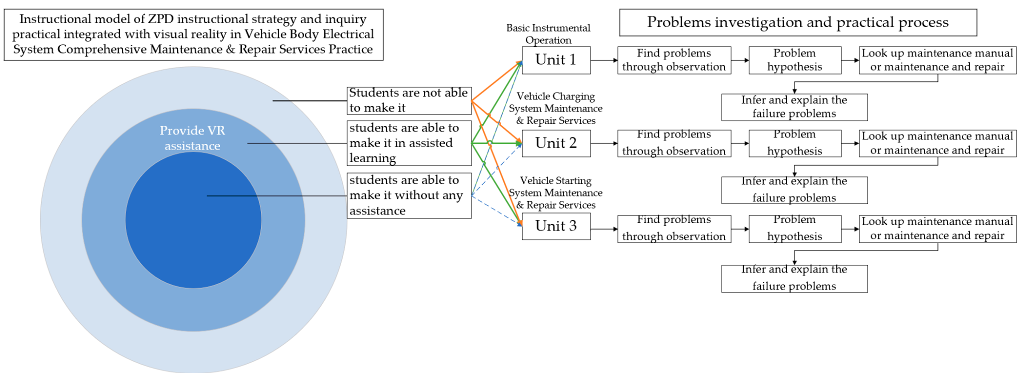

Figure 3. Strategy model of integrating virtual reality into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice investigational practical capability.

2.6.3. Learning Effectiveness in Practice Capability Instruction Units

Through the strategy model of inquiry practice capability mentioned above, scaffolding and level learning were integrated into the following three units of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice for the inquiry practice instruction. The three units are (1) Basic Instrumental Operation, (2) Vehicle Charging System Maintenance and Repair Services, and (3) Vehicle Starting System Maintenance and Repair Services, which were planned and divided into three levels (entry level, basic level, and advanced level) and redefined into the following new unit names: (1) Unit 1—Get Familiar With Practice Factory Environment and Maintenance Tools Operating Procedure, (2) Unit 2—Disassembly and Functional Testing of the Automotive Alternator and Starting Motor, and (3) Unit 3—Functional Testing and Troubleshooting of the Automotive Alternator and Starting Motor. In this study, systematic testing and repair images built in virtual reality were used to comply with learning key points of curriculum units in order to meet the target of learning effectiveness through practical verification. The relationship of practical skills instruction among the three different units is explained as follows.

1. Entry Level: In "Unit 1—Get Familiar with Practice Factory Environment and Maintenance Tools Operating Procedure", virtual reality assisted students with the vehicle maintenance plant environment to become familiar with the tool equipment, operating line and safety and hygienic knowledge simulation practice. Then, the investigation of students' learning effectiveness in knowing basic tools and operation processes and knowing the vehicle maintenance plant environment was conducted through their practical skills evaluation, which is shown in Figure 4.

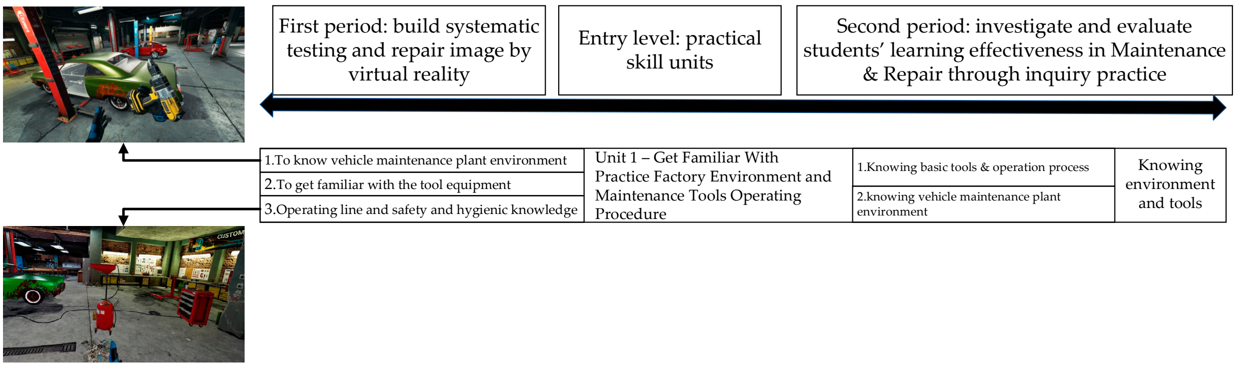

Figure 4. Unit 1: Virtual reality that integrates into becoming familiar with the vehicle maintenance plant environment and maintenance tools operating procedure.

2. Basic Level: In "Unit 2—Disassembly and Functional Testing of the Automotive Alternator Starting Motor", virtual reality assisted students with becoming familiar with disassembly processes and tools and equipment usage. Then, the investigation of students' learning effectiveness was conducted through their practical skills evaluation, which is shown in Figure 5.

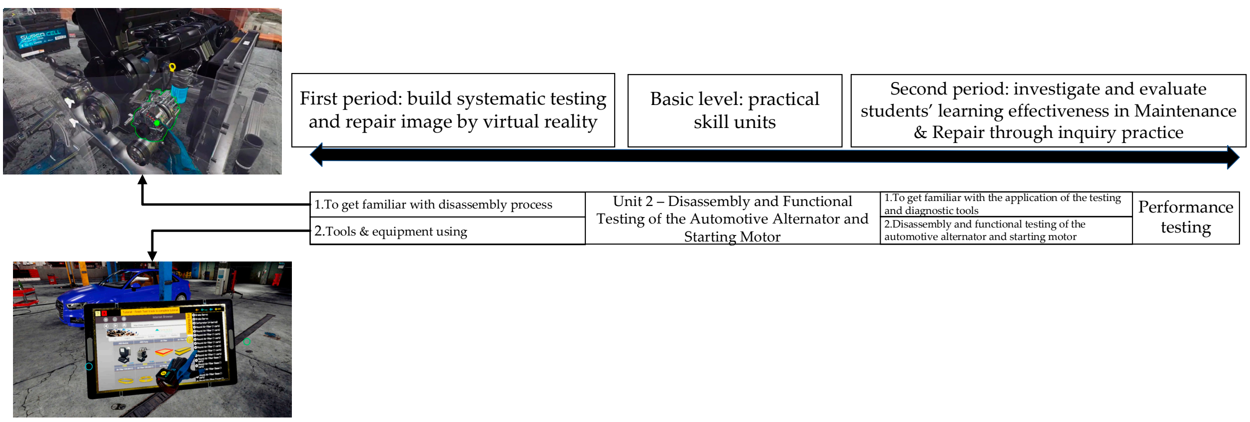

Figure 5. Unit 2: Virtual reality that integrates into an automotive alternator, starting motor disassembly and functional testing.

3. Advanced Level: In “Functional Testing and Troubleshooting of the Automotive Alternator Starting Motor”, virtual reality assisted students with observing abstract failed components to explore the troubleshooting strategy and then investigate and clear the fault causes, in which students’ practical skills helped them quickly understand the fault causes and reach the target of their learning effectiveness in functional testing and troubleshooting by using the maintenance manual and applying diagnostic tools, which is shown in Figure 6.

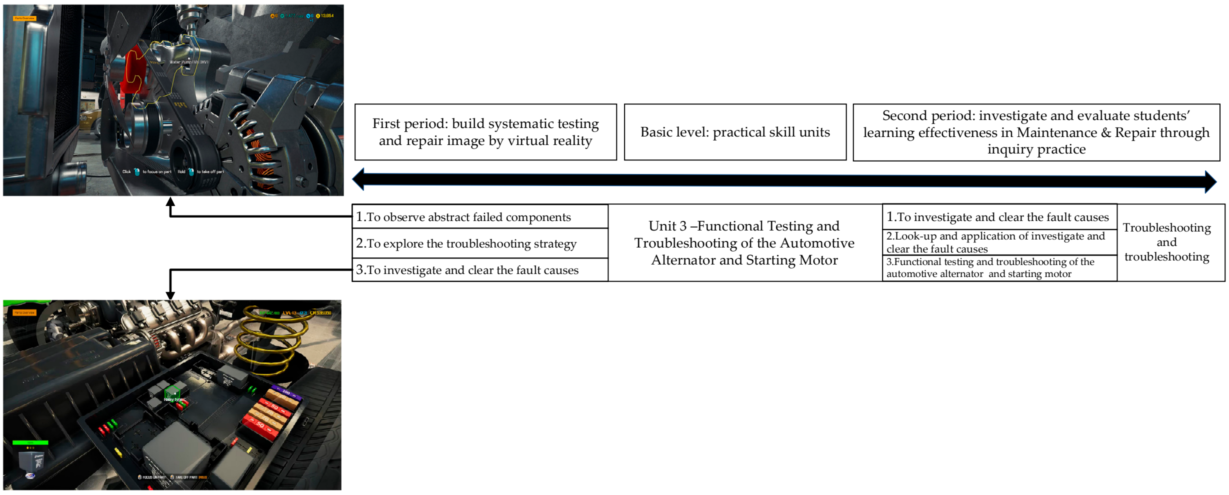

Figure 6. Unit 3: Virtual reality that integrates into automatic maintenance and fault clearing.

Based on the background and motivation mentioned above, this study complied with the execution of 12-Year Basic Education Curricula General Guidelines and developed the ZPD instruction strategy in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice curriculum for the Study Area of the Power Machinery in a skills-based senior high school so as to position teachers as guiders and helpers in teaching and learning while students are self-directed learners. This encourages students to connect daily situational contexts from their learning experiences and therefore cultivates students’ integration capability in their knowledge, skills and affection and further strengthens students’ inquiry practice and learning effectiveness.

3. Methodology

3.1. System Architecture

The Steam Game Platform was used in this study as the development platform as an instruction system development platform, and the Car Mechanic Simulator VR vehicle repair simulation software was used as an instruction scene. Car Mechanic Simulator VR is equipped with abundant and realistic vehicle repair scenes, and multiple missions and learning methods in vehicle maintenance and repair-related knowledge and skills are included in the VR games. Therefore, Meta’s Oculus Quest 2 (VR equipment used in this study) has an independent tracker, helmet and joystick for participants to interact with game avatars, pick up items in the game scenes and operate missions. The testing system developed in this study for Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice helps students complete their training and testing in automotive diagnostic troubleshooting through providing students with virtual reality simulation game operation and, meanwhile, providing them with suitable virtual scenes.

In this study, games missions designed for Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice were considered instructional environments. Three different sets of scenes and missions were designed for grouped students to practice their skills in fault causes diagnosis and troubleshooting, and the system architecture is shown in Figure 7. First, the projection of the visual scenes was shown on the computer screen. Then, secondly, the instructor helped and assisted students with mission completion. Finally, lesson-observation teachers and peers helped record the interaction situation between the instructor and the students. The record is aimed at evaluating how instructors and peers helped solve problems and complete missions in VR games.

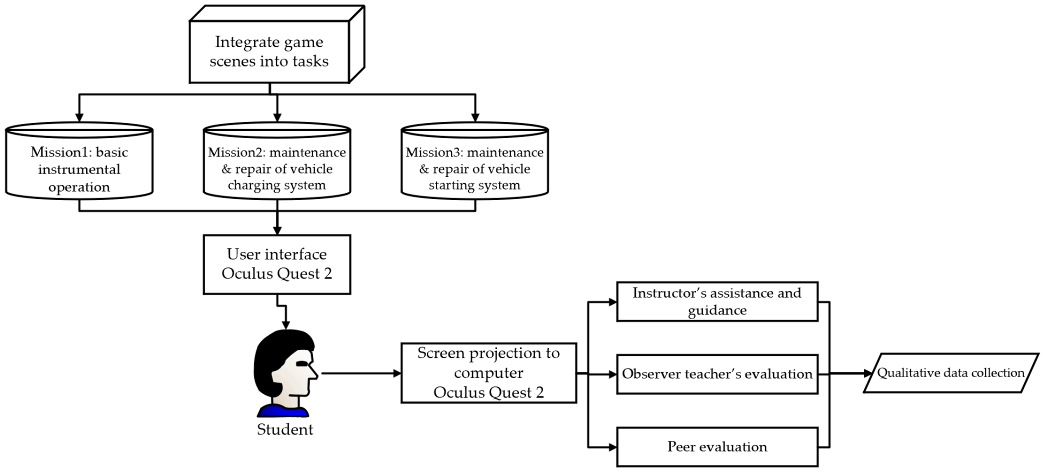

Figure 7. System architecture.

3.2. System Function and Design

Virtual reality (VR) was used in this study as the instructional tool, and the Car Mechanic Simulator VR simulation game was used in practical simulation instruction in which three different missions were designed and planned by projecting the VR scenes on the computer screen and by instructor's assisting. Students' assessments were conducted by lesson-observation teachers and peers in class to collect qualitative data.

Before the game simulation, the instructor recorded the VR game scenes and provided students with VR equipment and operative examples in order to help those students who first use VR to know and become more familiar with the VR system operation and its environment and to make it easier for students to be more proficient with VR equipment and adapt to it. Oculus Quest 2 equipment functions include microphones and sound systems, in which the voice output provides students with immersive experiences in VR game scenes. Students could operate the VR handles to control the location and direction in the VR game environment and also to use the maintenance tools or other components through VR handles. This study used a series of VR equipment for students to simulate the scenes of vehicle maintenance plant and complete the missions. The practice scenes are shown in Figure 8. Students were able to give feedback to lesson-observation teachers many times in the experimental instruction process when they felt dizzy or disoriented, and they could take off the VR equipment if they felt uncomfortable.

There is a slight gap between the VR simulation game scene and the real vehicle repair plant working environment. Therefore, through the comparison between the real vehicle repair plant and the simulation scene, students are able to figure out the fault causes in the missions and find solutions to the problems. In addition, different failure cases enable students to think for themselves, discuss with peers, reason logically, solve problems, and strengthen their self-reflection skills, as shown in Figure 9.

