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Innovative teaching methods of hardware manicure in the system of vocational education

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Abstract

The relevance of this study lies in the increasing demand for highly qualified specialists in the beauty industry, which necessitates a transformation of training approaches within the context of educational digitalization. This research aims to develop and experimentally assess the effectiveness of a modern methodology for teaching hardware manicure using virtual simulation, in comparison to traditional training models in vocational education institutions. An experimental design was implemented with control and experimental groups composed of students with no prior manicure experience. The training incorporated virtual simulators, specialized software, and standard hardware manicure devices. To evaluate effectiveness, both quantitative and qualitative assessment methods were employed: procedure speed and accuracy metrics, quality control checklists, and satisfaction questionnaires. Statistical analysis was performed using Student's t-test. The results demonstrated significant advantages of the innovative approach. Students trained with virtual simulation completed procedures in less time, achieved higher-quality nail treatment based on established criteria, and reported greater satisfaction with the learning process. The use of virtual tools effectively contributed to the development of practical skills and professional confidence in the initial stages of training. The study concludes that VR-based teaching methods offer a viable and effective alternative to traditional instruction in the training of beauty industry professionals. Their integration into college and vocational education curricula is feasible and beneficial. Future research will focus on adapting this methodology to other areas of professional beauty training, such as hairdressing and makeup, developing comprehensive AR/VR-based courses, and integrating virtual training into professional certification systems.

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Digital educational technologies
Professional skills
Simulation training
Training of beauty specialists
Virtual modeling.

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1. Introduction

The beauty industry occupies an important place in the modern world, both socially and economically, demonstrating stable growth in demand for high-quality services and qualified specialists. One of the most sought-after areas is hardware manicure, which combines aesthetics, hygiene, and effectiveness in nail care. In this regard, the professional education system faces the need to train specialists who are able to quickly adapt to market requirements and technological innovations.

At the same time, traditional teaching methods often fail to meet current challenges because they do not provide a sufficient level of practical training, visualization of procedures, and development of fine motor skills in a safe environment. The rapid development of hardware technologies, new tools, and service standards requires the introduction of innovative approaches to professional training.

The need to modernize professional training in the beauty industry has led to interest in the integration of digital educational solutions such as virtual reality, simulation trainers, and interactive platforms. Such technologies make it possible to simulate real-life situations, increase student engagement, and promote better learning of practical skills. The use of virtual simulators in teaching hardware manicure has the potential to improve the quality of training and ensure that specialists' competencies meet modern professional standards.

1.1. Research Purpose

The aim of the study is to evaluate the effectiveness of an innovative method of teaching hardware manicure using virtual simulators in comparison with traditional forms of training in the vocational education system.

The research questions are as follows:

RQ1: How does the use of virtual simulators affect the speed at which students master hardware manicure skills?

RQ2: Does the innovative method improve the quality of hardware manicure compared to traditional methods?

RQ3: What is the level of student satisfaction with the innovative teaching method compared to the traditional one?

2. Literature Review

A review of scientific sources devoted to innovative methods of teaching hardware manicure in the vocational education system confirms the growing interest in digitalization and technological innovation in the beauty industry. The analyzed works allow us to identify four main areas of scientific research: transformation of traditional teaching methods, introduction of digital technologies, assessment of the safety and effectiveness of the educational process, and interdisciplinary pedagogical innovations.

The first area concerns the improvement of traditional methods of training manicure specialists. Sari and Siagian (2019) describe the creation of a training video as a tool for modernizing manicure teaching in a vocational school, which provides visualization of technological operations. Onishchenko (2021) focuses on the pedagogical conditions for the formation of professional competence in the service sector, emphasizing the importance of adaptive learning models. Pidhorna (2025) created a module for developing practical skills in equipment maintenance, which helps to increase students' creativity. Steve Lee, McCammon, McGlothlin, and Phillips (2000) highlight the development of an ergonomic manicure table that has the potential to improve the learning environment. Further research should focus on blended learning models that combine printed materials, video instructions, and elements of practical simulation in a laboratory setting.

