BBHE Vol.14 No.2 (2025)

BEAUTY AND BEAUTY HEALTH EDUCATION JOURNAL

https://journal.unnes.ac.id/sju/index.php/bbhe

Applying Augmented Reality in Color and Aesthetic Education: An Empirical Study on Enhancing Learning Outcomes of Students in a Five-Year Junior College Beauty Program

Ju-Hsuan Yeh

Assistant Professor, Department of Styling and Cosmetology, Tainan University of Technology, Tainan, Taiwan

*Corresponding author: * alice690414@gmail.com*

Abstract. *This study aimed to investigate the impact of integrating Augmented Reality (AR) technology into color and aesthetics education on the learning effectiveness of students enrolled in a five-year junior college beauty program. The research was conducted at a vocational college in northern Taiwan, targeting 58 first-year female students (aged 16–17) from the Department of Cosmetic Application and Management. All participants were enrolled in a required color and aesthetics course and had no prior experience using AR technology in educational settings, allowing for an objective assessment of AR as a novel instructional tool. A mixed-methods approach was adopted, combining paired-samples t-tests to analyze pre- and post-test data with qualitative methods such as student interviews and project work analysis. The results demonstrated that AR-created immersive and multisensory learning environments enabled students to visualize and simulate color combinations under varying lighting and material conditions, deepening their understanding of color theory and coordination. Moreover, the interactive features of AR fostered real-time collaboration and stimulated creative thinking and problem-solving. Compared to traditional teaching methods, AR-integrated instruction significantly enhanced students' motivation, professional skill development, and overall satisfaction. These findings confirm the feasibility and pedagogical value of using AR in beauty education, offering both theoretical insights and practical evidence for its implementation in vocational and interdisciplinary curricula*.
Keywords: *Augmented Reality (AR), Learning Effectiveness, Beauty and Styling Education.*

Abstrak. Kajian ini bertujuan untuk menyelidik kesan integrasi teknologi Realiti Terimbuh (Augmented Reality, AR) dalam pendidikan warna dan estetik terhadap hasil pembelajaran pelajar dalam program kecantikan kolej vokasional lima tahun. Kajian ini dijalankan di sebuah kolej vokasional di utara Taiwan, menggunakan pendekatan kaedah campuran yang merangkumi tinjauan literatur, soal selidik sebelum dan selepas pengajaran, temu bual dengan pelajar, serta analisis hasil projek kreatif. Kajian ini secara sistematik menilai kesan pengajaran inovatif berasaskan AR dalam beberapa dimensi, termasuk motivasi pembelajaran, kemahiran profesional, pemikiran kreatif, dan pengalaman penggunaan teknologi.

Penemuan kajian menunjukkan bahawa persekitaran pembelajaran imersif dan multisensori yang diwujudkan melalui AR telah memudahkan simulasi masa nyata oleh pelajar terhadap pelbagai pencahayaan, bahan, dan kombinasi warna, sekali gus meningkatkan pemahaman mereka tentang teori warna dan prinsip penyelarasan warna. Selain itu, aplikasi AR menggalakkan interaksi segera dan pembelajaran kolaboratif dalam kalangan pelajar, merangsang pemikiran kreatif dan keupayaan menyelesaikan masalah. Berbanding dengan kaedah pengajaran tradisional, pengajaran berasaskan AR secara signifikan meningkatkan penglibatan pelajar dan kepuasan keseluruhan terhadap proses pembelajaran.

Kajian ini mengesahkan kebolehgunaan dan keberkesanan praktikal penggunaan teknologi AR sebagai alat pengajaran inovatif dalam pendidikan kecantikan. Ia bukan sahaja memperkaya pendekatan pedagogi dan amalan dalam kurikulum warna dan estetik, malah turut menyediakan sokongan empirik bagi aplikasi AR yang lebih meluas dalam pendidikan vokasional, sekali gus menawarkan sumbangan berharga dari segi teori dan praktikal.
Kata Kunci: Realiti Terimbuh (AR), Pendidikan Warna dan Estetik, Pengajaran Inovatif, Keberkesanan Pembelajaran, Pendidikan Kecantikan dan Penggayaan

INTRODUCTION

The rapid evolution of information and communication technologies has transformed how people learn, work, and interact. Among these emerging innovations, Augmented Reality (AR) has gained increasing attention in education for its ability to merge digital content with the physical world. AR, short for Augmented Reality, refers to a technology that overlays computer-generated virtual elements onto real-world environments in real time. Although its roots can be traced back to the late 1960s, the term "Augmented Reality" was formally introduced by Thomas Caudell in 1990 (Lin, Lin, & Chen, 2017). In recent years, AR has seen widespread adoption across industries. According to the Photonics Industry & Technology Development Association (2022), the AR market reached USD 60 billion in 2023, with an estimated 1.4 billion global users, and is projected to reach 1.73 billion mobile users by 2024.

In the field of education, AR offers immersive, interactive, and multisensory learning environments that enhance student engagement and understanding. Studies have shown that AR facilitates experiential and contextualized learning, making it particularly useful in disciplines that involve visual and spatial cognition (Wu & Lin, 2023). Furthermore, Santos, Jones, and Morgan (2024) emphasized that the integration of AR into creative learning fosters imagination, reasoning, and higher-order thinking through active interaction and contextual communication.