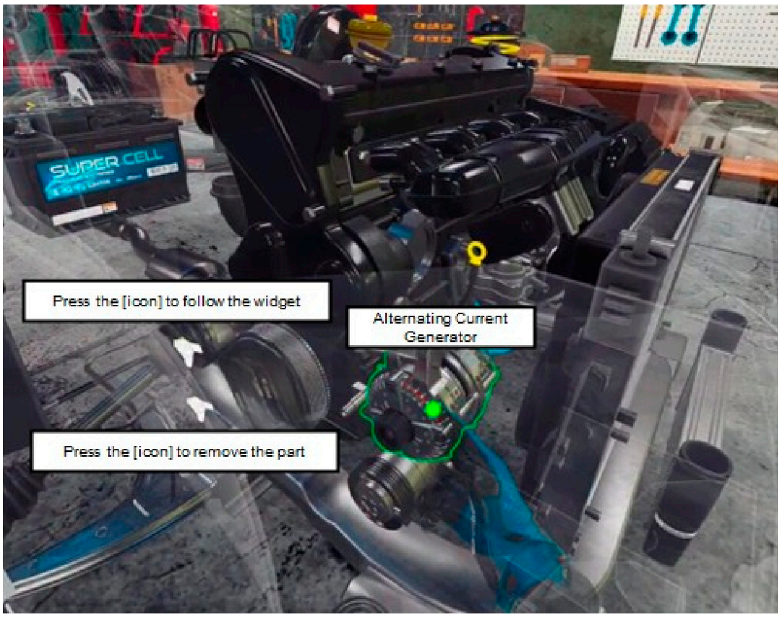

Figure 8. Interface of practice scene.

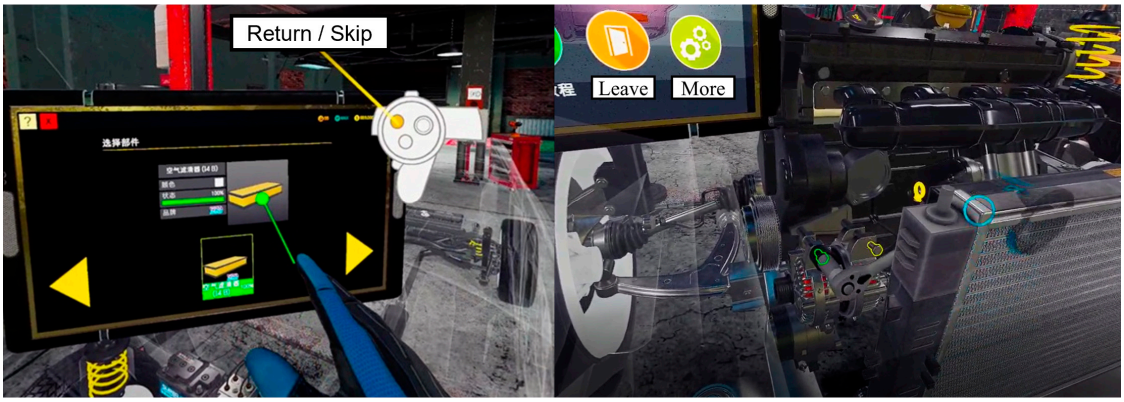

Figure 9. Components selection and diagnostic troubleshooting.

3.3. Research Purpose

This study aims to apply the interdisciplinary/cross-region knowledge into the curriculum design of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice for students in the Dept. of Auto Mechanics of a skills-based senior high school. Then, the technique of virtual reality was applied, and the instructional materials were digitalized in order to verify students' inquiry practice capability and learning effectiveness by their experiment instruction activities. The research purposes are described as follows:

1. To develop curriculum design that integrates with interdisciplinary/cross-region instructional strategies as well as digitalization-oriented virtual reality technique design in the Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice curriculum in the Dept. of Auto Mechanics of a skills-based senior high school.
2. To develop interdisciplinary/cross-region instruction learning assessment for the Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice curriculum in the Dept. of Auto Mechanics of a skills-based senior high school.
3. To investigate students' inquiry practice learning effectiveness after integrating VR simulation game curriculum into the Vehicle Body Electrical System Comprehensive

Maintenance and Repair Services Practice curriculum in the Dept. of Auto Mechanics of a skills-based senior high school.

3.4. Participants

Two classes of students in the Dept. of Auto Mechanics taking Electrical Engineering practical subjects in one skills-based senior high school in central Taiwan were chosen as the participants for this study. Those students completed the Electrical Engineering practice curriculum before the instruction experiment. There were a total of 36 students in the control group in which the traditional didactic instruction strategy was conducted, and meanwhile, there were a total 43 of students in the experimental group in which the VR simulation game instructional strategy was conducted. Heterogeneous grouping is adopted in the instruction process in this study in which there were a total of five groups. According to the announcement of the Statistics Office of the Ministry of Education, the Dept. of Auto Mechanics in the country in 2022 were divided as follows [81]: Taipei-New Taipei-Keelung (14), Taoyuan-Hsinchu-Miaoli (16), Yilan-Hualien-Taitung (5), Taichung-Changhua-Nantou (16), Yunlin-Chiayi-Tainan (15), Kaohsiung-Pingtung (13), and Penghu-Kinmen-Lienchiang (2). Among them, the Taichung-Changhua-Nantou is one of the areas with the most Dept. of Auto Mechanics schools, so the consideration is to obtain the materials needed for its research and its teaching stability and fairness [82,83], so this study focuses on schools in central Taiwan.

3.5. Research Design

This study uses a quasi-experimental design in which the students' academic performance in the Vehicle Body Electrical System Comprehensive Maintenance and Repair Services practical subject is measured by their pretest scores. In addition, the instruction environment control was conducted before the instruction experiment in which the control variables were students' grades, instructors, instruction hours, students' degrees, instruction content and evaluation. The instructional experiment progress was conducted for 8 weeks (four hours each week), and there were a total of 32 instruction hours, including the instructional preparation week, assessment week and the final-examination week. The instruction experimental design is shown in Table 2, and the instruction experiment progress is shown in Figure 10.

Table 2. Instruction experimental design.

Instruction Period	Grouping Method	Pretest	Experimental Treatment	Post-Test
Experimental group	Heterogeneous grouping	O_1	X_1	O_2
Control group	Heterogeneous grouping	O_3	X_2	O_4

X_1 ZPD instructional strategies. X_2 Traditional didactic instructional strategies.

3.6. Instructional Material Development

This study used competence-oriented instructional material design and integrated inquiry practice capability based on technology education issues, and it referred to 12-Year Basic Education Curricula General Guidelines in the study area as well as the approved textbooks by the National Academy for Educational Research. The National Academy for Educational Research is the highest authority on educational research in the Republic of China (Taiwan) and is part of the Ministry of Education [84]. The instructional activities content was designed to include learning performance, a definition of core competencies, integration of issues, connection with other regions and subjects and the building of curriculum learning outcome, in which three topics ("Basic Instrumental Operation" "Fault Diagnosis Maintenance and Repair of Automatic Charging System" and "Fault Diagnosis Maintenance and Repair of Automatic Starting System") were developed as reference in instructional strategy development and at the same time were conducted referring to the following methods proposed by Huang (2021), including "Situational Mission Learning" and "Integrating with Cases Experiences" [85].

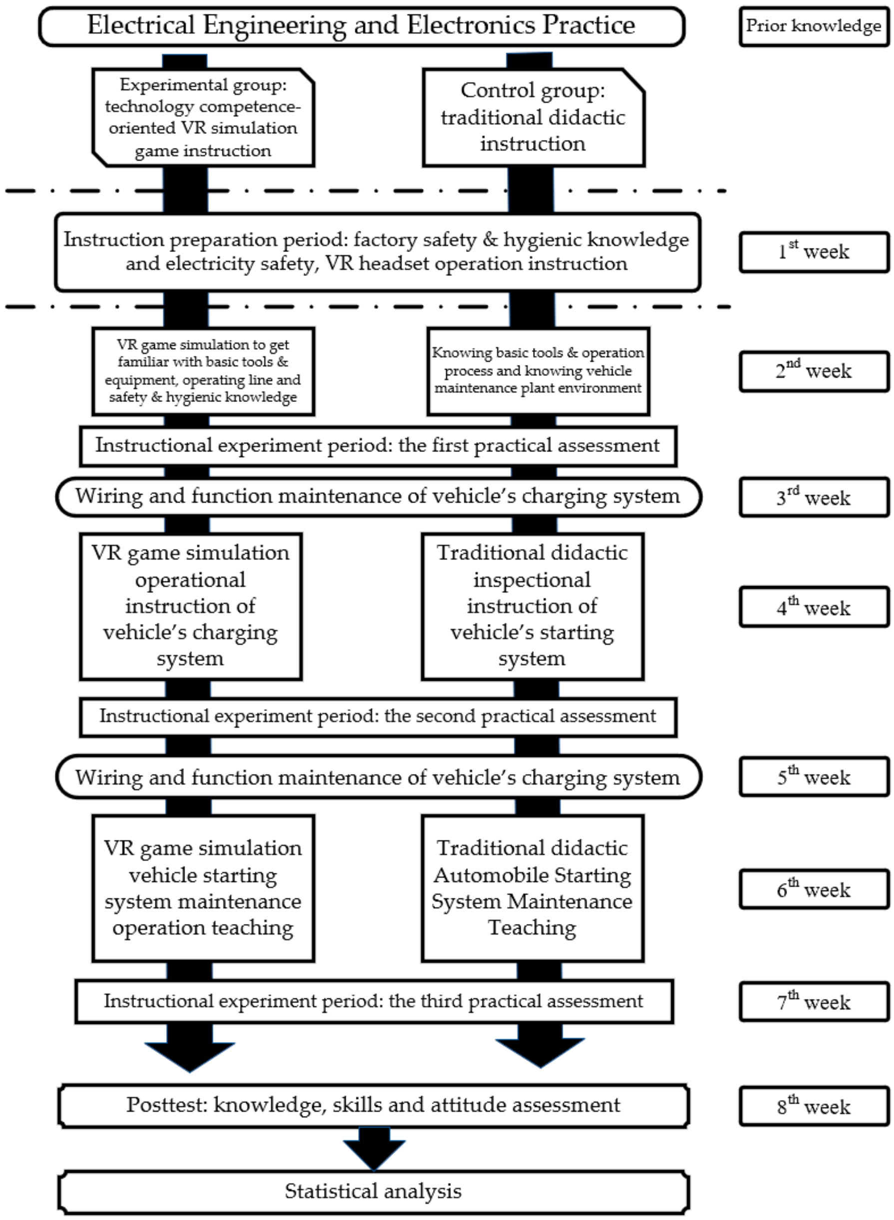

Figure 10. Process flow of instruction implementation.

After the integration analysis of virtual reality integrated into practice capability units through this reference, the relationship diagram of the completion in the investigation of students' practice capability and learning effectiveness was finished and shown in Figure 11, in which the unit analysis was reorganized and planned in hierarchical and periodical models to execute the curriculum design of inquiry instruction. The vertical item stands for the objective of practice capability instruction in which three classifications were listed (entry level, basic level, and advanced level), while the horizontal items stands for the curriculum content and items. The relationship between the first and second periods is explained in sequence as follows.

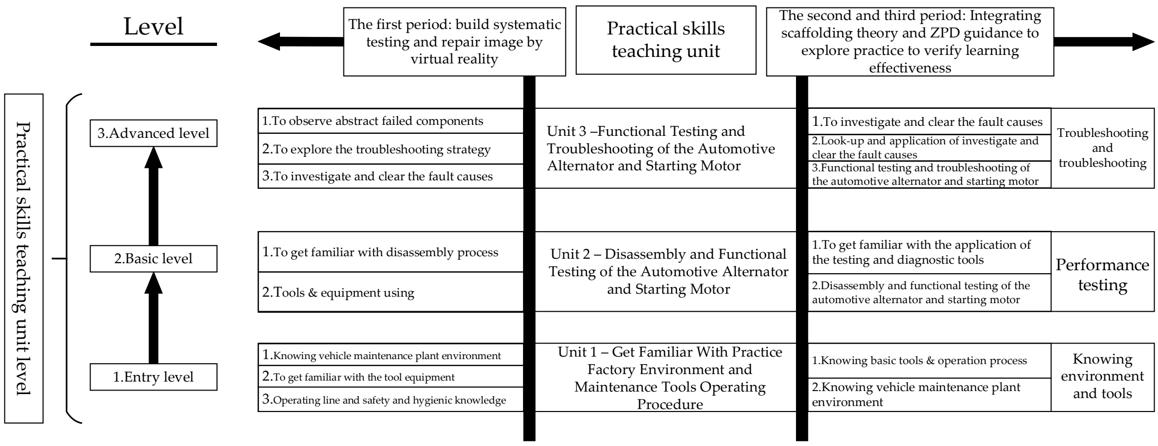

Figure 11. Relation chart of investigation practical capabilities and learning effectiveness when integrating/combing virtual reality into practical skills instruction units.

1. In the first period, the virtual reality-assisted building system was considered as the goal in which the curriculum instruction was conducted at the entry level in "Unit 1—Get Familiar With Practice Factory Environment and Maintenance Tools Operating Procedure" with the issues of factory environment safety and hygienic knowledge. In the second period, the testing of practical evidence and students' learning effectiveness in maintenance and repair were considered as the goal in order to verify and test students' practical learning effectiveness in basic tools and equipment and their operation processes in vehicle maintenance plants.
2. At the basic level, the virtual reality-assisted building system was considered as the goal in which the curriculum instruction was conducted in the first period in "Unit 2—Disassembly and Functional Testing of the Automotive Alternator and Starting Motor". The curriculum was designed for students to become familiar with virtual reality components disassembly processes and choosing tools and equipment. In the second period, the testing of practical evidence and students' learning effectiveness in maintenance and repair were considered as the goal in order to verify and test students' application in familiarity with testing and diagnostic tools and their learning effectiveness in vehicle maintenance and the disassembly of an automotive alternator and starting motor.
3. At an advanced level, the virtual reality-assisted building system was considered as the goal in which the curriculum instruction was conducted in "Unit 3—Functional Testing and Troubleshooting of the Automotive Alternator and Starting Motor" in order to help students' observations of abstract failed components and explore students' troubleshooting strategies and investigation in fault clearing. In the second period, the testing of practical evidence and students' learning effectiveness in maintenance and repair were considered as the goal in order to verify and test students' operation capabilities in fault causes and troubleshooting, to evaluate students' application process in looking up maintenance manuals and eventually to verify their learning effectiveness in automatic maintenance and fault clearing.