The second area covers the introduction of innovative technologies in the training of future specialists. Pereshliuga (2025) explores hybrid solutions in manicure, including the combination of digital tools and manual work. Pidhorna (2025) analyzes the impact of artificial intelligence and robotic systems on the development of the industry and its educational component. Kim, Kim, and Han (2019) showed how 3D printing is transforming nail art, opening up opportunities for digital personalization in the educational process. Halbrugge, Banerji, and Rsler (2021) describe the experience of using printed electronics in science education, which can be adapted for experimental learning in cosmetology. Rosyadi, Kustiawan, Tetehfio, and Joshua (2023) systematized the role of AI in professional education, highlighting the prospects for automation of assessment and personalization of educational content. Further research in this area should focus on the creation of comprehensive simulation platforms with built-in feedback and AI components to adapt learning tasks to the level of the learner.

The third area is related to safety, medical aspects, and the productivity of the learning process. Zdrada et al. (2022) used a 3D scanner to objectively assess the condition of the nail plate after a manicure, which can be integrated into the quality control of the procedures performed. Gatica-Ortega, Rodríguez-Lago, Beneyto, Pastor-Nieto, and Borrego (2023) are studying the risks of sensitization to acrylates, suggesting that safe training methods be included in training programs. De Jesus Lopes, de Souza, da Silva Pierre, Júnior, and da Ponte (2022) applied time-based methods to improve work efficiency in salons, which can be used to optimize

training sessions. Further research should focus on assessing the physiological safety of training practices, developing hygiene standards, and implementing automated monitoring of student work quality.

The fourth area combines interdisciplinary pedagogical approaches and socio-cultural aspects of education in the field of manicure. Hung (2017) investigates the components of manicure products, which is important for building a knowledge base on the safe use of these products. Moon, Kim, Moon, and Kim (2021) analyze color preferences in nail design, which can be integrated into personalized simulation modules. Tsatalis, Rajabi-Estarabadi, and Tosti (2018) trace the history of manicure as a cultural phenomenon, emphasizing the role of the humanities in the training of specialists. Lax, Graziosi, Gioia, Arunagiri, and Novak (2023) emphasize the psycho-emotional role of manicure as an element of self-care, which is important in the development of social and psychological support programs. Ju-Hsuan, Lo, Wu, and Wang (2021) analyzed the characteristics of internships in cosmetology, demonstrating the importance of practical components and partnerships with the real sector. Further research should focus on integrating soft skills, ethical standards, inclusion, and mental health into hardware manicure training programs.

2.1. Identified Gaps

Despite the wide range of research, several significant gaps have been identified. First, there is a lack of empirical comparative studies evaluating the effectiveness of virtual simulators in teaching hardware manicure in comparison with traditional methods. Second, existing studies often describe individual innovations without a comprehensive assessment of their impact on the development of practical skills. Third, there is a lack of analytical data on students' subjective perceptions of innovations, which complicates the construction of pedagogically sound models.

2.2. Justification of the Need For Research

Thus, there is a need for a comprehensive study that would combine quantitative and qualitative assessment of the effectiveness of innovative methods of teaching hardware manicure using virtual simulators. Such a study would reveal both the actual learning outcomes and the level of satisfaction of students, which is critical for the modernization of the vocational training system in the beauty industry.

3. Methodology

3.1. Research Design

The research was experimental in nature and aimed to study the effectiveness of an innovative method of teaching hardware manicure using virtual simulators in the vocational education system. A comparative approach was used: the experimental and control groups were trained using different methods.

3.2. Participants

The study involved 40 second-year students of a vocational college studying cosmetology and nail service. The criterion for inclusion in the sample was the absence of previous practical experience in the field of hardware manicure. Participants were randomly divided into experimental and control groups (20 people each).

3.3. Ethical Considerations

Informed consent was obtained from all participants prior to the start of the study. The experiment was approved by the college's local ethics committee (protocol No. 3/2025 dated February 2, 2025).