Despite these advantages, color and aesthetics education—especially in beauty and styling programs—continues to rely heavily on static images, textbook illustrations, and two-dimensional demonstrations. Such methods limit students' ability to perceive the dynamic interplay of color, lighting, texture, and materials. More critically, students often struggle to grasp abstract concepts such as color harmony, contrast, and spatial arrangement. In traditional classroom settings, the lack of interactivity and real-time visualization tools further hinders their understanding and application of theoretical knowledge.

This research addresses a clear pedagogical gap: how to transform the traditionally static and abstract instruction of color theory into a more engaging, experiential, and interactive learning process. To this end, AR is adopted not merely as a technological enhancement but as a pedagogical intervention grounded in immersive learning theory and constructivist learning perspectives, both of which emphasize active, experiential, and learner-centered environments.

To confront the limitations of conventional instruction and cultivate a more dynamic learning atmosphere, this study introduces AR into the color and aesthetics curriculum of a five-year junior college beauty program. Using the MAKAR AR platform, students engaged in group-based projects to design and present fashion color planning concepts, including hairstyling, makeup, fashion coordination, and accessories. The aim was to determine whether AR integration could enhance students' learning motivation, professional color application skills, creative thinking, and overall satisfaction through an interactive, task-based learning approach.

By exploring the educational application of AR technology in a real-world vocational context, this study aims to offer empirical insights into innovative pedagogical strategies that bridge the gap between abstract theory and practical design application in the domain of color and aesthetics education.

Literature Review

1. The Concept of Augmented Reality (AR) Technology and Its Application in Education

Augmented Reality (AR) refers to the integration of computer-generated digital content with the real-world environment in real time, thereby adding new visual information to the existing environment. Broadly speaking, AR is characterized by four essential elements: (a) the blending of the real and virtual worlds, (b) real-time interaction with the environment, (c) accurate registration of virtual and real objects, and (d) three-dimensional visualization (Salmi et al., 2017).

At the beginning of the 21st century, educational technology experienced a new revolution with the emergence of so-called "emerging technologies," which expanded the possibilities of educational practices and transformed the roles of teachers and students. Among these, AR has been identified as a highly valuable resource in education, allowing students to immerse themselves in environments where reality and digitality coexist. Several studies have confirmed that AR can enhance students' learning motivation and foster the construction of knowledge through social interactions (Marín et al., 2022).

AR technology provides a contextual learning environment that seamlessly integrates classroom knowledge with students' daily experiences. Within AR contexts, learners can enhance their spatial cognition, practical skills, and conceptual understanding while participating in inquiry-based activities such as group discussions and collaborative learning, enabling the immediate exchange of creative ideas and feedback (Lee et al., 2022). In the field of color and aesthetic education, AR enables students to simulate the effects of different color combinations and lighting conditions in real time, encouraging exploration of innovative possibilities during interactive activities. Consequently, AR not only strengthens professional skills but also fosters learning interest through immersive experiences, supporting students' development of creativity and professional judgment within a flexible, visually enriched environment.

2. Integration of AR Technology into Color Theory Courses in Five-Year Junior College Beauty Programs

The color theory curriculum in five-year junior college beauty programs primarily focuses on the application and practice of color theory and design elements. The goal is to help students build a comprehensive understanding of

color systems, grasp the principles of color coordination, and master the basic concepts of color perception and mixing (Tsai & Hsiao, 2016). According to Yeh and Lee (2020), color theory is widely designated as a core compulsory course in Taiwan's five-year junior college beauty-related programs. Whether in fields such as overall styling, cosmetic product development, beauty, female hairstyling, male hairdressing, or chemistry-related professional certification programs, a solid foundation in color theory and practical application is crucial for skills like makeup design, hair dyeing, and cosmetic color matching.

Thus, color theory education not only emphasizes theoretical instruction but also focuses on enhancing students' professional skills and creative thinking through hands-on practice to meet the diverse demands of the future workplace.

In recent years, the beauty and fashion industries have actively adopted emerging technologies, integrating Artificial Intelligence (AI), Augmented Reality (AR), and big data analytics to offer consumers more convenient and personalized product experiences. For example, the beauty brand Shu Uemura launched the "Smart Eyebrow Drawing Tool," which uses AR and AI technologies to recommend suitable eyebrow shapes through an app and allows users to preview the results instantly (Yeh, 2023). Such technological advancements have not only revolutionized consumer shopping experiences but have also introduced new possibilities for beauty education, promoting a shift toward digitized and interactive teaching models.

As technological innovations and aesthetic trends evolve, color theory teaching in beauty-related programs has also continued to innovate. Some institutions have introduced digital tools and AR technology, enabling students to instantly simulate the effects of different lighting, materials, and color combinations. This approach enhances students' learning outcomes and their ability to apply knowledge creatively, aligning course design with industry development trends and improving students' future workplace competitiveness. It cultivates beauty professionals with both professional expertise and creative thinking skills.