Instructional activities and materials were designed and planned in the way of synchrotie, in which after the instructor explained the issues about circuit application, energy issues and safety, students would be able to think about the concrete concept and practical connection first; then, they could observe related information in vehicle maintenance and repair cases or experiences as well as in industrial development. In addition, concerning the instruction hours, issue-integrating depth and student's acceptable skills development during the instruction activities period, students were guided to implement situational induction, problems investigation and interdisciplinary/cross-region thinking. The instruction process is shown in Figure 12, while the competence-oriented instruction materials are shown in Figures 13–15.

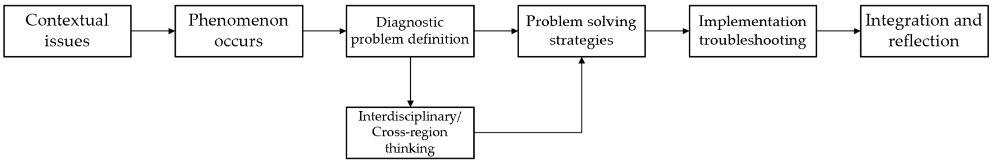

Figure 12. Process flow of instruction in this study.

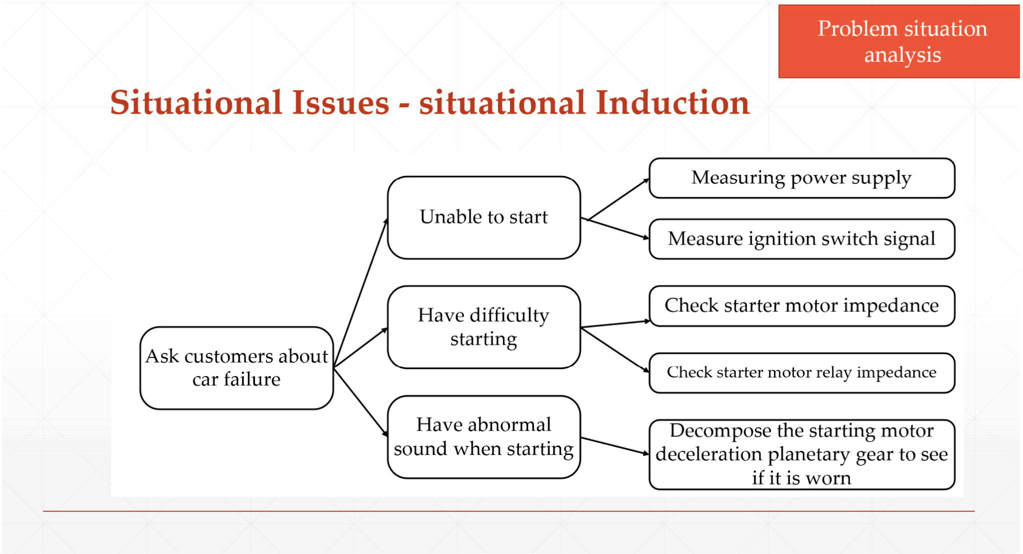

Figure 13. Competency-based instructional materials used in this study—problems situational analysis skills.

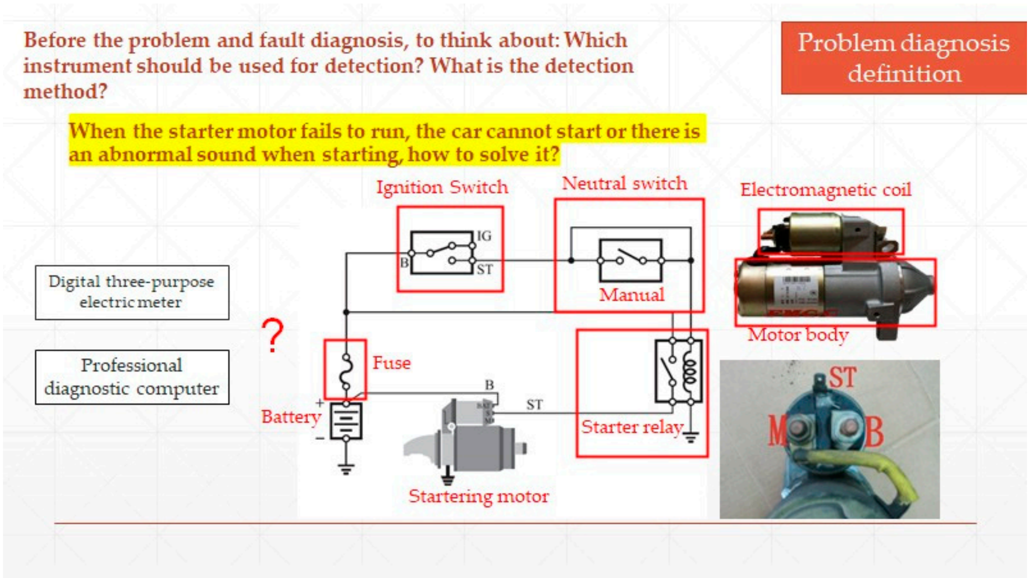

Figure 14. Competency-based instructional materials used in this study—problem diagnosis and definition.

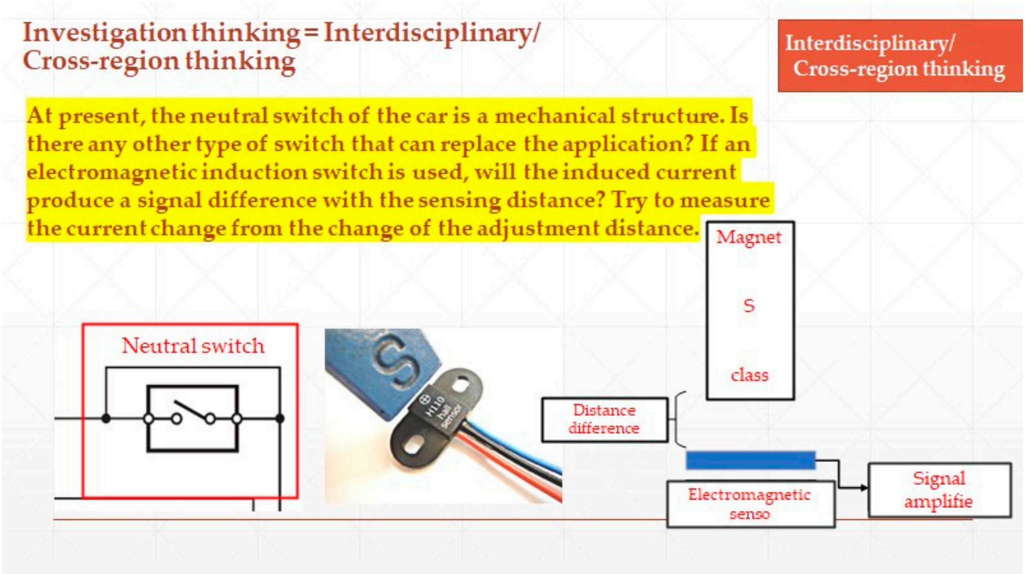

Figure 15. Competency-based instructional materials used in this research—interdisciplinary/cross-region thinking.

The following is a brief description of the instruction process in this study.

1. Contextual issues: guide students to observe the classification in vehicle industry, vehicle types, vehicle driver's driving and operative behavior and then determine the differences between different vehicle types and operative behaviors.
2. Phenomenon occurs: the induction and analysis were conducted from the phenomenon results in the situations. Example: What is the relationship between the vehicle's starting system and the starting motor? What is the difference between motor's types and specifications, and are there any alternatives?
3. Diagnostic problem definition: help students define the range and distinguish problems fields from the fault phenomenon. For example, how do students solve problems when the starting motors cannot work which causes the vehicles to not be able to start, or in the situation of abnormal noise when the starting system works?
4. Interdisciplinary/cross-region thinking: To seek related instructional materials and investigate interdisciplinary/cross-region problems. For example, electric fire switch and brake switch signals are required to start the motor, but if the detection signal is changed to magnetic induction, what would happen to the sensoring condition?
5. Problem-solving strategies: to plan circuit prospecting, diagnostic equipment operation, and dynamic and static detection from the content of the "Problem Definition" section.
6. Implementation troubleshooting: to implement the process of system troubleshooting and plan fault clearing strategies to conduct the practical operation according to the diagnosed problems.
7. Integration and reflection: to organize and classify the problems students encountered in the practical and judging process during the automatic fault cases in order to avoid making the same mistakes.

3.7. Research Tools

Hsieh (2021) indicated that learning assessment aims to help students improve their learning quality, guide students' learning methods and provide them with feedback for students to understand their learning developing direction and, meanwhile, help develop the knowledge, skills and attitude that they need in lifelong learning. Students agreed that college students' self-evaluation help is beneficial to their own learning process supervision, and at the same time, they also valued the judging and feedback skills for peer review [86].

In Hsu (2021), when conducting competence-oriented instruction assessment, other than developing and designing multiple and appropriate assessment methods and tools, the coherency in learning targets, learning key points and learning assessments is more important, in which the competence-oriented instruction assessment should focus on curriculum, instruction and assessment systematization [87]. In addition, the learning targets of the curriculum were designed according to the learning key points. Therefore, learning activities design should comply with the learning targets while the assessment design should also respond to learning objectives. Lin and Chen (2021) thought that competence-oriented instruction learning effectiveness assessment should be designed in situational, open and including but not limited to single correct answers, and they also emphasized students' capabilities for using the skills and knowledge they have learned to solve problems in real situations [88]. In Tseng and Hsu (2018), the examination in instructors' rolls and assessment models changing is required in order to help learners appropriately develop and learn, and the implementation is also necessary for learners to cultivate their core competencies. Moreover, how students express their learning process is considered one of the key points of the learning assessment in which the difference between traditional paper and pencil tests and modern multiple assessment promotion was reviewed [89]. Wu (2019) indicated that the following four elements, including life situations, learning content, learning performance and core competencies in the study area should be designed and planned into the learning assessment [90].

Core competencies are considered the curriculum development target in the curriculum guidelines of the 12-Year Basic Education General Guidelines in order to highlight the subjectivity of scholars and at the same time help students build their life confidence and increase their learning desire and inspire their creative courage, in which instructors play the roles of helpers as well as counsellors. By creative curriculum design and implementation, students' learning engagement capabilities could be strengthened while the ideal of whole-person education could be realized.

Positive learning assessment is helpful for instructors to diagnose learners' learning difficulties, and Wu (2017) indicated that there are educators who advocate adopting three other learning assessments, including "Assessment for Learning", "Assessment as Learning" and "Assessment of Learning", in which by the timely modification according to the assessment results and the implementation of instructional activities, learners' learning motivation and learning engagement would be increased while difference learning was balanced [91].

The learning assessment designed in this study includes situational assessment, learning process assessment and practical assessment, which were designed and planned according to the integration induction of experts and scholars' research experiences as well as referred after the literature review of the previous section in this article. The learning effectiveness assessment tool developed in this study belongs to situational, open, essay-questioned proposition (without the limitation of one single model answer). Moreover, the assessment rubrics were conducted in multiple assessments in which the "Assessment Rubrics" was developed based on the fundamental premise of learning targets with fields in knowledge, skills and attitude [26,29,88,92–100]. The development plan of the assessment tool is explained as follows.

3.7.1. Learning Assessment Testing Method

By situation entry and integration into the learning process through real car failure scenarios, the test questions are designed with one question and one answer to situational fault diagnosis troubleshooting. After making an inductive analysis based on the situational questions, students write the troubleshooting process and method based on the results of the inductive analysis and then use the VR game case simulation to carry out practical exercises, real car disassembly and assembly practice testing. Finally, the students write their learning experiences and reflections, as shown in Figure 16.

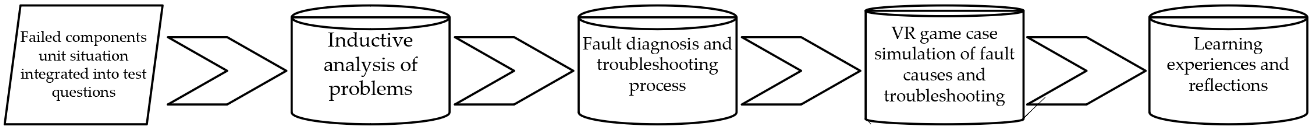

Figure 16. Process flow of learning assessment testing in this study.

3.7.2. Evaluation Rubric Scale Developed in This Study

The performance evaluation rubric scale for Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice in this study, adapted from Liao et al. (2023) [29], was classified into three components: knowledge, skills and attitude. Using the performance evaluation scoring viewpoint of Tang (2019), Tseng et al. (2021), Sui (2021) and Huang (2021), we also adopted the rating scale of rubrics [101–104]. The evaluation items were divided into 3 parts, knowledge (K), skills (S) and attitude (A), and 5 performance levels in which the critical points of the evaluation were stated and listed. Knowledge (K) occupied 33% of the total scores in the learning performance part, skills (S) occupied 34%, and attitude (A) occupied 33%. The performance range was 20 points in terms of the five performance levels. The performance evaluation was conducted by 3 observers and was commonly scored by them in which the average value was considered as the practical evaluation grades of the students.

Rubrics can be used to measure complex and subjective learning tasks [105] and are a good tool when the expected learning outcomes are presented in terms of performance, and there are different levels of performance that need to be observed for appropriateness, completion or completeness [98]. Rubrics can be used to measure the results of oral presentations, research reports, discussion participation, personal documents and teamwork, for example [106].

A rubrics scale usually consists of four sections: task description, performance vector, performance level and performance description [98,105], which differentiate learning tasks into performance vectors and describe in detail the performance behaviors at different levels of each vector [106], serving as indicators of learning outcomes, which helps students understand teachers' performance expectations and enhances the transparency and efficiency of teachers' marking [98].

The evaluation rubric scale developed in this study is shown in Table 3 as follows.

Table 3. Evaluation rubric scale developed in this research.