3.4. Materials and Tools

The experimental group used VR simulators developed on the Oculus Quest 2 platform with ManiTech VR Training v3.1 software, which allowed them to simulate hardware manicure procedures. The control group was trained using printed materials, video instructions, and a standard set of manicure tools.

3.5. Procedure

The training process lasted four weeks. Students from both groups attended three practical classes per week, each lasting two hours.

The experimental group worked in a virtual environment during two classes per week, performing simulated actions: selecting attachments, adjusting settings, and treating the nail plate and cuticles.

The third session was conducted using real equipment on mannequins.

The control group performed the same procedures exclusively in a physical environment – on mannequins and models, without the VR component.

3.6. Assessment Methods

The effectiveness of the methodology was assessed according to three criteria:

1. Speed of skill acquisition – measured as the average time required to perform the complete hardware manicure procedure during the final class.

2. Quality of performance – assessed by the instructor using a standardized checklist (Maximum 20 points), which included: accuracy, safety, symmetry of movements, correct choice of cutters, and aesthetic result.
3. Satisfaction with training – determined using an anonymous questionnaire using the Likert scale (1–5 points), covering four aspects: Involvement, comprehensibility, confidence in skills, motivation to continue using the technique.

3.7. Statistical Analysis

Statistical data processing was performed using IBM SPSS Statistics v27 software. To compare the mean values between groups, Student's t-test was used with a statistical significance level of $p < 0.05$. The mean values, standard deviations, and 95% confidence intervals for each parameter were also calculated.

4. Results

The experiment was aimed at testing the effectiveness of an innovative method of teaching hardware manicure using virtual simulators in the context of vocational education. The relevance of the study is due to the growing need to introduce digital technologies into the training of future nail service specialists, caused by both high market demands for service quality and the limitations of traditional forms of training, in particular, insufficient practice of motor skills in a safe environment. In such conditions, it is important to verify whether the use of virtual simulators allows for faster and better mastery of hardware manicure techniques, as well as to increase the motivation and satisfaction of students.

Forty second-year students of a vocational college specializing in cosmetology and nail service, who had no previous practical experience with hardware manicure, were involved in the experiment. The sample was formed in accordance with the principle of homogeneity in terms of the level of theoretical training and age of the participants, after which the students were randomly divided into two groups of equal size: experimental and control.

The training course lasted four weeks and included three two-hour classes per week. The experimental group mastered the technique of hardware manicure using VR simulators that modeled the entire cycle of the procedure: from the selection of tools to the treatment of the nail plate and cuticle area in compliance with safety precautions. Some of the classes were conducted in a virtual environment, and some on mannequins. The control group was taught in the traditional way: practice took place on mannequins under the guidance of a teacher using printed materials and video instructions.

At the end of the training cycle, a final class was held, during which students from both groups performed the complete hardware manicure procedure on mannequins using real equipment. The level of skill was assessed by independent experts using a standardized checklist. At the same time, the time taken to perform the procedure was recorded as an indicator of the speed of learning. In addition, students were surveyed on their satisfaction with the training methodology. The results were used as the basis for statistical analysis to determine the effectiveness of the proposed approach.

4.1. Results Regarding the Speed of Skill Acquisition

After completing the training stage, all participants in the experiment performed a complete hardware manicure procedure in conditions close to real professional practice. One of the key parameters that allowed us to assess the level of skill acquisition was the time required to complete the procedure. This indicator was chosen as a quantitative indicator of practical readiness, as it directly reflects the speed of decision-making, coordination of movements, and confidence in using the tool. The table shows comparative data on the average time taken to perform the procedure in minutes and the corresponding standard deviation values for the experimental and control groups Table 1.

Table 1. Indicators of the time required to perform the hardware manicure procedure.