Moreover, the application of AR technology in education has been proven to significantly enhance student learning outcomes. Specifically, it exhibits unique advantages in boosting learning motivation, facilitating skills acquisition, and stimulating creative thinking. Hsu et al. (2021) summarized that AR technology, with its high degree of interactivity, provides a more vivid and engaging learning experience compared to traditional text-based or static visual materials. Students can interact with 2D or 3D virtual objects and integrate them with the real environment, thereby improving learning attitudes and promoting the "flow experience." Compared with traditional teaching methods, AR-based immersive learning models significantly enhance student engagement and participation, ultimately leading to better educational outcomes.

RESEARCH METHODOLOGY

This study was designed based on the concept of innovative teaching, integrating Augmented Reality (AR) technology into fashion aesthetics education. The instructional content was structured through a practice-oriented and interdisciplinary approach, incorporating fundamental concepts of fashion and color across professional domains including hairstyling, makeup, fashion coordination, nail art, and accessories design. The teaching strategy emphasized experiential learning and aimed to bridge the gap between theoretical knowledge and practical application in the field of beauty and styling.

1.Participants

The participants were 58 first-year female students, aged between 16 and 17, enrolled in a five-year junior college beauty program in northern Taiwan. All students were taking the Color and Aesthetics course as part of their required curriculum. Importantly, none of the participants had any prior experience using AR technology in an educational context, ensuring the study assessed the impact of AR as a new instructional tool.

2.Instructional Intervention

The course integrated the use of the MAKAR AR platform, which enabled students to develop interactive AR content related to fashion color planning. Students were grouped to collaboratively design AR-based fashion styling projects, using the platform to simulate color combinations, material textures, and lighting effects within a digital environment. The pedagogical approach followed a Task-Based Learning (TBL) model embedded with immersive learning elements, aimed at enhancing student engagement, creative thinking, and professional skill development.

3.Research Design and Instruments

This study adopted a mixed-methods research design, incorporating both quantitative and qualitative data collection and analysis to comprehensively evaluate the effectiveness of the AR-integrated instruction.

(1) Quantitative Data

A pre-test and post-test questionnaire design was employed. The pre-test was administered during the 9th week of the course, and the post-test during the 18th week. The questionnaire consisted of 15 items covering five dimensions:

- Learning Motivation

- Professional Skills
- Creative Thinking
- Technology Use Experience
- Overall Learning Satisfaction

Each item was rated using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaire was adapted from established instruments used in studies on educational technology and vocational training. To ensure content validity, the instrument was reviewed by two scholars in educational technology and one domain expert in beauty education. Based on their feedback, minor revisions were made for contextual appropriateness.Reliability analysis using Cronbach's α indicated high internal consistency:

- Learning Motivation (α = 0.87)
- Professional Skills (α = 0.89)
- Creative Thinking (α = 0.85)
- Technology Use Experience (α = 0.83)
- The Overall Learning Satisfaction dimension was a single-item measure and thus excluded from reliability testing.

(2) Qualitative Data

To complement the quantitative findings, qualitative data were collected through:

- Structured classroom observations conducted by the instructor and two teaching assistants.
- Student reflection logs submitted at the end of the course
- Analyses of final AR-based fashion styling projects

These data sources provided insights into students' engagement, collaboration, use of AR tools, and perceived learning outcomes.By combining both quantitative and qualitative approaches, this study aimed to systematically evaluate whether the integration of AR technology into the Color and Aesthetics curriculum could enhance students' learning motivation, professional skill development, creative thinking, and overall satisfaction. The methodological rigor ensured that both statistical outcomes and student experiences were adequately represented, providing a solid foundation for examining the practical value of AR-based instructional strategies in vocational education.

RESEARCH RESULTS

This study utilized questionnaire surveys and statistical analyses to obtain empirical data, aiming to further illustrate the effects of integrating Augmented Reality (AR) technology into color and aesthetics education on various dimensions of student outcomes in a five-year junior college beauty program. These dimensions included learning motivation, professional skills, creative thinking, technology use experience, and overall learning satisfaction. The main statistical methods employed were descriptive statistics, reliability analysis, and paired-sample t-tests.

1. Reliability Analysis of the Questionnaire

To examine the internal consistency of the questionnaire dimensions, this study conducted a reliability analysis using Cronbach's α coefficient. The results are presented in Table 1.

Table 1. Reliability Analysis of the Questionnaire

Dimentions	Cronbach's α
Learning Motivation	0.87
Professional Skills	0.89
Creative Thinking	0.85
Technology Use Experience	0.83
Learning Satisfaction	-（Learning Satisfaction is measured by a single item and therefore excluded from the internal consistency (Cronbach's α) analysis）

The results of the reliability analysis indicated that the Learning Motivation dimension (α = 0.87), Professional Skills dimension (α = 0.89), Creative Thinking dimension (α = 0.85), and Technology Use Experience dimension (α = 0.83) all achieved high reliability levels, with Cronbach's α coefficients exceeding 0.8. This demonstrates that the questionnaire possesses good internal consistency. As the Learning Satisfaction dimension consisted of only a single item, it was excluded from the reliability analysis.