Performance	**Level**	**Excellent 100–81**	**Very Good 80–61**	**Good 60–41**	**Fair 40–21**	**Poor 20–0**
Knowledge (33%)	Industrial safety and hygienic knowledge	Be excellent in industrial safety and hygienic knowledge	Be very good in industrial safety and hygienic knowledge	Be good in industrial safety and hygienic knowledge	Be fair in industrial safety and hygienic knowledge	Be poor in industrial safety and hygienic knowledge
	Fault diagnosis and problem definition	Be excellent in fault diagnosis and problem definition	Be very good in fault diagnosis and problem definition	Be excellent in fault diagnosis and problem definition	Be very good in fault diagnosis and problem definition	Be excellent in fault diagnosis and problem definition
	Technical terms and application of tools and instruments	Be excellent in technical terms and application of tools and instruments	Be very good in technical terms and application of tools and instruments	Be good in technical terms and application of tools and instruments	Be fair in technical terms and application of tools and instruments	Be poor in technical terms and application of tools and instruments

Table 3. *Cont.*

Performance \ Level		Excellent 100–81	Very Good 80–61	Good 60–41	Fair 40–21	Poor 20–0
Skills (34%)	Tools assembly and position planning	Be excellent in tools assembly and position planning (meet the situational requirements: more than 4 items) and comply with the standard of the maintenance manual	Be very good in tools assembly and position planning (meet the situational requirements: 3 items) and comply with the standard of the maintenance manual	Be good in tools assembly and position planning (meet the situational requirements: 2 items) and comply with the standard of the maintenance manual	Be fair in tools assembly and position planning (meet the situational requirements: 1 item) or partially comply with the standard of the maintenance manual	Be poor in tools assembly and position planning (fail to meet the situational requirements: 0 items) and fail to comply with the standard of the maintenance manual
	Diagnostic instrumental operation	Be able to complete the diagnostic trouble shooting progress alone before the deadline	Be able to complete the diagnostic trouble shooting progress alone on the deadline	Be able to complete the diagnostic trouble shooting progress alone after the deadline	Be able to complete part of the diagnostic trouble shooting progress alone after the deadline	Fail to complete the diagnostic trouble shooting progress alone after the deadline
	Operation after VR assist	Be able to complete the breakdown maintenance and explain the solutions before the deadline	Be able to complete the breakdown maintenance and explain the solutions on the deadline	Be able to complete the breakdown maintenance and explain the solutions after the deadline	Be able to complete part of the breakdown maintenance and explain the solutions after the deadline	Fail to complete the breakdown maintenance and explain the solutions after the deadline
Attitude (33%)	Tools using and materials application performance during practical process	Circuit measurement, computer diagnosis, VR assist learning and disassembly & assembly inappropriate (0–3 items)	Circuit measurement, computer diagnosis, VR assist learning and disassembly & assembly inappropriate (3–5 items)	Circuit measurement, computer diagnosis, VR assist learning and disassembly & assembly inappropriate (6–8 items)	Circuit measurement, computer diagnosis, VR assist learning and disassembly & assembly inappropriate (9–11 items)	Circuit measurement, computer diagnosis, VR assist learning and disassembly & assembly inappropriate (include and over 12 items)
	Group sharing during practical process and performance of problem-solving capability	Be able to instruct most of the classmates who are far behind (4 persons)	Be able to instruct most of the classmates who are far behind (3–2 persons)	Be able to instruct most of the classmates who are far behind (1 person)	Be not able to instruct most of the classmates who are far behind	Need other classmates' support to complete the practical process
	Site preparation performance after practical process	Be excellent in site preparation after practical process wire or element left: 0–3 items	Be very good in site preparation after practical process wire or element left: 4–6 items	Be good in site preparation after practical process wire or element left: 7–9 items	Be fair in site preparation after practical process wire or element left: 10–12 items	Be poor in site preparation after practical process

4. Results and Discussion

4.1. Results

4.1.1. Prior Knowledge Analysis of Students' Learning Effectiveness in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice under Different Instructional Strategies

The students in both the experimental and control groups have completed Electrical Engineering and Electronics Practice before the instructional experiment. Therefore, students' learning effect is considered as their prior knowledge. The instructional experiment progress was conducted for 8 weeks, in which three periodical learning effectiveness assessments designed in situational and multiple ways and according to the unit implementation content are required for students during the instructional experiment. During the assessments, students explained the content of the case according to the situation, and they applied the knowledge and skills learned in the classroom to conduct detection analysis, diagnosis induction, diagnosis process, solution, and operation tests.

In order to understand the difference in students' learning effectiveness between VR game simulation instruction and the traditional didactic instruction strategies in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice, the independent samples *t*-test was used to examine the difference between students in both control and experimental groups about their learning effectiveness. Academic performance in Electrical Engineering and Electronics Practice was considered as the covariance to conduct the homogeneity test on overall learning effectiveness and was further investigated to see if students' learning effectiveness would differ according the implementation of different instructional strategies under the condition of excluding the impact of students' prior knowledge. Meanwhile, the opinions and feedback from the two observers during the instruction and the results of the three practical learning assessments were induced and analyzed supported by the qualitative data in order to conduct the instruction activities, time distribution adjustment and the triangulation of qualitative data.

According to Table 4, "Recapitulation sheet of students' prior knowledge scores", when students participated in the Electrical Engineering and Electronics Practice curriculum before the instructional experiment, students in the experimental group received average scores of 57.44, while students in the control group received average scores of 57.50. There was a 0.06 points average score for the control group, which was slightly higher than that of the experimental group. After the academic performance was conducted in the independent samples *t*-test, the t value is −0.014, $p = 0.391 > 0.05$, which is below the level of significance. The results showed that there was no significant difference in the background capabilities of students before Electrical Engineering and Electronics Practice among both groups.

Table 4. Recapitulation sheet of students' prior knowledge scores.

Item	Group	Number of Students	Average Value	Standard Deviation	*t* Value
Academic performance in Electrical Engineering and Electronics Practice	Experimental group	43	57.44	19.89	−0.014
	Control group	36	57.50	16.41	

4.1.2. Variance Analysis in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice under Different Instructional Strategies

The periodical practical learning effectiveness assessments are conducted after the implementation of every unit, and the results are shown in Table 5. A brief description of the summary of learning effectiveness through the implementation of VR game simulation instructional strategies follows.

Table 5. Recapitulation sheet of students' prior knowledge scores in knowledge, skills, and attitude.

Item	Group	Number of Students	Average Value	Standard Deviation	*t*-Value
Knowledge	Experimental group	43	17.02	9.80	−0.883
	Control group	36	19.00	10.04	
Skills	Experimental group	43	23.34	8.50	2.245
	Control group	36	19.11	8.17	
Attitude	Experimental group	43	17.30	7.89	−1.118
	Control group	36	19.55	10.01	

1. Analysis of the effectiveness of the first learning assessment:

The assessment was conducted in the 3rd week of the instructional experiment, and the testing content was the safety and hygienic knowledge and basic instrumental operation in a vehicle maintenance plant. The testing results show that the average score of the control group students is 4.75 higher than that of the experimental group, and the t value is −1.257, $p = 0.339 > 0.05$, which fails to reach the level of significance. From the further questions regarding the analysis of knowledge, skills, and attitude from Table 6, the testing results show that the average score of control group students in the knowledge component is 3.24 higher than that of the experimental group, and the t value is −1.427, $p = 0.951 > 0.05$, which fails to reach the level of significance. The average score of control group students in the skill component is 1.29 higher than that of the experimental group, and the t value is 0.514, $p = 0.003 < 0.05$, which fails to reach the level of significance. The average score of control group students in the attitude component is 0.23 higher than the experimental group, and the t value is -0.330, $p = 0.787$, which fails to reach the level of significance.

Table 6. Recapitulation sheet of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice assessment learning effectiveness scores.

Item	Group	Number of Students	Average Value	Standard Deviation	*t* Value
The first assessment of learning effectiveness	Experimental group	43	66.13	15.21	−1.257
	Control group	36	70.88	18.36	
The second assessment of learning effectiveness	Experimental group	43	86.23	8.74	3.603 ***
	Control group	36	75.72	15.56	
The third assessment of learning effectiveness	Experimental group	43	90.79	6.26	3.599 ***
	Control group	36	84.00	9.76	

Note: *** $p < 0.001$.

2. Analysis of the effectiveness of the second learning assessment:

The assessment was conducted in the 5th week of the instructional experiment, and the testing content was the automatic fault diagnosis and maintenance and repair of the vehicle charging system. The tested results shows that the average score of experimental group students was 10.51 higher than the control group, and the t value was 3.603, $p = 0.000 < 0.05$, which reaches the level of significance. From the further questions analysis in knowledge, skills, and attitude from Tables 6–9, the tested results show that the average score of experimental group students in the knowledge component is 1.08 higher than that of the control group, and the t value is 0.860, $p = 0.000 < 0.05$, which reaches the level of significance. The average score of experimental group students in the skill component is 5.73 higher than that of the control group, and the t value is 2.182, $p = 0.000 < 0.05$, which reaches the level of significance. The average score of experimental group students in the attitude component is 3.69 higher than the control group, and the t value is 6.174, $p = 0.450 > 0.05$, which fails to reach the level of significance.

Table 7. Recapitulation sheet of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice assessment learning effectiveness scores in knowledge item.

Item	Group	Number of Students	Average Value	Standard Deviation	*t* Value
The first assessment of learning effectiveness	Experimental group	43	25.76	9.97	−1.427
	Control group	36	29.00	10.09	
The second assessment of learning effectiveness	Experimental group	43	37.02	4.19	0.860 ***
	Control group	36	35.94	6.83	
The third assessment of learning effectiveness	Experimental group	43	38.04	2.36	1.707 ***
	Control group	36	36.50	5.35	

Note: *** $p < 0.001$.

Table 8. Recapitulation sheet of Recapitulation sheet of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice assessment learning effectiveness scores in skill item.

Item	Group	Number of Students	Average Value	Standard Deviation	*t* Value
The first assessment of learning effectiveness	Experimental group	43	33.48	8.49	0.514 ***
	Control group	36	34.77	12.88	
The second assessment of learning effectiveness	Experimental group	43	39.06	6.75	2.182 ***
	Control group	36	33.33	15.59	
The third assessment of learning effectiveness	Experimental group	43	41.95	9.33	1.734 **
	Control group	36	39.00	5.61	

Note: *** $p < 0.001$; ** $p < 0.01$.

Table 9. Recapitulation sheet of Recapitulation sheet of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice assessment learning effectiveness scores in attitude item.

Item	Group	Number of Students	Average Value	Standard Deviation	*t* Value
The first assessment of learning effectiveness	Experimental group	43	6.88	3.06	−0.649
	Control group	36	7.11	3.04	
The second assessment of learning effectiveness	Experimental group	43	10.13	2.52	6.174
	Control group	36	6.44	2.75	
The third assessment of learning effectiveness	Experimental group	43	10.79	2.05	3.253 ***
	Control group	36	8.50	4.03	

Note: *** $p < 0.001$.

3. Analysis of the effectiveness of the third learning assessment:

The assessment was conducted in the 7th week of the instructional experiment, and the testing content was the automatic fault diagnosis and maintenance and repair of the vehicle starting system. The tested results show that the average score of experimental group students is 6.79 higher than that of the control group, and the t value is 3.599, $p = 0.004 < 0.05$, which reaches the level of significance. From the further questions analysis in knowledge, skills, and attitude from Tables 6–9, the tested results show that the average score of experimental group students in the knowledge component is 1.54 higher than that of the control group, and the t value was 1.707, $p = 0.000 < 0.05$, which reaches the level of significance; the average score of experimental group students in the skill component is 2.95 higher than the control group, and the t value was 1.734, $p = 0.042 < 0.05$, which reaches the level of significance; the average score of experimental group students in the attitude component was 2.29 higher than that of the control group, and the t value was 3.253, $p = 0.000 < 0.05$, which reaches the level of significance.

4.1.3. Variance Analysis in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice under Different Instructional Strategies

Analysis of overall learning effectiveness.

(1) Homogeneity of regression coefficients within groups in overall learning effectiveness.

The homogeneity test of the regression coefficient in overall learning effectiveness is shown in Table 10 in which F = 2.420, $p = 0.124 > 0.05$ (below the level of significance), and therefore, the analysis of one-way analysis of covariance (one-way ANCOVA) would be conducted in a later step.

Table 10. Homogeneity of regression coefficients within groups in overall learning effectiveness.

Resource	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Different instruction strategies * academic performance in Electrical Engineering and Electronics Practice	336.810	1	336.810	2.420	0.124

(2) Excluding the impact of prior knowledge on students of both groups on overall learning effectiveness, the testing result is F = 17.522, $p = 0.000 < 0.05$, which reaches significant difference and means that the overall learning effectiveness in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice will be affected according to the instructional strategies that shown in Table 11. From the recapitulation sheet of statistics in the overall learning effectiveness of the basic electricity practical (Table 12), the adjusted average scores of experimental group students are 11.26 points higher than the control group, which shows that the VR simulation game integrating into the ZPD instructional strategy has a positive effect on the overall learning effectiveness.

Table 11. Recapitulation sheet of analysis of covariance in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice overall learning effectiveness.

Source of Variation	SS	*df*	MS	*F*	*p*
Academic performance in Electrical Engineering and Electronics Practice	1020.362	1	1020.362	7.1966 ***	0.009
Instructional strategies	2484.476	1	2484.476	17.522 ***	0.000
Deviation	10,776.295	76	141.793		
Total	410,625.000	79			

Note: *** $p < 0.001$.

Table 12. Recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice.

Group	Number of Students	Average Value	Standard Deviation	Average Value after Adjustment
Experimental group	43	76.04	1.81	75.95
Control group	36	65.58	1.98	64.69

Analysis of overall learning effectiveness in knowledge components.

(1) Homogeneity test of regression coefficient in overall learning effectiveness—knowledge component.

In the homogeneity test of regression coefficient in the overall learning effectiveness-knowledge component (Table 13), the value was F = 2.199, $p = 0.142 > 0.05$ (below the level of significance), and therefore, the analysis of covariance (one-way ANCOVA) would be conducted in a later step.

Table 13. Homogeneity of regression coefficients within groups in overall learning effectiveness—knowledge component.