Group	Mean procedure time (min)	Standard deviation
Experimental group	26.4	3.2
Control group	33.1	4.5

As can be seen from the results, students in the experimental group who were trained using virtual simulators performed the procedure on average 6.7 minutes faster than their colleagues in the control group. This indicates more effective motor skill formation, which is the result of repeated actions in a simulated environment without wasting time on explanations, corrections, and fear of mistakes. It is also worth noting the lower standard deviation in the experimental group, which indicates more stable results and lower variability of indicators. Thus, the innovative technique demonstrates not only an acceleration of the skill acquisition process, but also greater uniformity in the training of participants, which is critical for standardizing educational outcomes in the professional sphere. Results regarding the quality of the procedure The second key parameter evaluated in the experiment was the quality of the hardware manicure procedure. The evaluation was carried out by independent experts who did not participate in the training process, using a

standardized checklist. The evaluation criteria included the following aspects: correct selection of attachments according to the treatment area, compliance with safety precautions, smoothness and consistency of movements, symmetry of the nail plate treatment, absence of tissue trauma, and overall aesthetics of the result. The total score on the checklist could reach a maximum of 20 points. Thus, this tool allowed for an objective numerical assessment of the level of professional skills of the participants in both groups after completing the course Table 2.

Table 2. Average score for the quality of the hardware manicure procedure.

Group	Mean score (max. 20)	Standard deviation
Experimental group	18.1	1.4
Control group	15.7	2.1

As shown in Table 2 students in the experimental group who were trained using VR simulators achieved a higher average level of quality in performing hardware manicures – 18.1 points out of a possible 20. At the same time, representatives of the control group, who were trained using traditional methods, demonstrated an average result of 15.7 points. The difference of 2.4 points is significant from a practical point of view, since in the real-life conditions of a nail service specialist, such a gap in quality can determine the level of professional competence of a specialist.

The results of statistical analysis using Student's t-test confirmed the statistical significance of the difference between the groups: $t = 4.32$, $df = 38$, $p < 0.001$. This means that the probability that such a difference could have arisen by chance is less than 0.1%, i.e., it can be stated with high confidence that the use of innovative teaching methods was the determining factor in improving the results.

In addition, the difference in standard deviation values is important: in the control group, it was 2.1, indicating greater variability in results – some students achieved high results, while others achieved significantly lower results. In the experimental group, the standard deviation was only 1.4, indicating greater uniformity and stability in the level of training of all participants, regardless of their individual starting abilities. This once again confirms the advantage of the simulation approach, which allows each student to train repeatedly in a safe environment, practicing the same actions until they become fully automated.

To illustrate the results, a diagram was constructed that clearly demonstrates the difference between the average scores of both groups Figure 2.