2. **AR Technology Enhanced Overall Learning Satisfaction and Improved Students' Professional Skills in Fashion Color Aesthetics**

A descriptive statistical analysis was conducted on the 15 questionnaire items across the five dimensions. The results showed that the mean score for the Learning Motivation dimension was 4.12 with a standard deviation of 0.65; the mean score for Professional Skills was 4.25 with a standard deviation of 0.52; the mean score for Creative Thinking was 4.08 with a standard deviation of 0.70; the mean score for Technology Use Experience was 4.16 with a standard deviation of 0.60; and the mean score for Overall Learning Satisfaction was 4.35 with a standard deviation of 0.58.

Overall, the mean scores for all items exceeded the midpoint value of 3.0, indicating that students generally held positive perceptions toward the course. Notably, Overall Learning Satisfaction and Professional Skills received the highest ratings, suggesting that the integration of AR technology into instruction effectively enhanced students' learning outcomes.

Table 2. Descriptive Statistics Analysis of the Questionnaire

Dimension	Item	Question	Mean	SD
(1) Learning Motivation	Q1	Has this AR-assisted course enhanced your learning motivation?	4.15	0.62
	Q2	Has this course increased your interest in color and aesthetics learning?	4.12	0.65
	Q3	Has this course helped you realize the importance of learning?	4.05	0.69
	Q4	Has the course content stimulated your further learning interest?	4.07	0.68
(2) Professional Skills	Q5	Has this course improved your application of color aesthetics in fashion styling?	4.26	0.50
	Q6	Has this course enhanced your color analysis and design execution skills?	4.20	0.53
	Q7	Has this course enhanced your practical color matching abilities?	4.25	0.54
	Q8	Has this course strengthened your professional skills related to color aesthetics?	4.29	0.50
(3) Creative Thinking	Q9	Has the course stimulated your creative thinking?	4.00	0.75
	Q10	Has the course encouraged you to generate innovative ideas?	4.12	0.68
	Q11	Has the course inspired you to experiment with different color combinations?	4.12	0.67
(4) Technology Use Experience	Q12	Were you able to operate AR tools smoothly during the course?	4.08	0.60
	Q13	Has the AR system helped you organize your color design ideas?	4.16	0.58
	Q14	Has this course increased your familiarity with AR technology?	4.24	0.62
(5) Learning Satisfaction	Q15	How satisfied are you with the overall AR-assisted color and aesthetics course?	4.35	0.58

(1) Strengthening Color and Aesthetic Knowledge

By using the free AR application “MAKAR,” students were able to conduct real-time fashion styling simulations, allowing for a more intuitive understanding of color theory and its application in design. Teachers were able to qualitatively assess students’ classroom performance, the creativity demonstrated during the design process, and the level of engagement shown during group discussions through these simulations.

Group discussions and preliminary presentations

Discussion of the AR production process

Figure 1. Students Using the "MAKAR" AR Application to Strengthen Color and Aesthetic Knowledge

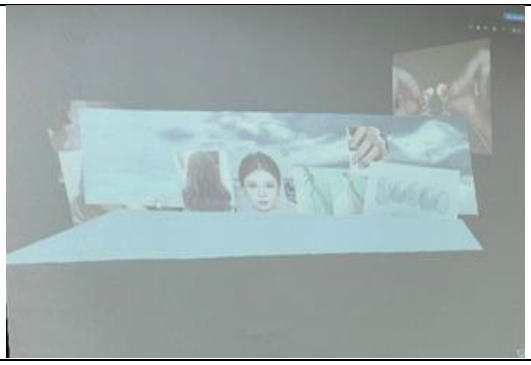
(2) Enhancing Students' Creativity and Design Abilities in Fashion-Related Color and Aesthetics

Through the color planning units, each group conducted fashion color design analyses, enabling students to express richer creative ideas and improve their application of color in fashion styling. During the color planning competition activities, judges and instructors assessed the teams based on their color planning proposals, the documentation of their design processes, and the final presentation of their fashion styling color outcomes. Evaluations focused on creativity, the uniqueness of color application, and the overall coherence of design.

AR work on cosmetic color scheme design

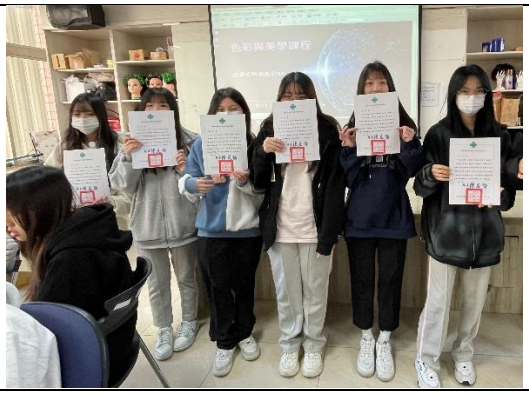
Explanation of makeup and hair color coordination

Presentation of fashion colors through AR components



Integration of color concepts into styling creations

Student Presentation on Color Coordination of Accessories



Group Photo of Award-Winning Students in the AR Fashion Color Team Competition

Figure 2. Snapshots of Group Presentations During the Final Color Planning Projects

(3) Significant Learning Effectiveness Through AR Integration in Color and Aesthetic Courses

To investigate the impact of AR technology integration on students' learning effectiveness across different dimensions, a paired-samples t-test was conducted comparing pre-test and post-test results. The statistical outcomes are presented below:

Table 3. Paired-Samples T-Test Analysis of Pre- and Post-Test Scores

Dimension	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Difference	t-value	df	p-value	Significance
Learning Motivation	3.75 (0.61)	4.15 (0.58)	0.40	4.32	59	< .001	***
Professional Skills	3.68 (0.55)	4.26 (0.52)	0.58	5.10	59	< .001	***
Creative Thinking	3.80 (0.63)	4.12 (0.60)	0.32	3.25	59	.002	**
Technology Use Experience	3.92 (0.60)	4.20 (0.55)	0.28	2.88	59	.006	**
Overall Learning Satisfaction	3.95 (0.62)	4.35 (0.51)	0.40	3.89	59	< .001	***

($p < .05$, $p < .01$, $p < .001$)

The analysis revealed that after implementing AR-based innovative teaching, students' mean scores across all dimensions significantly improved, with all differences reaching statistical significance ($p < .01$). This indicates that the integration of AR technology effectively enhanced students' learning motivation, professional skills, creative thinking, and technology usage experience.

From the perspective of Cognitive Load Theory, any instructional activity should prioritize managing learners' cognitive load to ensure both efficient and effective learning outcomes. This implies that instructional strategies must be adjusted based on the complexity of the learning tasks to optimize students' cognitive engagement and facilitate learning performance (Harvey & Cope, 2025). In practical teaching settings, instructors must consider three types of cognitive load: (1) intrinsic load, (2) extraneous load, and (3) germane load. Intrinsic load refers to the inherent difficulty of the material relative to the learner's prior knowledge and capacity to process it. Extraneous load, on the other hand, stems from poorly designed instructional materials or distracting environmental factors (e.g., unclear instructions, irrelevant tasks, or background noise), which do not support learning and should be minimized. Finally, germane load represents the cognitive effort directly contributing to learning, which should be enhanced through evidence-based strategies such as scaffolding and guided practice (Kalyuga, 2011).

Cognitive Load Theory strongly advocates for situational and active learning environments. According to van Merriënboer and Kirschner (2007), the core of any effective learning environment is placing learners in authentic contexts where knowledge is applied. Appropriately designed multimedia learning environments, viewed through the lens of cognitive load theory, can reduce extraneous load and foster schema construction. In this study, the integration of an AR-based platform provided a visually rich and interactive context for students to explore fashion-related color aesthetics. The immersive AR environment enabled learners to engage in collaborative learning tasks, facilitating deeper understanding and critical reflection on color theory and aesthetic application.

By interacting directly with virtual styling components—including hair design, makeup, clothing, nail art, and fashion accessories—students were able to apply professional knowledge in a simulated, yet realistic setting. This process enhanced learning motivation, engagement, and practical comprehension. Because students could immediately visualize and manipulate their own creative designs within the AR space, their sense of ownership and satisfaction with the learning experience increased significantly. The improvement observed across the five learning dimensions measured in this study provides further evidence that AR effectively supports contextual learning, as illustrated in Figure 3.

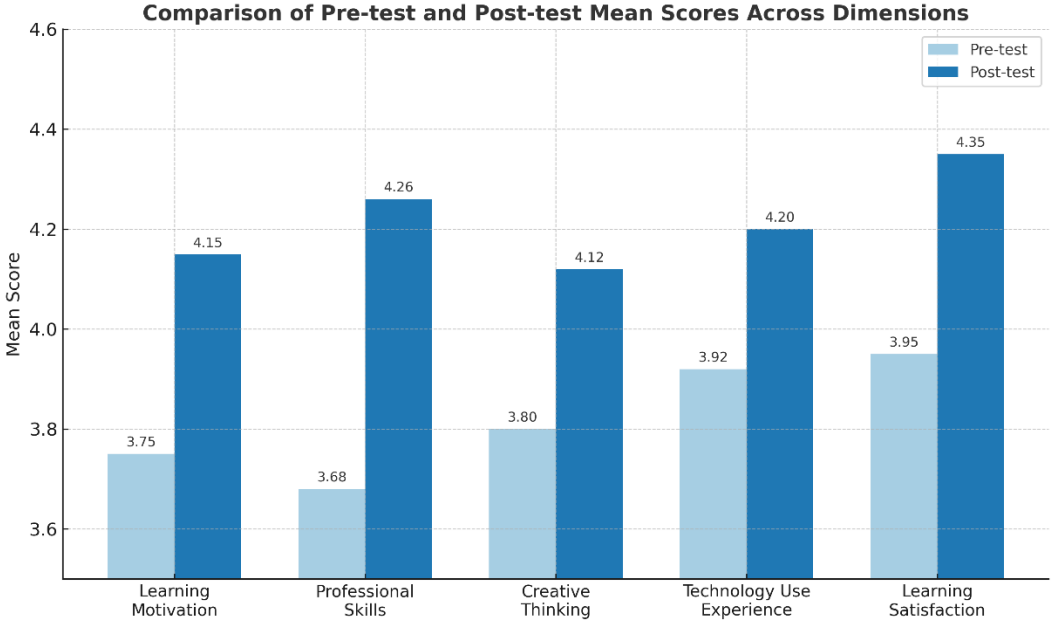


Figure 3. Comparison of Pre-test and Post-test Mean Scores Across Five Dimensions

According to the "Pre-test vs. Post-test Mean Scores Comparison" bar chart, students demonstrated notable improvements across all five learning dimensions covered in this course, indicating that the integration of Augmented Reality (AR) technology into color and aesthetics education is highly effective.