Resource	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Different instruction strategies * academic performance in Electrical Engineering and Electronics Practice—knowledge component	86.929	1	86.929	2.199	0.142

(2) Excluding the impact of the prior knowledge of students of both groups on the overall learning effectiveness, the testing result was F = 15.891, $p = 0.000 > 0.05$, which makes a significant difference and means the overall learning effectiveness in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice will be affected according to the instructional strategies that are shown in Table 14. From the recapitulation sheet of statistics in the overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice—knowledge component (Table 15), the adjusted average score of experimental group students is 6.29 points higher than the control group, which shows that there is a positive impact of the integration of competence-oriented instruction on students' overall learning effectiveness—knowledge component in VR simulation game integrating into the ZPD instructional strategy.

Table 14. Recapitulation sheet of analysis of covariance in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice overall learning effectiveness—knowledge component.

Source of Variation	SS	*df*	MS	*F*	*p*
Academic performance in Electrical Engineering and Electronics Practice—knowledge component	631.776	1	631.766	15.732 ***	0.000
Instructional strategies	638.150	1	638.150	15.891 ***	0.000
Deviation	3050.035	76	40.158		
Total	36,150.000	79			

Note: *** $p < 0.001$.

Table 15. Recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice—knowledge component.

Group	Number of Students	Average Value	Standard Deviation	Average Value after Adjustment
Experimental group	43	21.86	5.69	23.05
Control group	36	18.19	8.14	16.76

Analysis of overall learning effectiveness in skill components.

(1) Homogeneity of regression coefficients within groups in overall learning effectiveness—skill component.

In the homogeneity test of regression coefficient in overall learning effectiveness—skill component (Table 16), the value is F = 1.583, $p = 0.212 > 0.05$ (below the level of significance), and therefore, the analysis of covariance (one-way ANCOVA) would be conducted in a later step.

Table 16. Homogeneity test of regression coefficient in overall learning effectiveness—skill component.

Resource	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Different instruction strategies * academic performance in Electrical Engineering and Electronics Practice—skill component	104.335	1	104.335	1.583	0.212

(2) Analysis of covariance (one-way ANCOVA) in the overall learning effectiveness—skill component.

Excluding the impact of the prior knowledge of students of both groups on the learning effectiveness in the skill component, the testing result is F = 8.893, $p = 0.004 > 0.05$, which is a significant difference and means the learning effectiveness in the skill component of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice will be affected according to the instructional strategies that are shown in Table 17. From the recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice—skill component (Table 18), the adjusted average score of experimental group students is 6.54 points higher than the control group, which shows that there is a positive impact of the integration of competence-oriented instruction on students' overall learning effectiveness—skill component in a VR simulation game integrating into the ZPD instructional strategy.

Table 17. Recapitulation sheet of analysis of covariance in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice overall learning effectiveness—skill component.

Source of Variation	SS	*df*	MS	*F*	*p*
Academic performance in Electrical Engineering and Electronics Practice—skill component	437.209	1	437.209	6.584 ***	0.012
Instructional strategies	590.586	1	590.586	8.893 ***	0.004
Deviation	5046.932	76	66.407		
Total	69,256.250	79			

Note: *** $p < 0.001$.

Table 18. Recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice—skill component.

Group	Number of Students	Average Value	Standard Deviation	Average Value after Adjustment
Experimental group	43	32.38	6.54	30.98
Control group	36	22.77	10.26	24.44

Analysis of overall learning effectiveness in attitude components.

(1) Analysis of overall learning effectiveness in attitude component.

In the homogeneity test of regression coefficient in overall learning effectiveness—attitude component (Table 19), the value is F = 0.106, $p = 0.931 > 0.05$ (below the level of significance), and therefore, the analysis of covariance (one-way ANCOVA) would be conducted in a later step.

Table 19. Homogeneity test of regression coefficient in overall learning effectiveness—attitude component.

Resource	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Different instruction strategies * academic performance in Electrical Engineering and Electronics Practice—attitude component	4.041	1	4.041	0.106	0.745

(2) Analysis of covariance (one-way ANCOVA) in overall learning effectiveness—attitude component.

Excluding the impact of the prior knowledge of the students of both groups on the learning effectiveness in the attitude component, the testing result is F = 8.038, $p = 0.000 < 0.05$, which makes a significant difference and means that the learning effectiveness in the attitude component of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice will be affected according to the instructional strategies shown in Table 20. From the recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice-attitude component (Table 21), the adjusted average score of experimental group students is 3.97 higher than that of the control group, which shows that there is a positive impact of the integration of competence-oriented instruction on students' overall learning effectiveness—attitude component in a VR simulation game integrating into the ZPD instructional strategy.

Table 20. Recapitulation sheet of analysis of covariance in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice overall learning effectiveness—attitude component.

Source of Variation	SS	*df*	MS	*F*	*p*
Academic performance in Electrical Engineering and Electronics Practice—attitude component	1031.083	1	1031.083	27.407 ***	0.000
Instructional strategies	302.384	1	302.384	8.038 ***	0.000
Deviation	2859.179	76	37.621		
Total	36,768.750	79			

Note: *** $p < 0.001$.

Table 21. Recapitulation sheet of statistics in overall learning effectiveness of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice—attitude component.

Group	Number of Students	Average Value	Standard Deviation	Average Value after Adjustment
Experimental group	43	21.68	5.84	22.15
Control group	36	18.75	8.37	18.18

4.1.4. Inductive Analysis of Qualitative Data in Instructional Strategies Implementation

During the instructional experiment period, the opinions and feedback from the three observers during the instruction and the results of the three performance evaluation scores are used as the references for instructional activities and time adjustment, including the situated instruction, interdisciplinary/cross-region learning, graphics reading, and practice time distribution, etc. The qualitative data of the instructional strategy in this study are their feedback collected from two instructors and students of the experimental group after the instruction experiment, totaling nine copies in 8 weeks. After the triangulation of qualitative data by the instructor, one lesson-observation teacher and students, the results are shown in Tables 22–24.

Table 22. Statistical table of qualitative data common opinion under VR game simulation integrating into ZPD instructional strategy implementation—collection and organization of positive feedback.

Motif-Item	Sub-Item	Teacher (A)	Teacher (B)	Student (C)	Times
Learning atmosphere	A1. Is there a safe learning environment?	3	2	3	8
	A2. Is there a warm learning atmosphere?	3	3	3	9
	A3. Do students focus on learning contextual connections or not?	3	3	3	9
Teacher–student interaction	B1. Does the teacher encourage students to speak?	3	3	3	9
	B2. Does the teacher respond to the students' responses?	2	1	3	6
	B3. Are there rewards for the exceptional performance of students?	3	3	3	9
Individual learning	C1. Do students assist each other, discuss and dialogue, and integrate interdisciplinary/cross-region issues?	3	2	3	8
	C2. Do the students actively respond to the teacher's questions?	2	3	3	8
	C3. Do students ask questions?	2	3	3	8
Learning effectiveness	D1. Do students focus on individual or group exercises?	2	3	2	7
	D2. Are students learning effectively?	3	3	3	9
	D3. Does the student have learning difficulties?	2	1	2	5
	D4. Has the student's thinking level been deepened?	2	3	3	8
	D5. Are students interested in learning?	3	3	3	9

Table 23. Statistical table of qualitative data common opinion under VR game simulation integrating into ZPD instructional strategy implementation—collection and organization of multiple responses.

Motif-Item	Sub-Item	A Teacher			B Teacher			Experimental Group Students		
		Agree	Neutral	Disagree	Agree	Neutral	Disagree	Agree	Neutral	Disagree
Learning atmosphere	A1. Is there a safe learning environment?	3/9	0/9	0/9	2/9	1/9	0/9	3/9	0/9	0/9
	A2. Is there a warm learning atmosphere?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
	A3. Do students focus on learning contextual connections or not?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
Teacher–student interaction	B1. Does the teacher encourage students to speak?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
	B2. Does the teacher respond to the students' responses?	2/9	0/9	1/9	1/9	1/9	1/9	3/9	0/9	0/9
	B3. Are there rewards for the exceptional performance of students?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9

Table 23. *Cont.*

Motif-Item	Sub-Item	A Teacher			B Teacher			Experimental Group Students		
		Agree	Neutral	Disagree	Agree	Neutral	Disagree	Agree	Neutral	Disagree
Individual learning	C1. Do students assist each other, discuss and dialogue, and integrate interdisciplinary/cross-region issues?	3/9	0/9	0/9	2/9	1/9	0/9	3/9	0/9	0/9
	C2. Do the students actively respond to the teacher's questions?	2/9	1/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
	C3. Do students ask questions?	2/9	1/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
Learning effectiveness	D1. Do students focus on individual or group exercises?	2/9	1/9	0/9	3/9	0/9	0/9	2/9	1/9	0/9
	D2. Are students learning effectively?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
	D3. Does the student have learning difficulties?	2/9	1/9	0/9	1/9	1/9	1/9	2/9	1/9	0/9
	D4. Has the student's thinking level been deepened?	2/9	1/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9
	D5. Are students interested in learning?	3/9	0/9	0/9	3/9	0/9	0/9	3/9	0/9	0/9

Table 24. Statistical table of qualitative data common opinion about VR game simulation integrating into ZPD instructional strategy implementation—coefficient of observation.

Mo-Tif-Item	Sub-Item	Average Coefficient of Agreement	Total Amount of 3 Observers' Opinions					
			Coefficient of Agreement		Coefficient of Neutralization		Coefficient of Disagreement	
Learning atmosphere	A1. Is there a safe learning environment?	0.96	8	0.89	1	0.11	0	0.00
	A2. Is there a warm learning atmosphere?		9	1.00	0	0.00	0	0.00
	A3. Do students focus on learning contextual connections or not?		9	1.00	0	0.00	0	0.00
Teacher–student interaction	B1. Does the teacher encourage students to speak?	0.89	6	0.67	0	0.00	0	0.00
	B2. Does the teacher respond to the student's responses?		9	1.00	1	0.11	2	0.22
	B3. Are there rewards for the exceptional performance of students?		9	1.00	0	0.00	0	0.00
Individual learning	C1. Do students assist each other, discuss and dialogue, and integrate interdisciplinary/cross-region issues?	0.89	8	0.89	0	0.00	0	0.00
	C2. Do the students actively respond to the teacher's questions?		8	0.89	1	0.11	0	0.00
	C3. Do students ask questions?		8	0.89	1	0.11	0	0.00
Learning effectiveness	D1. Do students focus on individual or group exercises?	0.91	8	0.89	2	0.22	0	0.00
	D2. Are students learning effectively?		7	0.78	0	0.00	0	0.00
	D3. Does the student have learning difficulties?		9	1.00	3	0.33	1	0.11
	D4. Has the student's thinking level been deepened?		8	0.89	1	0.11	0	0.00
	D5. Are students interested in learning?		9	1.00	0	0.00	0	0.00

The results of Table 24 "Statistical table of qualitative data common opinion about VR game simulation ZPD instructional strategy implementation—coefficient of observations" shows that the top three items in sequence that the three observers focused on were "learning atmosphere", "learning effectiveness" and "learning process".

1. For the "learning atmosphere", the average coefficient of agreement in motif item is 4.33, and the coefficient of agreement reaches 0.96 on average. As part of "Is there a safe learning environment?", the scores in the sub-items are slightly lower, which means that teachers and students have positive confirmation in the learning environment and situated context, but few students think that their learning atmosphere will not be affected by a safe learning environment. Therefore, a situated connection helps students deepen and improve their learning atmosphere and the application of VR game simulation and, at the same time, it helps reduce students' learning gaps. The lesson-observation teachers suggested that the integration of the VR game simulation context into the curriculum could be carried out by guiding students to complete their diagnostic troubleshooting of the equipment and tools in the practice factory through the simulation of failure situations and also by helping students build complete knowledge of the utilization of vehicle body electrical systems comprehensive maintenance and repair, other related circuit systems and daily electricity. Students also participate in instructional activities through the internet multimedia community by the VR system to discuss solutions to failure problems in VR game simulation situation.

2. For the "learning effectiveness", the average coefficient of agreement in the motif item is 3.80, and the coefficient of agreement reaches 0.91 on average. As part of "Are students learning effectively?", the scores in the sub-item are 0.78 points lower. The lesson-observation teachers suggested guiding students step by step with their tools utilization, diagnostic computer using, problem defining, solutions and strategies to the problems through the start-up of "asking questions". From the situational description of the instructional process and periodical practical assessment by the lesson-observation teacher, students have a high similarity in teamwork learning and teamwork cooperation, in which students help each other investigate the fault causes. In terms of learning difficulties, it could be explained that the insufficient amount of VR equipment and computer software causes those students whose learning capabilities are weak to encounter learning difficulties during VR instructional activities. Few students are able to integrate VR situational requirements with graphic information, which causes their gap in cognitive expression.

3. For "teacher–student interaction" and "individual learning", the average coefficient of agreement in motif item is 0.89, and the coefficient of agreement reaches 0.89 on average. For the lower score sub-item "B1—Does the teacher encourage students to speak?", the score is lower because students are not able to adapt to the VR operational environment and students are also not able to understand environmental control and operation in VR game simulation, which is considered the main factor that causes low scores. This time, the students of an experimental group adopted an interdisciplinary/cross-region in which the questions are designed based on basic instrumental operation, fault diagnosis and inspection of the vehicles' starting system, and fault diagnosis and inspection of the vehicles' charging system. In addition, the questions are also designed in the interdisciplinary/cross-region concepts and demands in fan motors and electricity from wind power in daily lives, in which students are guided to understand how the application of vehicles' maintenance and repair can also be used in other fields as well as in daily life.

4.2. Discussion

4.2.1. The Impact of Integrating VR Simulation Games into ZPD Instructional Strategies Implementation on Students' Learning Effectiveness

The results of this study show that integrating VR simulation games into ZPD instructional strategies has a positive impact on students' overall learning effectiveness, and it has a significant impact difference on knowledge, skills and attitudes. The evaluation of each period is discussed below.