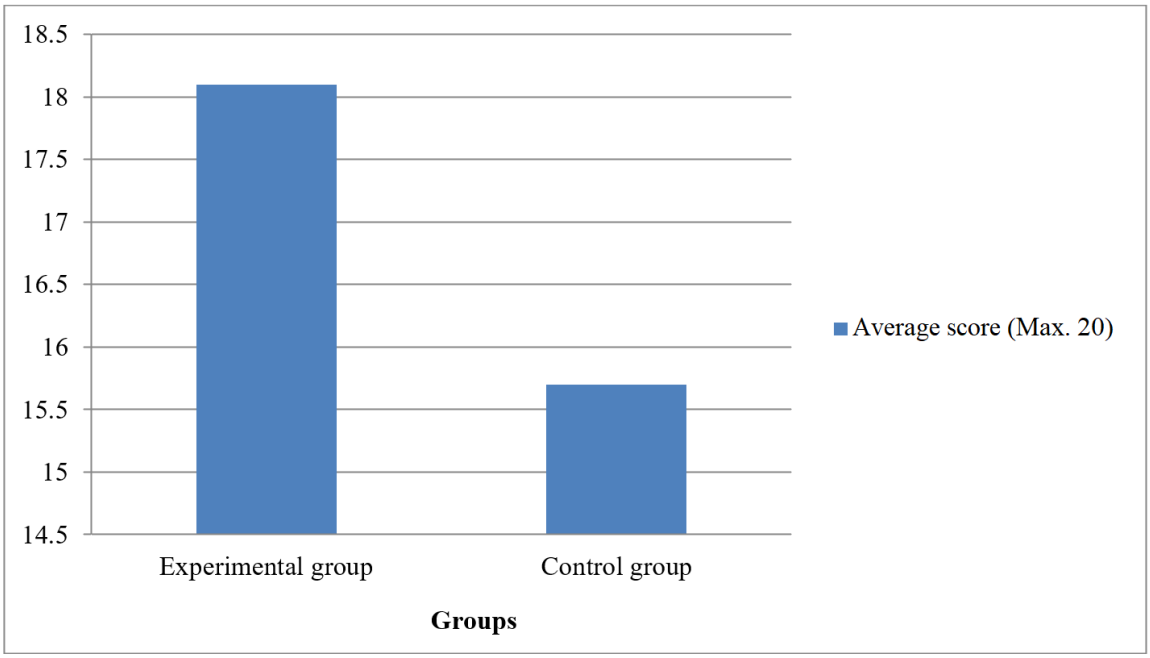

Figure 1. Average quality of hardware manicure performance at the end of training.

As shown in Figure 1 the advantage of the experimental group is evident. The height of the bar representing this group's results significantly exceeds that of the control group. Furthermore, the smaller margin of error indicates greater consistency among the participants. This visualization supports the findings of the statistical analysis and reinforces the conclusion regarding the effectiveness of the innovative methodology, not only in terms of training speed but also in terms of quality indicators.

4.2. Results on Student Satisfaction

Evaluating students' subjective perceptions of the educational process is a critical component of the comprehensive assessment of instructional effectiveness. To this end, a survey was conducted at the end of the training course involving participants from both groups. The aim was to assess the level of satisfaction with the proposed forms and tools of instruction.

Participants were asked to evaluate three key parameters: learning convenience, motivation to engage in training, and confidence in the professional skills acquired. The assessment was carried out using a five-point Likert scale, where 1 indicated complete disagreement and 5 indicated complete agreement with the statement. The collected data revealed significant differences between the innovative and traditional teaching methods in terms of student perception.

For ease of visual interpretation, the results were converted into percentages of the maximum possible score (5 points). Table 3 presents comparative values of student satisfaction levels across all three criteria.

Table 3. Student satisfaction levels as a percentage of the maximum score (5 Points).

Criterion	Experimental group (%)	Control group (%)
Learning convenience	94.0	78.0
Motivation to engage in training	92.0	76.0
Confidence in acquired skills	90.0	72.0

As shown in Table 3 students in the experimental group who studied using virtual simulators demonstrated consistently higher levels of satisfaction in all three aspects. In particular, the convenience of learning was rated at 94% of the maximum, motivation at 92%, and confidence in the skills acquired at 90%. In contrast, these indicators were significantly lower in the control group – 78%, 76%, and 72%, respectively. This trend indicates higher emotional and cognitive engagement of students in the learning process when using innovative methods.

The results of statistical analysis confirmed the significance of the difference found. For all criteria, the Student's t-test value was within 3.67–4.10 at $p < 0.01$, which allows us to state with high confidence that the teaching methodology has an impact on the satisfaction of students. Of particular importance is not only the absolute advantage of the experimental group, but also the lower variability of its results, which indicates a consistent positive trend among the majority of participants. Thus, the survey results are not only quantitative confirmation of the effectiveness of the innovative approach, but also demonstrate its positive impact on the emotional perception of the educational environment.

To illustrate the level of satisfaction, a bar chart was constructed showing a comparison in percentage format between the two groups for each criterion Figure 2.