A. Significant Improvement in Learning Motivation (+0.40): Immersive Engagement

The pre-test mean score for learning motivation was 3.75, increasing to 4.15 in the post-test, reflecting a meaningful gain of +0.40. This suggests that the immersive and interactive learning environment significantly enhanced students' interest and engagement. Open-ended questionnaire responses frequently included terms like "fun," "engaging," and "first-time experience," underscoring how AR-facilitated immersion positively influenced learning motivation. According to immersive learning theory and constructivist principles, learners build knowledge more effectively through contextual, experiential engagement. AR technologies offer precisely such environments, making them particularly conducive to enhancing motivation. As students shared:

"This course was very interesting. It sparked my motivation to learn, and I hope to have more opportunities like this in the future. Although it was difficult and a first-time experience, I'm really grateful to the teacher for guiding us through it."

"I really liked this course. It made me want to attend and learn more."

These reflections highlight that, compared to traditional paper-based instruction, AR's immersive experience more effectively fosters motivation and supports learner-driven engagement and knowledge construction, aligning with the constructivist model of "learning by doing."

B. Greatest Improvement in Professional Skills (+0.58): Visualization + Interactive Practice

The professional skills dimension saw the highest increase among all areas, rising from a pre-test mean of 3.68 to a post-test mean of 4.26 (+0.58). Students engaged in color planning and full styling projects using the MAKAR platform, which strengthened their grasp of color theory and practical skills. AR's real-time visual simulation—allowing manipulation of hue, value, and chroma—enabled students to observe design outcomes and make iterative improvements, an experience often lacking in traditional settings. Students were able to experiment freely with color schemes and styles, applying theoretical principles through hands-on digital tasks. As they commented:

"This class was fun! I could freely try out various combinations of colors and styles using digital materials. It helped me practice color application techniques."

"I learned a lot about color theory, and presenting it using technology was really cool."

This ability to visualize and revise in real-time proved essential to skill mastery, with AR's visual-interactive nature serving as a key driver in developing professional competencies.

C. Creative Thinking Improved Notably (+0.32): Interactive Exploration + Diverse Options

The creative thinking dimension improved from a pre-test mean of 3.80 to a post-test mean of 4.12 (+0.32), demonstrating growth in students' design inspiration and creative expression. AR's flexibility and visualization tools allowed students to explore various styles and color combinations, fostering creativity. Comments such as "designing with imagination" and "styling according to different themes" revealed how the interactive and exploratory learning environment encouraged creative ideation. For instance:

"*This course inspired my creativity and enhanced my sensitivity to color matching and aesthetic design."*

"I loved this class! We could use our imagination to design styling concepts and select accessories based on different themes—it was really fun."

The AR setting allowed real-time experimentation and reflective revision, enhancing visual expression, collaboration, and problem-solving—all core aspects of creative thinking.

D. Slight Improvement in Technology Use Experience (+0.28): High Baseline Limited Growth

This dimension rose modestly from 3.92 to 4.20 (+0.28), likely because students already had a relatively high pre-test score, indicating baseline familiarity with digital tools. Nonetheless, AR usage still helped translate familiarity into practical skills and confidence. Students shared:

"I learned a lot from this course, especially about AR. Although it was hard at first, I worked hard and was so happy when I completed my project."

"I learned how to apply color in everyday life. AR helped me visualize styling and color effects, and it looked amazing!"

Students' acceptance of new technology increased, and the AR-based experiences provided solid groundwork for digital literacy and workplace readiness. Additionally, AR's simulation of various real-world styling contexts (e.g., casual, formal, themed events) supported their understanding of color application in diverse environments.

E. Highest Post-Test Score in Overall Learning Satisfaction (4.35): Synergy of Engagement, Visualization, and Interactivity

Although learning satisfaction increased by +0.40 (from 3.95 to 4.35), it was the highest among all post-test dimensions. This indicates that students were highly satisfied with the overall learning experience—spanning design, interaction, and outcomes. The combined effect of engagement, visualization, and interactivity contributed to this result. Student reflections included:

"The teacher was great! This course helped me understand how to use color practically."

"It was my first time experiencing such an interesting course. I really enjoyed creating digital styling projects with my classmates."

"I learned the principles of color matching and how to apply them in everyday life. Super useful!"

These comments reveal that students deeply appreciated the innovative, practical, and enjoyable nature of the AR-integrated course. The ability to simulate and present their creations in real time enhanced their understanding of aesthetics, motivation, and self-efficacy.

Overall, AR technology effectively overcomes the limitations of traditional instruction in color and aesthetics courses, offering an immersive, interactive, and innovative learning environment. Students demonstrated significant improvements in professional skills, creative thinking, and digital literacy, confirming the pedagogical value of AR integration.

This course model not only introduces a novel approach to career-oriented beauty education but also illustrates AR's high potential for interdisciplinary teaching and practical application—offering concrete directions for future curriculum reforms in vocational education.