First of all, students' scores in "Electrical and Electronic Practice" that were completed before the instructional experiment were statistically analyzed. The overall results show no significant difference, in which the average score of the control group was 0.06 points higher than the average score of the experimental group. After 3 weeks of the instructional experiment, there is no significant difference in the overall results of the first practical learning effectiveness assessment, and among them, skill items have significant differences, and the average score of the control group is 1.29 points higher than that of the experimental group. From the further exploration of the evaluation results and the implementation of VR games into the ZPD instructional strategy implementation qualitative data, it is found that all three observers responded positively to the question, "Does the teacher encourage students to speak?" In the VR course, teachers tried to respond to different questions from students, solved problems quickly when difficulties arose, and their instant problem solving resulted in difficulties in VR operation. This part affected knowledge and attitude only, and it is speculated that the reason is the small difference in learning effectiveness between the two groups. This study made up for it through after-school time by encouraging students to leave messages through social software groups, and then the teacher answered the questions one by one.

After the first learning effectiveness assessment, the instructional activities content was adjusted according to the assessment results and feedback. The second learning effectiveness assessment was carried out in the 5th week of the instructional experiment. There is a significant difference in the overall results of the second learning effectiveness assessment, and there are significant differences in the knowledge items, in which the average score of the experimental group is 1.07 points higher than the average score of the control group. There are significant differences in skill items, in which the average score of the experimental group is 5.73 points higher than that of the control group. There are significant differences in attitude items, in which the average score of the experimental group is 3.69 points higher than that of the control group. From the further investigation of the assessment results and the qualitative data of VR games into ZPD instructional strategy implementation, it is found that all three observers have improved in VR operation after the adjustment of instructional activities, and they become more thoughtful about the information in the cognitive context. It is speculated that VR manipulation is essential for familiarity and adaptability, and it would become one of the specific factors for the effectiveness of ZPD instructional strategy implementation.

There are significant differences in the overall results of the third learning effectiveness assessment, and among them, there are significant differences in the knowledge items, in which the average score of the experimental group is 1.54 points higher than the average score of the control group. There are significant differences in skill items, in which the average score of the control group is 2.95 points higher than the average score of the experimental group. There are significant differences in attitude items, in which the average score of the experimental group is 2.29 points higher than that of the control group. The third learning effectiveness evaluation of this experiment is carried out for the third learning effectiveness assessment, and after referring to Table 21 "Statistical table of qualitative data common opinion under VR game simulation integrating into ZPD instructional strategy implementation—collection and organization of positive feedback", it is speculated in terms of knowledge and skills that a significant difference is reached after statistical analysis in terms of teacher–student interaction and personal learning effectiveness for the students in the experimental group. From the results of the instruction and assessment process, it is speculated that the two groups of students had difficulty operating VR games at the beginning. However, there is a significant difference between the two groups (experimental group and control group) without specific guidance. In terms of attitude, it is speculated that the students in the experimental group focus on the fault diagnosis, troubleshooting and maintenance of the car charging system and its application, in which it helps guide students to solve the fault problem and define the content of the fault in the VR game situation in a timely manner.

4.2.2. VR Qualitative Data Evaluation of VR Simulation Games Integrated into ZPD Instructional Strategies

In this study, the design of integrating VR game simulation into ZPD curriculum instructional activities is relatively complicated, and it takes time to become familiarized with operating VR. Through the integration of knowledge, skills and attitudes, as well as the integration of students' actual car failure situations and daily life applications, the overall contextualized instructional method of automotive circuits has developed. During the instructional experiment, the instructional activities are appropriately adjusted according to the students' learning profiles. Students' curiosity and enthusiasm for VR game simulation can be seen in Table 23, "Statistical table of qualitative data common opinion about VR game simulation integrating into ZPD instructional strategy implementation—coefficient of observation". Therefore, in this study, these three sub-items that the teachers and students are more concerned about are described as follows:

1. "Are there rewards for the exceptional performance of students?"

After the VR game simulation curriculum, the teacher will use the 5 min before the end of the class to encourage the students who have performed outstandingly in the class by giving bonus points with lesson-observation teachers and other students. They will also ask the students to come up with the difficulties they encountered and the strategies to solve them. Then, the teacher in class and the teacher who observes the class discuss the problem together.

2. "Are students learning effectively?"

It is certain that VR game simulation ought to be integrated into the implementation of ZPD instructional strategies. After the third week of the curriculum, the practice and auxiliary instruction of VR game operation after class was carried out in this study, in which assisted instruction is mainly based on VR application experience, and the practices are classified into space sensing, joystick operation, sound and light sensing, and object grasping exercises through two sets of VR games in order to assist students with familiarizing themselves with the virtual space and meanwhile help the VR game simulation instructional strategy be implemented smoothly.

3. "Are students interested in learning?"

In learning effectiveness, it can be found that students have the highest scores for learning difficulties and willingness to learn, because students are trying to use VR games to simulate three units of courses, and they are very popular in the scene of car failure simulation using VR for game simulation. However, it is difficult to operate VR games because the troubleshooting time in the scenario is relatively long. Therefore, the teacher in class slowed down the speed of solving the problem to let students become familiar with the VR game simulation environment and operating procedures.

5. Conclusions and Suggestions

5.1. Conclusions

5.1.1. Completion of Investigation between Students' Practical Capabilities and Learning Relationship in the Construction of the ZPD Virtual Reality Integrated into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice

In order to let students complete the task through the teacher's auxiliary tools between the possibility of solving the problem and not being able to solve the problem, this study utilizes the inquiry practice curriculum design by integrating the scaffolding theory to build supports for the infrastructure at different levels, integrates learning themes into context and the simulation of practical skills built by "virtual reality", provides assistance via teachers' prompts, which led instruction, introduces the inquiry practice capability and learning effect into the hierarchical structure, and also constructs exclusive VR game simulation and integrates it into the practical skills instructional unit of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice.

5.1.2. Students' Learning Effectiveness by Adopting ZPD Virtual Reality Integrating into Vehicle Charging and Starting System

After the implementation of the practical curriculum of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice, the results found that students' performance reached the level of significance in the third learning assessment from the difference analysis of different instructional strategies on the evaluation of the learning effect of Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice. Students' learning effectiveness was outstanding in corresponding to the ZPD Unit 3—Functional Testing and Troubleshooting of the Automotive Alternator and Starting Motor curriculum.

5.1.3. Students' Learning Effectiveness in Maintenance Equipment Operation Procedures Corresponding to ZPD Virtual Reality Integrating into Being Familiar with the Practice Factory Environment

Among the induction of qualitative data on the implementation of instructional strategies, students received the highest recognition score in the learning atmosphere from the sub-item "Is there is an enthusiastic learning atmosphere?" and "The contextual connection of whether students focus on learning", corresponding to ZPD Unit 1—"Get Familiar With the Practice Factory Environment and Maintenance Tools Operating Procedure".

5.1.4. Students' Learning Effectiveness in VR Simulation Game of the Disassembly and Function Inspection of the Car Charging and Starting System

In the summary of qualitative data on the implementation of ZPD instructional strategies, students received the highest recognition score in learning effectiveness from the sub-item "Do students have learning difficulties?" and "Do students enjoy learning?", corresponding to ZPD Unit 2—"Disassembly and Functional Testing of the Automotive Alternator and Starting Motor".

5.1.5. The Implementation of Integrating VR Simulation Games into ZPD Instructional Strategies Has a Positive Impact on Students' Overall Inquiry and Practical Learning

In this study, independent samples *t*-test and the analysis of one-way analysis of covariance (one-way ANCOVA) were used for testing. The test items include "students' overall prior knowledge", "knowledge, skills and attitudes of students' prior knowledge", "students' periodical learning effectiveness in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice", students' periodical learning effectiveness of knowledge, skills and attitude in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice", "Students' overall learning effectiveness in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice" and "Students' overall learning effectiveness of knowledge, skills and attitude in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice", etc. The results showed that there are significant differences in students' learning effectiveness in the three periods in the periodical learning effectiveness evaluation, in which the experimental group students had better learning effectiveness than the students of the control group. From the results of an independent sample *t*-test and the analysis of one-way analysis of covariance (one-way ANCOVA), the students in the experimental group were better than those in the control group.

5.1.6. VR Instructional Activities Need to Be Modified According to the Students' Learning Situation during the Implementation Process of the Virtual Reality Simulation Game Integrating into ZPD Instructional Strategies

This study is based on the teaching experiment process in which three observers were invited to observe the course and record teaching activities. In addition, after each periodical assessment, students are asked to give substantive feedback on the instructional courses. A triangulation of qualitative data was then performed by three observers, and meanwhile, the instructional activities were revised in a rolling manner by the teacher according to the qualitative data. It was found that there were significant differences in the comparison of students' periodical learning performance. By integrating the quantitative and qualitative data of the research, it was found that during the implementation of ZPD teaching activities, in addition to the planning and design of instructional activities that require special attention, students' attitude and ability to adapt to VR games are also worth noting. The attitudes of the two groups of students were comparable, and there was no significant difference when there was no special guidance for student groups to discuss in the first three weeks of instructional activities. The instructional activities were adjusted after the fifth week, according to instruction feedback. There was a significant difference in the performance of the students in the third learning effect after adaptively guiding student groups to discuss and share case studies. Therefore, this study utilized other games such as space sensing, handle joystick operation, sound and light sensing, and VR games for object grasping practice to assist students' learning in order to stimulate their curiosity and enthusiasm for VR games in the course of these games and at the same time to guide students to assist in the VR game simulation instructional strategy implementation in the future. Through familiarity with the VR game simulation situation, students will be able to acquire knowledge, reading comprehension, and interdisciplinary and interdisciplinary abilities, and meanwhile, it helps increase students' understanding of the "abstract concept of electronic circuits" in Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice. This study found the obstacles and difficulties that the students encountered in the operation experience. To arouse students' curiosity about VR games through after-school tutoring, the operation process is as follows:

1. By letting students experience the situation in virtual space, their responses to light, sound, and touch were stimulated, and their curiosity and learning enthusiasm for VR games arose by using the exploration games and by giving them training in the situation with systematic thinking.

2. By guiding students to explore themselves through VR game simulation in the situation, their knowledge and skills were improved through the relevant knowledge of detection tools, maintenance fields, industrial safety and so on provided in the game. It also effectively trained the students' patience and professional attitude in the workplace for Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice.

3. In the VR game simulation instructional strategy through situational case simulation, maintenance tips through the games were provided to help students collect possible causes of failure and equip students with the ability to judge, in which they shared and reviewed the troubleshooting process with the team members.

4. After the course was over, we let the students in the control group and the experimental group have the situational experience of VR game simulation, and we let the students in the experimental group and the teacher assist the students in the control group to experience the situational experience of the VR game simulation. During the experience, it was found that the students in the experimental group and the students in the control group can propose different solutions to the same failure case, and the two groups of students can coordinate with each other about the knowledge and skills given by the cooperation situation, which accelerates the understanding and familiarity of students in the control group with VR game simulation.

5.2. Suggestions

5.2.1. Suggestions for the Implementation of Virtual Reality Simulation Games Integrating into ZPD Instructional Strategies

A quasi-experimental design is adopted in this study, in which virtual reality simulation games are integrated into ZPD instructional strategies and students' learning effectiveness is investigated and evaluated through the instructional experiments to shape students' learning performance. The results of this study show that integrating virtual reality simulation games into ZPD instructional strategies has a positive and significant impact on students' overall learning effectiveness. After referring to Table 23 "Statistical table of qualitative data common opinion about VR game simulation ZPD teaching strategy implementation—coefficient of observation", the suggestions are explained as follows:

1. Strengthen the practice of internet and VR equipment operation.

The theme of this research instructional curriculum is "Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice", in which the curriculum content is mainly based on basic instrument operation, vehicle charging system fault diagnosis and detection, and the use of VR games in the situational mode to let students experience the simulated vehicle fault diagnosis process and the process of troubleshooting. However, operating VR games also requires time to adapt, the content of situational integration is not as much as that of general subjects, and there are also limitations in the description of life applications. Therefore, during classroom instruction time, students are often allowed to use the time after class or club activities to become familiar with the VR game environment and operation methods so that they can get started quickly.

2. Integrate interdisciplinary/cross-region issues into subjects, not limited to a single theme.

This study recommends integrating interdisciplinary/cross-region issues into subject content without limitation to a single theme in the process of integrating VR game simulation into the implementation of ZPD instructional strategy and furthermore adding the in-depth experience of VR situational applications. Because the cross-field topics can be adjusted in accordance with the course theme, they are easier for teachers to use, and at the same time, they help students learn even more effectively.

5.2.2. Suggestions for Future Research

1. Research methods:

This study is mainly based on quantitative analysis, supplemented by qualitative feedback data induction, in which the student's performance in the learning process appears to be weakened. As a consequence, the research time in the future could be extended, and the implementation of the course content could be extended. Through various methods such as student learning process, teacher observation and classroom video, the collection of students' long-term course records, multidisciplinary feedback across fields, and records of students' learning experience and learning outcomes, from the perspective of objectivity and diversity, mastering the integration of VR game simulation into ZPD instructional strategy implementation affects the whole picture of learners. In terms of data analysis, it is suggested that future researchers could add some VR-based tools for qualitative analysis, such as the System Usability Scale (SUS) [107] or Simulator Sickness Questionnaire (SSQ) [108], to make the whole study more diverse and enriching.

2. Research topic:

This research mainly focuses on the implementation of the ZPD instructional strategy integrated into Vehicle Body Electrical System Comprehensive Maintenance and Repair Services Practice. Related research on literacy teaching and assessment includes different combinations of competence-oriented instructional assessment, reading literacy, independent learning, learning history files, competence-oriented instructional flipped classrooms, competence-oriented instructional and scaffolding learning, etc. It is hoped that in the future, it will be possible to develop research topics for the implementation of VR game situations into competence-oriented instruction in technical high school majors and practical courses.

3. Competence-oriented instructional strategies applied to distance teaching:

VR virtual conferences in both remote synchronous and asynchronous teaching have been adopted. It will be a big challenge for skills-based senior high schools in practical curricula. However, with VR virtual conferences, students can enter the virtual world remotely at home where situational learning in line with the subject content of the course is created through the virtual space, but the effectiveness of student learning has yet to be tested. Integrating VR simulation games into competence-oriented instruction is quite different from previous teaching that focused on knowledge content. Its emphasis is placed on considering the questions of car failure cases and maintenance logic and the application of their learned knowledge and skills to solve fault cases and to clarify the problems faced. Therefore, it is worth studying how to integrate VR game simulation into competence-oriented instruction and apply it to the distance teaching of practical curriculum in skills-based senior high schools. To cater to the new era of digital distance learning, the research results can also be used for skills-based senior high school teachers to understand and learn in the future.