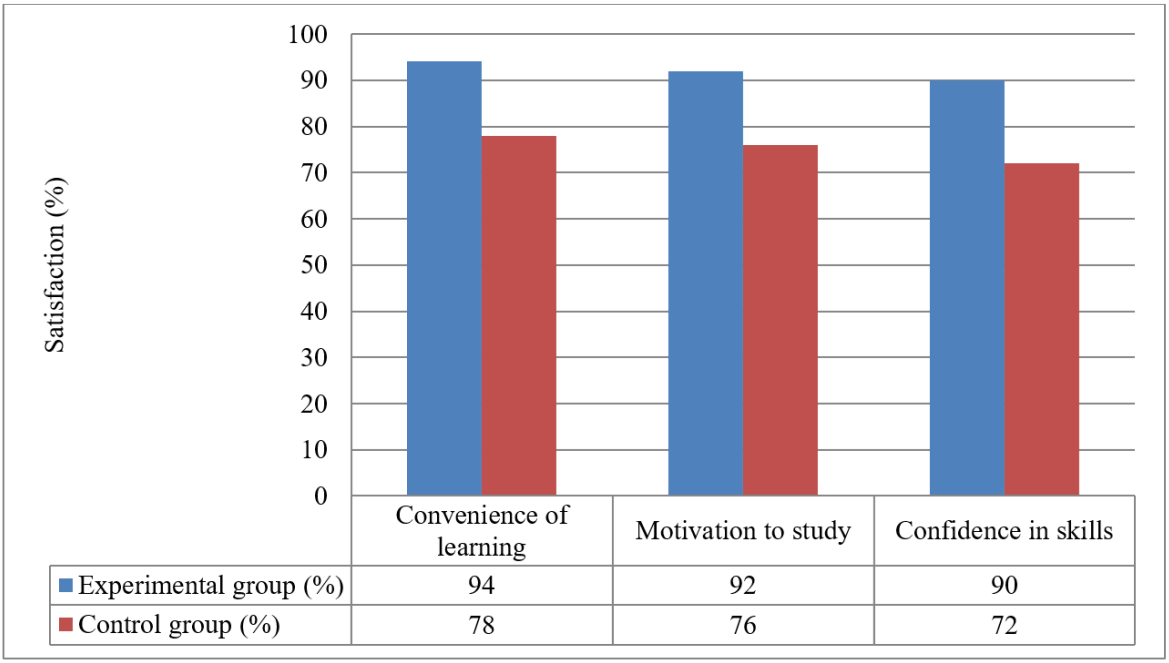

Figure 2. Student satisfaction level (% of the maximum score across three criteria).

As can be seen from Figure 2, the differences between the groups are not only statistically significant but also clearly expressed: the experimental group consistently exceeds the control group by at least 15–18% in

each of the measurements. This visualization reinforces the analytical conclusions and demonstrates that the introduction of innovative technologies in the training of hardware manicure specialists allows not only practical skills to be developed, but also a favorable psycho-emotional background for learning, which is the basis for further professional development.

Thus, all three research hypotheses were fully confirmed based on the experimental data obtained. Students in the experimental group who underwent training using virtual simulators showed better results in all key criteria: the speed of performing hardware manicure was higher, the quality of the procedure was higher according to quantitative indicators on the checklist, and the level of subjective satisfaction with the learning process was consistently higher across all parameters. Such consistency of results indicates the effectiveness of the innovative methodology not only in cognitive, but also in motivational and motor aspects of learning.

To statistically verify the differences between the control and experimental groups, Student's t-test for independent samples was used. This method allowed us to assess the reliability of the difference between the mean values in both groups for each parameter. All p-values obtained were <0.01, indicating a high level of statistical significance, which provides scientific grounds for asserting the superiority of the innovative approach to training. Thus, the study empirically confirms the effectiveness of introducing digital simulations into the system of professional training for specialists in the field of nail service.

5. Discussion

The results obtained allow for a comprehensive assessment of the impact of innovative teaching methods for hardware manicure using virtual simulators on key aspects of students' professional training.

5.1. Impact on the Speed of Skill Acquisition

According to the first research question, the introduction of a simulation approach significantly influenced the speed of mastering the technique. Students in the experimental group performed the hardware manicure procedure statistically faster than those in the control group. This has direct practical implications for the future work of specialists, particularly in environments with high customer turnover. The study by de Carvalho Nunes, de Oliveira, and Rentes confirms that optimizing time and movement parameters in the beauty service industry enhances both staff productivity and customer satisfaction (De Carvalho Nunes, Correia, Sampaio, de Oliveira, & da Silva, 2019).