Importantly, the observed differences in AR's impact across learning dimensions can be attributed to three key pedagogical mechanisms:

a) Enhanced Engagement: Immersive, context-driven environments stimulate motivation and sustained learner participation.

b) Visual Support: Real-time simulations and editing tools support understanding, application, and internalization of professional knowledge.

c) Interactive Reinforcement: Opportunities for experimentation, feedback, and iterative improvement foster creativity and problem-solving.

In summary, AR is not merely a digital tool—it is a transformative instructional strategy that enriches the learning process and expands the pedagogical possibilities for color and aesthetics education.

(4) Students' Qualitative Feedback Highlighted the Effectiveness of AR-Based Innovative Teaching

To gain deeper insights into students' learning experiences with AR-integrated instruction, open-ended feedback was collected at the end of the course and initially visualized using a word cloud (Figure 4). The most frequently appearing keywords included: *"fun," "course," "teacher," "very enjoyable," "I feel," "application," "color," "like," "life,"* and *"learned,"* reflecting an overall positive attitude toward the course and strong engagement with the learning content.

In addition to the word cloud visualization, **thematic coding and direct quotations** were used to strengthen the qualitative findings. Three key themes emerged:

A. Increased Learning Motivation and Positive Emotions

Students frequently expressed heightened enthusiasm and interest in the learning process.

"I never thought learning color theory could be this fun. The AR activities kept me motivated throughout the course."

"It was exciting to see my designs come to life in AR—it made me want to learn more."

These sentiments support the immersive learning framework and align with the concept of "flow experience," where learners feel a deep sense of engagement and enjoyment.

B. Integration of Professional Knowledge with Aesthetics and Technology

Responses showed that students successfully grasped core content related to color and styling.

"I finally understood how different colors work under lighting—something I couldn't get from textbooks alone."

"The teacher helped us connect theory with real-world styling. Using AR made it easier to visualize the effects."

These quotes suggest that AR helped bridge the gap between abstract theory and tangible application, enhancing both conceptual understanding and contextual relevance.

C. Enhanced Creativity and Real-World Application

Students appreciated opportunities for innovation and experimentation.

"I used the AR tools to create different styling combinations. It helped me be more creative and think outside the box."

"I can imagine using this kind of technology in the beauty industry—it makes me more confident about my future career."

These reflections indicate that AR technology not only stimulated students' creative thinking but also fostered a sense of vocational relevance and confidence in applying skills in practical contexts.

In summary, moving beyond the word cloud, students' qualitative responses strongly validated the effectiveness of AR-based learning in enhancing motivation, aesthetic understanding, and creative capacity. The direct quotes reinforce the broader trends and illustrate how immersive technologies can transform traditional content into engaging, student-centered learning experiences.

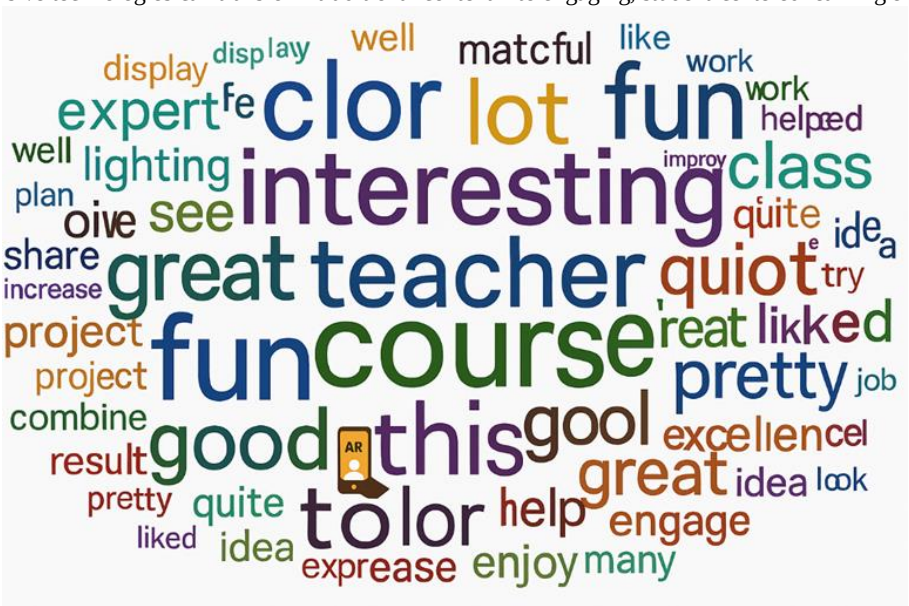


Figure 4. Word Cloud Generated from Students' Qualitative Feedback on AR-Based Innovative Teaching

CONCLUSION AND RECOMMENDATION

1. Conclusions

This study investigated the feasibility and instructional effectiveness of integrating Augmented Reality (AR) technology into color and aesthetics education within a five-year junior college beauty program. By employing a mixed-methods approach—combining pre- and post-tests, quantitative analysis, qualitative feedback, and final project evaluations—the study yielded several key insights:

1.1 AR-Facilitated Learning Promoted Engagement and Skill Development

The immersive, interactive features of AR were found to significantly enhance students' motivation to learn, their ability to visualize color combinations, and their willingness to engage with digital tools. Rather than merely improving scores, AR fostered active exploration, task-based learning, and visual experimentation, which helped bridge the gap between abstract theory and hands-on practice.