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References

1. Ministry of Economic Affairs. 2022 Biotechnology Industry White Pape. 2022. Available online: https://www.biopharm.org.tw/images/2022/2022Biotechnology-Industry-in-Taiwan.pdf (accessed on 1 April 2023).
2. Ministry of Economic Affairs. The Output Value of Automobile and Parts Industry Is Expected to Turn Positive in 2022. 2022. Available online: https://www.moea.gov.tw/mns/populace/news/News.aspx?kind=1&menu_id=40&news_id=98412 (accessed on 15 May 2023).
3. Ministry of Economic Affairs. Taiwan International Tradeshows: Epidemic Recovery vs. New Consumer Trends: Who Can Master the Next Step in the Automotive Aftermarket? 2022. Available online: https://www.taiwantradeshows.com.tw/zh_TW/news-info-28496/004.html (accessed on 15 May 2023).
4. CTCI Foundation. Research on the Resilience Development of the Post-Epidemic Industrial Supply Chain. 2022. Available online: https://reurl.cc/1el9y9 (accessed on 1 April 2023).
5. Automotive Research & Testing Center. Global Vehicle Supply Chain Development Trends and Opportunities in Taiwan. 2022. Available online: https://www.artc.org.tw/tw/knowledge/articles/13674 (accessed on 1 April 2023).
6. Ministry of Economic Affairs. Opportunities for the Transformation of the Automotive Industry in the Post Epidemic Period. 2021. Available online: https://reurl.cc/NqOv1e (accessed on 1 April 2023).
7. Taiwan Transportation Vehicle Manufacturers Association. Vehicle Industry Output Value. 2023. Available online: https://www.ttvma.org.tw/industry (accessed on 1 April 2023).
8. Chung-Hua Institution for Economic Research. Smart Electric Vehicle Industry Outlook Study 2021. Available online: https://www.cier.edu.tw/publish/projects/detail/4121 (accessed on 15 May 2023).
9. Environmental Information Center. Can Electric Cars Help Solve the Climate Problem? 2020. Available online: https://e-info.org.tw/node/226403 (accessed on 15 May 2023).
10. Environmental Protection Administration, Executive Yuan. My Country's National Greenhouse Gas Emissions Inventory Report (2021 Edition). 2021. Available online: https://unfccc.saveoursky.org.tw/nir/tw_nir_2021.php (accessed on 1 April 2023).
11. Chen, P.-H.; Lee, C.-H.; Wu, J.-Y.; Chen, W.-S. Perspectives on Taiwan's Pathway to Net-Zero Emissions. *Sustainability* **2023**, *15*, 5587. [CrossRef]
12. Ministry of Transportation and Communications. Taiwan 2050 Net Zero Transformation "Electrification and Carbon Free Transportation" Key Strategic Action Plan. 2023. Available online: https://reurl.cc/vkyb61 (accessed on 15 May 2023).
13. Muzir, N.A.Q.; Mojumder, M.R.H.; Hasanuzzaman, M.; Selvaraj, J. Challenges of Electric Vehicles and Their Prospects in Malaysia: A Comprehensive Review. *Sustainability* **2022**, *14*, 8320. [CrossRef]

14. Huang, Q.M. The Vehicle Industry Is Deploying Talents Ahead of Time, and Wanneng University of Science and Technology Is Providing a Cradle for Talent Education. 2022. Available online: https://money.udn.com/money/story/5723/6486962 (accessed on 1 April 2023).
15. Global Views—Commonwealth Publishing Group. The Big Future of the Electric Vehicle Industry. 2022. Available online: https://www.sanmin.com.tw/product/index/010696623 (accessed on 15 May 2023).
16. Automotive Research & Testing Center. Development Trends of Electric Vehicle Platforms of Major International Automakers. 2023. Available online: https://www.artc.org.tw/tw/knowledge/articles/13693 (accessed on 1 April 2023).
17. Technical Senior High School Power Machinery Group Cente. Center Introduction. 2023. Available online: https://vtedu.mt.ntnu.edu.tw/nss/s/power/0301 (accessed on 1 April 2023).
18. Piaget, J. *Piaget's Theory*; Wiley: New York, NY, USA, 1970; Volume 1, pp. 1–5. Available online: http://trentu.ca/faculty/nim-bolter/cdoshawa/281H_2006FA_OSH_L4_6Slides.pdf (accessed on 1 April 2023).
19. Wadsworth, B.J. *Piaget's Theory of Cognitive and Affective Development: Foundations of Constructivism*; Longman Publishing: London, UK, 1996; Available online: https://psycnet.apa.org/record/1996-97227-000 (accessed on 4 April 2023).
20. Organisation for Economic Cooperation and Development. The Future of Education and Skills 2030. 2022. Available online: https://www.oecd.org/education/2030-project/ (accessed on 1 April 2023).
21. Lan, W.Y. Teaching Power: The Key to Deepening Competence-Oriented Learning. 2019. Available online: https://www.books.com.tw/products/0010833900 (accessed on 15 May 2023).
22. Su, H.T.; Chen, C.C. Implications of Piaget's Cognitive Development Theory for Physical Education Teaching. *Sport. Res. Rev.* **2010**, *108*, 30–37. [CrossRef]
23. Yeh, K.L.; Tasi, Y.C.; Chung, T.T.; Chang, M.W.; Chiang, C.H.; Dai, C.Y. Longitudinal Study on the Learning Performance of Problem-Based Computational Thinking for Students in Non-Information Field. *J. Cardinal Tien Coll. Nurs.* **2021**, 10–17. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=18100961-202110-202112030008-202112030008-10-17 (accessed on 4 April 2023).
24. Chan, Q.I. Discussing the Development of the Cloud Gate Dance Theater from Its 2013 Production "Rice". 2015. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20110309002-201510-201603230034-201603230034-47-55 (accessed on 15 May 2023).
25. Lin, Z.W.; Lin, Y.S. Reflections of Scaffolding Theory on Technical Teaching—An Example of Mechanical Practice. In Proceedings of the A Narriative on CSQ 43th Annual Congress and the 13th National Quality Management Symposium, Taipei, Taiwan, 10 November 1996; pp. 1–13. Available online: https://reurl.cc/Q41kAZ (accessed on 15 May 2023).
26. Liao, C.-W.; Liao, Y.-H.; Chen, B.-S.; Tseng, Y.-J.; Ho, W.-S. Elementary Teachers' Environmental Education Cognition and Attitude: A Case Study of the Second Largest City in Taiwan. *Sustainability* **2022**, *14*, 14480. [CrossRef]
27. Shyr, W.-J.; Ho, W.-S.; Chen, J.-R.; Chang, L.-Y.; Chen, I.-M. Effectiveness of Social Participation Courses Applied in the Disaster Prevention for Taiwanese K-12 Education. *Sustainability* **2022**, *14*, 8221. [CrossRef]
28. Lin, C.N. Sharing the planning and practice of a new curriculum-based internship program for Skills-Based Senior High School: The example of the Dept. of Mold and Die Engineering and the New Taipei Municipal San-Chung Commercial and Industrial Vocational High School. *Taiwan Educ. Rev. Mon.* **2020**, *9*, 47–53. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-202008-202008030012-202008030012-47-53 (accessed on 15 May 2023).
29. Liao, C.-W.; Tseng, Y.-J.; Liao, Y.-H.; Chen, B.-S.; Ho, W.-S.; Wang, I.-C.; Lin, H.-I.; Chen, I.-M. A Practical Curriculum Design and Learning Effectiveness Evaluation of Competence-Oriented Instruction Strategy Integration: A Case Study of Taiwan Skills-Based Senior High School. *Behav. Sci.* **2023**, *13*, 43. [CrossRef] [PubMed]
30. Kao, H.H. An The Influence of Virtual Reality to the Education. Master's Thesis, National Taipei University of Education, Taipei, Taiwan, 2017. Available online: https://hdl.handle.net/11296/3hgxzg (accessed on 15 May 2023).
31. Chen, W.S. Interactive Design of a Chinese Synchronous Telecourse for Intermediate Chinese Learners as a Teaching Example. *World Chin. Lang.* **2018**, *122*, 127–138. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=10170855-201812-201901020017-201901020017-127-138 (accessed on 15 May 2023).
32. Lin, Y.H. Safety education and training combined with VR technology to reduce the risk of high-job accidents more efficiently. *J. Labor Occup. Saf. Health* **2021**, *29*, 18–21. Available online: https://reurl.cc/EGqlXk (accessed on 15 May 2023).
33. Lee, Z.Y. The research on the virtual reality of the ship dynamic positioning control simulation. *J. Taiwan Soc. Nav. Archit. Mar. Eng.* **2021**, *40*, 123–134. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=10234535-202108-202208090003-202208090003-123-134 (accessed on 15 May 2023).
34. Woon, A.P.N.; Mok, W.Q.; Chieng, Y.J.S.; Zhang, H.M.; Ramos, P.; Mustadi, H.B.; Lau, Y. Effectiveness of virtual reality training in improving knowledge among nursing students: A systematic review, meta-analysis and meta-regression. *Nurse Educ. Today* **2021**, *98*, 104655. [CrossRef]
35. Yammine, K.; Violato, C. A meta-analysis of the educational effectiveness of three-dimensional visualization technologies in teaching anatomy. *Anat. Sci. Educ.* **2015**, *8*, 525–538. [CrossRef]
36. An, D.; Deng, H.; Shen, C.; Xu, Y.; Zhong, L.; Deng, Y. Evaluation of Virtual Reality Application in Construction Teaching: A Comparative Study of Undergraduates. *Appl. Sci.* **2023**, *13*, 6170. [CrossRef]
37. Checa, D.; Saucedo-Dorantes, J.J.; Osornio-Rios, R.A.; Antonino-Daviu, J.A.; Bustillo, A. Virtual Reality Training Application for the Condition-Based Maintenance of Induction Motors. *Appl. Sci.* **2022**, *12*, 414. [CrossRef]

38. Jin, C.Y. Exploration on Strategies to Promote Teachers to Use Fragmented Time Micro-Learning in the Era of Web3.0. 2021. Available online: https://www.cnki.com.cn/Article/CJFDTotal-ZSWK202103037.htm (accessed on 1 April 2023).
39. Fang, C.Y. A Preliminary Exploration on How to Practice the Concept of Whole-Person Education in the School's Core Literacy Curriculum. *Taiwan Educ. Rev. Mon.* **2021**, *10*, 142–147. Available online: http://www.ater.org.tw/journal/article/10-2/free/14.pdf (accessed on 4 April 2023).
40. Tasi, C.T. The Core Literacy of the 12-Year National Basic Education Curriculum Syllabus. *Taiwan Educ. Rev. Mon.* **2020**, *9*, 8–12. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-202001-202001030026-202001030026-8-12&PublishTypeID=P001 (accessed on 4 April 2023).
41. Hung, Y.S.; Fan, S.X. Walking Together ~ Walking into the 12-year National Basic Education Curriculum Outline. 2015. Available online: https://gpi.culture.tw/books/1010401227 (accessed on 1 April 2023).
42. National Academy for Educational Research. 12-Year National Basic Education Curriculum Development Guidelines. 2014. Available online: https://reurl.cc/QW9AZp (accessed on 1 April 2023).
43. Lee, Y.F.; Tseng, P.K.; Sung, H.T. Design and Practice of the Competency-Oriented Teaching for Vocational High Schools. *J. Taiwan Educ. Stud.* **2022**, *3*, 333–358. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20220316001-202201-202203230012-202203230012-333-358 (accessed on 4 April 2023).
44. Chen, L.H. Observations on the Current Situation of Teaching Materials and Methods in Primary and Secondary Schools and Opportunities for Reform: A Literacy Oriented Perspective. *J. Book Res.* **2018**, *11*, 109–145. Available online: https://ej.naer.edu.tw/JTR/v11.2/2018-08-jtr-v11n2-109.pdf (accessed on 4 April 2023).
45. Lu, H.L. Evaluation of the core literacy of the 12-year national education 107 curriculum. *Taiwan Educ. Rev. Mon.* **2017**, *6*, 1–6. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201703-201703020016-201703020016-1-6 (accessed on 15 May 2023).
46. Wu, C.S. Competency-Based Teacher Education: Ideas, Challenges and Practices. *Sch. Adm.* **2017**, *112*, 14–27. [CrossRef]
47. Yang, Y.R.; Chen, L.C. Bringing General Liberal Studies to Work. *Soc. Educ. Bimon. Mag.* **1997**, 10–12. Available online: http://rportal.lib.ntnu.edu.tw/handle/20.500.12235/1413 (accessed on 4 April 2023).
48. Chen, K.T. Key points of curriculum development and design: Analysis the core competencies of 12-year Compulsory Education. *J. Res. Elem. Educ.* **2016**, *13*, 21–44. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=18146783-201612-201812180013-201812180013-21-44 (accessed on 4 April 2023).
49. Wang, C.K. Problem Analysis and Suggestions on Literacy-Oriented Instructional Design. *Taiwan Educ. Rev. Mon.* **2021**, *10*, 186–192. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-202101-202012310021-202012310021-186-192 (accessed on 15 May 2023).
50. Wu, C.S. Research on Connotation Construction and Practice of Literacy-Oriented Teacher Education. *J. Res. Educ. Sci.* **2018**, *63*, 261–293. [CrossRef]
51. Gardner, H. Assessment in context: The alternative to standardized testing. In *Changing Assessments: Alternative Views of Aptitude, Achievement and Instruction*; Springer: Dordrecht, The Netherlands, 1992; pp. 77–119. [CrossRef]
52. Ho, Y.C. Design and Evaluation of Literacy-Oriented Instruction: A Case Study of a Primary School in the East. *Taiwan Educ. Rev. Mon.* **2017**, *6*, 15–19. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201703-201703020016-201703020016-15-19 (accessed on 4 April 2023).
53. Wu, C.S.; Lin, T.Y. Standards-based assessment. *J. Educ. Res.* **2012**, *221*, 133–134. Available online: http://ericdata.com/tw/detail.aspx?no=150033 (accessed on 8 April 2023).
54. Vygotsky, L.S.; Cole, M. *Mind in Society: Development of Higher Psychological Processes*; Harvard University Press: Cambridge, MA, USA, 1978; Available online: https://reurl.cc/2Wx1Nv (accessed on 4 April 2023).
55. Doolittle, P.E. Vygotsky's Zone of Proximal Development as a Theoretical Foundation for Cooperative Learning. *J. Excell. Coll. Teach.* **1997**, *8*, 83–103. Available online: http://capacity-resource.middletownautism.com/wp-content/uploads/sites/6/2017/03/vygotsky-zone-of-proximal-development.pdf (accessed on 4 April 2023).
56. Wood, D.; Bruner, J.S.; Ross, G. The role of tutoring in problem solving. *J. Child Psychol. Psychiatry* **1976**, *17*, 89–100. [CrossRef]
57. Davis, E.A.; Miyake, N. Explorations of scaffolding in complex classroom systems. *J. Learn. Sci.* **2004**, *13*, 265–272. [CrossRef]
58. Bruner, J. Vygotsky: A historical and conceptual perspective. *Cult. Commun. Cogn. Vygotskian Perspect.* **1985**, *21*, 34.
59. Artaud, A. *Theatre and Its Double*; Alma Books: London, UK, 2018; Available online: https://reurl.cc/qkaxln (accessed on 4 April 2023).
60. Sin, J.; Munteanu, C. Let's Go There: Combining Voice and Pointing in VR. In Proceedings of the 2nd Conference on Conversational User Interfaces, Bilbao, Spain, 22–24 July 2020; Article No.: 31. pp. 1–3. [CrossRef]
61. Syamimi, A.; Gong, Y.; Liew, R. VR industrial applications—A Singapore perspective. *Virtual Real. Intell. Hardw.* **2020**, *2*, 409–420. [CrossRef]
62. Chang, C.Y. Spherical video-based virtual reality on students' learning experience in maternity education. *J. Lib. Arts Soc. Sci.* **2020**, *16*, 235–252. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=18197205-202009-202009260013-202009260013-235-252 (accessed on 4 April 2023).
63. Kumar, A.; Srinivasan, B.; Saudagar, A.K.J.; AlTameem, A.; Alkhathami, M.; Alsamani, B.; Khan, M.B.; Ahmed, Z.H.; Kumar, A.; Singh, K.U. Next-Gen Mulsemedia: Virtual Reality Haptic Simulator's Impact on Medical Practitioner for Higher Education Institutions. *Electronics* **2023**, *12*, 356. [CrossRef]