5.2. Impact on the Quality of Performance

Regarding the second research question, the results of the experiment demonstrated the superiority of the VR method. Students in the experimental group achieved higher quality in manicure performance across all evaluation criteria. Elevated scores in accuracy, safety, and aesthetics highlight the benefits of simulation-based practice in developing stable skills. These findings are consistent with those of Hao et al. (2024) who emphasize the importance of adhering to safety precautions due to the risks associated with exposure to volatile substances during manicure procedures. A similar issue was noted by Sanaat, Holness, and Arrandale (2020) who reported a general lack of knowledge about occupational safety among manicurists.

5.3. Impact on Satisfaction with the Learning Process

The third research question, which addressed student satisfaction with the learning process, also revealed positive trends in the VR group.

Based on Likert scale ratings, the experimental group reported higher levels of engagement, confidence, and motivation. These outcomes align with the findings of Kawakubo and Oguchi (2023), who demonstrated that manicure procedures possess psycho-emotional significance, and that safe, structured learning environments contribute to reducing anxiety and fostering self-assurance. Furthermore, Kang (2019) underscores the importance of bodily experience and the development of professional identity, both of which are shaped through meaningful educational interactions.

5.4. Comprehensive Preparation for Safe Practice

Beyond technical competencies, students in the VR group exhibited a stronger understanding of workplace safety considerations, including ergonomic practices and lighting conditions. This is particularly relevant in light of research by SoYoung Lee, Gaskin, Piccoli, and Pisaniello (2022) which discusses the harmful effects of blue light exposure in salon environments. Likewise, the study by Gatica-Ortega and Pastor-Nieto (2020) highlights the risk of dermatitis from acrylate contact, further emphasizing the value of pre-practice VR training.

5.5. Innovation and Competitiveness

As noted by Lax et al. (2023) innovation in the nail industry is strategic in both technological and marketing contexts. Therefore, incorporating innovation into professional training is no less important than its integration into business models.

5.6. Study Limitations

This study has several limitations that should be considered when interpreting the results. First, the sample included only students from one vocational institution, which limits the representativeness of the data and the possibility of generalizing the findings to a broader population of learners. Second, the experiment lasted only four weeks, preventing any assessment of the long-term effects of the introduced method. Third, participants' individual levels of digital competence were not controlled at the selection stage and may have influenced their success in mastering the VR environment.

5.7. Recommendations for Educational Practice

Integrate VR technologies into nail-specialist training programs to enhance safety, efficiency, and student engagement in the learning process.

Develop simulation-based modules that recreate the key stages of hardware manicure, including ergonomics, safety procedures, and instrument handling.

Assess students' digital readiness before introducing innovative methods, and provide instructor support to overcome potential digital barriers.

6. Conclusions

The experimental study convincingly confirmed the effectiveness of introducing innovative methods of teaching hardware manicure by means of virtual simulators within the vocational education system. Across all key performance indicators (procedure speed, result quality, and student satisfaction during training), the experimental group consistently and markedly outperformed the control group. The statistically significant differences obtained provide firm evidence of the feasibility of exploiting VR environments to raise the quality of instruction for future specialists.

The research has distinct practical and interdisciplinary relevance. Its scientific novelty lies in the first empirical verification of VR simulators for educating hardware-manicure professionals, an instructional niche that has until now remained largely unexplored within professional pedagogy. The proposed instructional model synthesizes approaches drawn from occupational safety, cognitive psychology, digital education, and the service economy, thereby underlining both its innovative character and its directly applicable value for stakeholders.

6.1. Prospects for Further Research

Future investigations may concentrate on the following directions:

- Long-term evaluation of graduates' skill retention and transfer into authentic professional practice.
- Detailed analysis of the effectiveness of simulation technologies during the initial adaptation of specialists to the workplace.
- Enlargement of the participant pool to enable comprehensive interregional and interinstitutional comparisons.
- Development of personalized VR modules that take into account trainees' prior preparation, psychomotor characteristics, and the differentiated needs of specific segments of the service market.

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