1.2 AR Integration Encouraged Creative Expression and Collaborative Design

Through the final team-based styling project, students applied theoretical knowledge in a design task that required problem-solving, communication, and creativity. This experiential process demonstrated how AR could facilitate real-world professional competencies, including visual storytelling and digital presentation skills.

1.3 Qualitative Evidence Validated Instructional Impact

Student reflections and visualizations (e.g., word cloud) revealed high levels of satisfaction and perceived usefulness of AR-integrated instruction. Recurring themes such as "fun," "practical," and "interactive" reinforced the effectiveness of immersive technology in fostering student-centered learning experiences.

2. Recommendations

Based on the findings, the following instructional and research recommendations are proposed:

2.1 Promote Scalable AR Adoption in Vocational Education

Given its value in enhancing visual and creative engagement, AR should be promoted across vocational programs, especially in design-related fields. However, its scalability must be considered, particularly for resource-constrained institutions. The use of mobile-based AR platforms (e.g., MAKAR) offers a relatively low-cost entry point, though attention should be given to infrastructure support and digital literacy gaps.

2.2 Support Cross-Disciplinary Curriculum Development

AR enables integration of knowledge from color theory, styling, digital tools, and marketing. Future courses should leverage this potential by designing interdisciplinary modules that combine aesthetics, technology, and industry trends, fostering students' holistic thinking and practical application skills.

2.3 Invest in AR-Specific Assessment Instruments

There is a need to establish validated and reliable tools for assessing the effectiveness of AR-based teaching in vocational education. Custom rubrics for creative output, spatial understanding, and digital fluency can help better capture the depth of student learning outcomes.

2.4 Expand Research Scope Across Diverse Contexts

To strengthen generalizability, future studies should include larger and more diverse samples across institutions, student backgrounds, and instructional formats. Comparative studies may reveal how gender, prior digital exposure, or learning preferences mediate AR learning effects.

2.5 Provide Teacher Training on AR Instructional Design

To ensure sustainable implementation, educators must be equipped with pedagogical and technical skills to design meaningful AR learning experiences. Professional development programs focusing on AR content creation, curriculum integration, and classroom management are crucial.

2.6 Conduct Longitudinal Research on Skill Retention and Transfer

While short-term gains are evident, it is equally important to assess whether AR-enhanced learning leads to long-term retention of knowledge and whether these skills transfer to workplace settings. Follow-up studies after graduation could offer valuable insights into the practical impact of AR-integrated instruction.

REFERENCES

Cardinal Tien Photonics Industry & Technology Development Association. (2022). Exploration of AR/VR Trends in 2023. Optical Link: Optoelectronics Industry and Technology Intelligence, (180), 23–28.

Harvey, S., & Cope, E. (2025). Making learning happen in Teaching Games for Understanding with cognitive load theory. Education Sciences, 15(5), 631. https://doi.org/10.3390/educsci15050631

Hsu, Y., Chen, J.-C., Gu, C., & Wu, W.-L. (2021). Exploring the flow experience of applying augmented reality in basic design education. Journal of Design Science, 26(2), 43–66.

Kalyuga, S. (2011). Cognitive load theory: How many types of load does it really need? Educational Psychology Review, 23(1), 1–19. https://doi.org/10.1007/s10648-010-9150-7

Lin, H.-C., Lin, L.-J., & Chen, S.-C. (2017). Interactive sensing technologies for AR/VR. Computer and Communications, (170), 1–4.

Lee, W.-H., Lee, H.-K., & Geraghty, L. (2016). The usability attributes and evaluation measurements of mobile media AR (augmented reality). Cogent Arts & Humanities, 3(1), 1–16. https://doi.org/10.1080/23311983.2016.1241171

Marín, V., Sampedro, B. E., Muñoz González, J. M., & Vega, E. M. (2022). Primary education and augmented reality: Other form to learn. Cogent Education, 9(1), 1–19. https://doi.org/10.1080/2331186X.2022.2082082

Salmi, H., Thuneberg, H., & Vainikainen, M.-P. (2017). The invisible observable by augmented reality in informal science education context. International Journal of Science Education, Part B, 7(3), 253–268. https://doi.org/10.1080/21548455.2016.1254358

Santos, M., Jones, R., & Morgan, K. (2024). Developing creative coaches through action research: Why and how context matters. Sport, Education and Society. https://doi.org/10.1080/13573322.2024.2405607

van Merrienboer, J. J. G., & Kirschner, P. A. (2007). Ten steps to complex learning: A systematic approach to four-component instructional design. Routledge.

Wu, C.-Y., & Lin, C.-H. (2023). Integrating AR and VR into international education curricula: New opportunities for expanding learning. Taiwan Educational Review Monthly, 12(11), 68–72.

Yeh, J.-H., & Lee, H.-S. (2020). Exploring the correlation between university curricula and certification using ISM: A case study on cosmetic application and management programs. Huagang Agricultural Science Journal, 46, 38–61.

Yeh, C.-C. (2023). Becoming beautiful with ease: AI and AR revolutionizing the experience of dressing and makeup. Retrieved from https://www.find.org.tw/index/indus_trend/browse/5023d8ae64f11966e0b4de86dc7299d2