64. Ryu, J.-H.; Park, J.-W.; Choi, S.I.; Kim, J.Y.; Lee, H.; Yoo, H.-J.; Han, S.-H. Virtual Reality vs. Tablet Video as an Experiential Education Platform for Pediatric Patients Undergoing Chest Radiography: A Randomized Clinical Trial. *J. Clin. Med.* **2021**, *10*, 2486. [CrossRef]
65. Kuna, P.; Hašková, A.; Borza, L'. Creation of Virtual Reality for Education Purposes. *Sustainability* **2023**, *15*, 7153. [CrossRef]
66. Gómez-Cambronero, Á.; Miralles, I.; Tonda, A.; Remolar, I. Immersive Virtual-Reality System for Aircraft Maintenance Education: A Case Study. *Appl. Sci.* **2023**, *13*, 5043. [CrossRef]
67. Ministry of Education. 12-Year National Basic Educational Technology Senior Secondary School Group Curriculum Outline-Power Machinery Group. 2018. Available online: https://reurl.cc/AdXQx3 (accessed on 1 April 2023).
68. K-12 Education Administration, Ministry of Education. 108 New Curriculum Guidelines. 2023. Available online: https://shs.k12ea.gov.tw/public/12basic/108course/index.html (accessed on 15 May 2023).
69. Osborne, J. Arguing to learn in science: The role of collaborative, critical discourse. *Science* **2010**, *328*, 463–466. [CrossRef]
70. Lin, H.H.; Kuo, C.Y.; Wu, H.K. Relationship Among Engagement and Curiosity of Individual Level Variables of Students, Group Level Variables of Teachers, and Scientific Inquiry Abilities: Conference of Cross-Level Moderated Mediation. *J. Res. Educ. Sci.* **2021**, *66*, 75–110. [CrossRef]
71. Minner, D.D.; Levy, A.J.; Century, J. Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002. *J. Res. Sci. Teach. Off. J. Natl. Assoc. Res. Sci. Teach.* **2010**, *47*, 474–496. [CrossRef]
72. National Academy of Sciences-National Research Council, Washington, DC; National Research Council (US); National Research Council Staff; National Research Council; Board on Science Education Staff; Division of Behavioral; Assessment Staff. *National Science Education Standards*; Joseph Henry Press: Washington, DC, USA, 1996; Available online: https://reurl.cc/GegWep (accessed on 15 May 2023).
73. Ministry of Education. Twelve-Year National Basic Education Curriculum Outline-National Primary and Secondary Schools and Ordinary Senior High Schools-Natural Science Field. 2018. Available online: https://reurl.cc/zAOxY0 (accessed on 1 April 2023).
74. Huang, C.W. Explore Systems Thinking and Its Application in The Process of Independent Research. *Forum of Gifted Education* **2021**, *19*, 3–19. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130730001-202110-202112210016-202112210016-3-19 (accessed on 4 April 2023).
75. Gharajedaghi, J. *Systems thinking: Managing Chaos and Complexity: A Platform for Designing Business Architecture*; Elsevier: Amsterdam, The Netherlands, 2011; Available online: https://reurl.cc/RvRxWZ (accessed on 4 April 2023).
76. Jacobson, M.J. Problem solving, cognition, and complex systems: Differences between experts and novices. *Complexity* **2001**, *6*, 41–49. [CrossRef]
77. Kuo, L.Y. Integrating Vygotsky's Cognitive Development Theory & Weiner's Attribution Theory into Cheerleading Teaching. *Danc. Educ.* **2013**, *11*, 40–46. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20110309002-201308-201312160041-201312160041-40-46 (accessed on 15 May 2023).
78. Chen, S.W. Exploring the Meaning of "Inquiry and Practice" in 12-Year National Science Curriculum from the Perspectives of Philosophy of Science. *Sci. Educ. Mon.* **2021**, *437*, 11–22. [CrossRef]
79. Wang, H.W. Applying Blended Learning Teaching Method to Assist Cooperative Learning in Teaching Practice. *J. Natl. Kaohsiung Univ. Sci. Technol.* **2022**, *4*, 1–15. [CrossRef]
80. Reigosa, C.; Jiménez-Aleixandre, M.P. Scaffolded problem-solving in the physics and chemistry laboratory: Difficulties hindering students' assumption of responsibility. *Int. J. Sci. Educ.* **2007**, *29*, 307–329. [CrossRef]
81. Ministry of Education, Basic Statistical Information for Schools (2021–2022). 2022. Available online: https://reurl.cc/xlYnGb (accessed on 21 May 2023).
82. Chang, S.H. *Research Methods: Social Science and Biomedical Methodology*; Wu-Nan Book: Taipei, Taiwan, 2020; Available online: https://reurl.cc/QLVRdo (accessed on 4 April 2023).
83. Babbie, E.R. *The Practice of Social Research*, 15th ed.; Cengage: Boston, MA, USA, 2021; Available online: https://reurl.cc/9Gb78O (accessed on 4 April 2023).
84. National Academy for Educational Research. Introduction to the National Academy for Educational Research. 2023. Available online: https://www.naer.edu.tw/PageDoc/Detail?fid=20&id=3 (accessed on 15 May 2023).
85. Huang, C.F.; Chen, Z.H.; Chen, H.J. Virtual English Village: Using a Situational, Task-Based 3D Game to Enhance Students' English Learning. *Res. Educ. Commun. Technol.* **2021**, *127*, 1–15. [CrossRef]
86. Shieh, J.J. Perception of Learning Assessment: Focus on Education Teachers and Students in Taiwan. *J. Taiwan Educ. Stud.* **2021**, *2*, 137–170. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20220316001-202101-202203240014-202203240014-137-170 (accessed on 4 April 2023).
87. Hsu, H.C. The evolution of learning assessment and the implementation of literacy orientation in the comprehensive program of activities. *Taiwan Educ. Rev. Mon.* **2021**, *10*, 48–51. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-202103-202103030013-202103030013-48-51 (accessed on 15 May 2023).
88. Lin, Y.D.; Chen, X.H. Comments and Analysis of Practice Evaluation in Technical Senior High School Cooperating with the New Curriculum. *Taiwan Educ. Rev. Mon.* **2019**, *8*, 34–41. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201909-201909040014-201909040014-34-41 (accessed on 4 April 2023).

89. Tseng, C.W.; Hoi, S.K.; Chen, H.W. Instruction Assessment and literacy-based of key competencies. *J. Prof. Teach.* **2018**, *16*, 77–102. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=22250042-201812-201907010016-201907010016-77-102 (accessed on 4 April 2023).
90. Wu, J.S. The Approaches of Developing Mathematical Literacy-Based Assessment. *Second. Educ.* **2019**, *70*, 11–35. [CrossRef]
91. Wu, P.H. Learning Assessment in Literacy-Oriented Teaching. *Taiwan Educ. Rev. Mon.* **2017**, *6*, 30–34. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201703-201703020016-201703020016-30-34 (accessed on 4 April 2023).
92. Chen, K.M.; Chang, J.C. Planning and Suggestions on the Practice Evaluation of Horticulture in Technical High Schools. *Taiwan Educ. Rev. Mon.* **2019**, *8*, 26–33. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201909-201909040014-201909040014-26-33&PublishTypeID=P001 (accessed on 4 April 2023).
93. Ku, B.H.; Chen, C.S.; Wen, M.C. Exploring the Effectiveness of Guided Discovery Teaching by Performance Assessment on the Concept of Sound Wave. *Chin. J. Sci. Educ.* **2014**, *22*, 57–86. [CrossRef]
94. Su, J.L.; Huang, S.D.; Fu, S.M. The application of rubrics in the evaluation of college students' learning outcomes. *J. Educ. Res.* **2011**, *207*, 18–31. Available online: http://ericdata.com/tw/detail.aspx?no=66780 (accessed on 4 April 2023).
95. Yao, K.-C.; Huang, W.-T.; Xu, J.-R.; Huang, S.-H.; Tsai, C.-T.; Ho, W.-S.; Liao, C.-C. Application of the TRIZ Innovation System Method to Bicycle Handlebars. *Machines* **2023**, *11*, 507. [CrossRef]
96. Chen, C.Y. Using Rubrics to Assess Core Literacy. *Taiwan Educ. Rev. Mon.* **2017**, *6*, 87–90. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201703-201703020016-201703020016-87-90&PublishTypeID=P001 (accessed on 4 April 2023).
97. Liu, Y.C. Development and Evaluation of Rubrics for Assessing the Performance of College Students in Human Resource Management Courses. *Educ. J. NHCUE* **2016**, *33*, 77–108. [CrossRef]
98. Brookhart, S.M. *How to Create and Use Rubrics for Formative Assessment and Grading*; Ascd: Alexandria, VA, USA, 2013; Available online: http://www.ascd.org/publications/books/112001.aspx (accessed on 1 April 2023).
99. Lesh, R.E.; Doerr, H.M. *Beyond Constructivism: Models and Modeling Perspectives on Mathematics Problem Solving, Learning, and Teaching*; Lawrence Erlbaum Associates Publishers: Mahwah, NJ, USA, 2003; Available online: https://psycnet.apa.org/record/2003-00984-000 (accessed on 4 April 2023).
100. Andrade, H.G. Teaching with rubrics: The good, the bad, and the ugly. *Coll. Teach.* **2010**, *53*, 27–31. [CrossRef]
101. Tang, J.L. The Implications and Responses of Promoting Practical Evaluation. *Taiwan Educ. Rev. Mon.* **2019**, *8*, 46–50. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-201909-201909040014-201909040014-46-50&PublishTypeID=P001 (accessed on 4 April 2023).
102. Tseng, C.L.; Hwang, T.M.; Chien, P.T.; Tung, Y.S. The Design and Development of Competency-Based Performance Assessment of Project-Based Learning at Taipei Municipal Jianguo High School. *Taiwan Educ. Rev. Mon.* **2021**, *10*, 167–191. Available online: https://www.airitilibrary.com/Publication/alDetailedMesh?DocID=P20130114001-202105-202105030020-202105030020-167-191 (accessed on 4 April 2023).
103. Sui, C.J. Development and Implementation of a Scientific Inquiry Performance Assessment Using Go-Lab Platform. Master's Thesis, National Taiwan Normal University, Taipei, Taiwan, 2021. [CrossRef]
104. Huang, J.J. Student evaluation and test reflection on the teaching scene of life science and technology in my country. *Taiwan Educ. Rev. Mon.* **2021**, *10*, 135–138. Available online: http://www.ater.org.tw/journal/article/10-7/free/11.pdf (accessed on 4 April 2023).
105. Taggart, G.L.; Phifer, S.J.; Nixon, J.A.; Wood, M. (Eds.) *Rubrics: A Handbook for Construction and Use*; R&L Education: Lanham, MD, USA, 1999; Available online: https://reurl.cc/y71QD6 (accessed on 4 April 2023).
106. Stevens, D.D.; Levi, A.J. *Introduction to Rubrics: An Assessment Tool to Save Grading Time, Convey Effective Feedback, and Promote Student Learning*; Stylus Publishing, LLC: Sterling, VA, USA, 2013; Available online: https://reurl.cc/WGak0k (accessed on 4 April 2023).
107. Avola, D.; Cinque, L.; Foresti, G.L.; Marini, M.R. An interactive and low-cost full body rehabilitation framework based on 3D immersive serious games. *J. Biomed. Inform.* **2019**, *89*, 81–100. [CrossRef] [PubMed]
108. Wang, J.; Liang, H.N.; Monteiro, D.V.; Xu, W.; Chen, H.; Chen, Q. Real-time detection of simulator sickness in virtual reality games based on players' psychophysiological data during gameplay. In Proceedings of the 2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), Recife, Brazil, 9–13 November 2020; IEEE: Piscataway, NJ, USA, 2020; pp. 247–248. [CrossRef]