Exploring an innovative apprenticeship model in design education: a case study in transportation design

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Design education faces challenges due to rapid technological and societal changes. As we move towards modern professional education, important values such as guidance, experience sharing, and cultivating craftsmanship are being lost. This study proposes an innovative design apprenticeship model that combines traditional apprenticeship with modern education to improve quality and cultivate innovative designers with strong technical skills. The research methods include literature review and case application and analysis. Through literature review, key elements of traditional apprenticeship inheritance are integrated into the innovative design apprenticeship model, which is then applied and explored in teaching practice. This model emphasizes improving students’ practical and problem-solving skills. Key factors are: 1) personalized guidance to foster interaction and collaboration between teachers and students; 2) guide students with projects to enhance the inheritance of practical experience; 3) introduce exclusive industry mentor collaborative teaching to enhance knowledge and experience transfer. The study proposes that implementing an innovative design apprenticeship model can be a productive method to improve design education. This model promotes interaction and cooperation between teachers and students, allowing students to better develop skills with personalized guidance. By collaborating with industry mentors to enhance students’ practical skills and fill the knowledge gaps that come with learning from one teacher alone. In summary, the results of this study provide an effective apprenticeship education model, demonstrating the significant application value of apprenticeship education in the field of design education. The research results have important social significance and academic value for improving the teaching quality of design education.

Keywords: mentorship system; design education; career development; education model
1 Introduction
Recently, Taiwan has achieved significant progress in industrial design education, with improvements in curriculum design, course content, practical opportunities, and international perspectives. As a result, the number of exceptional designers has increased. Industrial design education no doubt plays a crucial role in the higher education system in Taiwan. Moving forward, industrial design education in Taiwan will then focus more on cultivating students' practical and creative abilities, strengthening industry-academic cooperation, enhancing practical education and technological innovation, and promoting the mutual advancement of industrial design education and industry in Taiwan.

However, while diverse cultural backgrounds, industry practice orientation, international perspectives, and innovation and creativity are all advantages of Taiwan's industrial design education, it also faces challenges such as resource shortages, market competition, educational system reform, and international competition. Therefore, Taiwan's industrial design education must continue to improve and innovate to enhance students' quality and competitiveness. Furthermore, it is important to consider the demand for design professionals in both industry and society. Aligning education with industry standards can improve the quality and marketability of design professionals.

Apprenticeship education has been used for centuries in traditional crafts and has proven effective in many professional and technical fields. Notable examples include American writer Hemingway and his student John Steinbeck, Japanese architect Ando Tadao and his student Ito Toyo. These cases demonstrate that apprenticeship education provides students with guidance and support that can help them reach their full potential, while also allowing them to carry on the traditions and spirit of their mentors.

In the realm of design education, improving the quality of education and cultivating students' professional skills have always been important concerns for both the education and design industries. Apprenticeship education, as a time-honoured teaching method, has been extensively utilized in traditional craftsmanship and professional technical fields across many nations, producing favourable outcomes. However, the use and development of apprenticeship in design education remain an untapped domain, which requires for further research and discussion. This research explores the use of apprenticeship education in design. We aim to develop and define a model for design education apprenticeships through literature review and empirical research, evaluating its effectiveness on students' understanding and skill improvement. Our goal is to promote creativity and innovation, enhance the quality of design education, and reduce the gap between theory and practice. We also hope to provide designers with effective means of passing on professional knowledge and skills. The results will provide essential references for future research on apprenticeship education.

2 Literature review
The literature review mainly focuses on traditional apprenticeship systems and their application in various fields as references, exploring theories, key elements, application scopes, and other aspects.

2.1 Apprenticeship system definition and theory
The apprenticeship system is a time-honoured and effective approach to education and learning. Typically, a master takes on one or more students and imparts their knowledge, skills, experience, and wisdom to the apprentice. Through long-term observation, imitation, practice, and reflection, the
Apprentice becomes an expert with an equal or higher level of skill, ultimately inheriting knowledge and contributing to the development of culture. The apprenticeship system has been successfully applied in various fields, including art, handicrafts, engineering, science, literature, and medicine (Cook-Sather, Bovill, & Felten, 2014).

Apprenticeships offer numerous benefits by providing an engaging learning environment that allows apprentices to gain hands-on experience and receive immediate feedback. Through this process, apprentices not only acquire valuable skills, but also develop important values and work attitudes. Additionally, apprenticeships foster strong mentor-student relationships and bolster apprentices' self-confidence and self-esteem. The traditional apprenticeship process usually involves 5 steps, as shown in Figure 1 and Figure 2.

![Five Stages of Traditional Apprenticeship](image)

*Figure 1. Five Stages of Traditional Apprenticeship*

![Traditional Apprenticeship process](image)

*Figure 2. Traditional Apprenticeship process*
In terms of educational theory, apprenticeships can be traced back to the mentor-apprentice relationships of ancient Greek philosopher Plato and his student Aristotle, as well as Chinese Confucian thinker Confucius and his students. These historical relationships have had significant impacts. Overall, apprenticeships represent an effective and time-honored educational model, with theoretical foundations dating back to ancient times and continuing to hold significant reference value in modern educational theories.

2.2 Application and development of the apprenticeship system

Apprenticeship education is a method where experienced masters guide apprentices in learning and practicing skills within the context of vocational and technical inheritance. Through this approach, apprentices acquire not only technical knowledge from their masters, but also a wide range of knowledge, including behavioral norms, life philosophy, and moral concepts (Chan & Luo, 2020). This educational method effectively transmits skills and promotes emotional exchanges between masters and apprentices, forming a long-term apprenticeship relationship.

Apprenticeship education has always been an important educational method, widely applied in various fields. This approach not only inherits traditional culture and skills but also cultivates students' character and ideological qualities, making it an educational method with unique value (Tenenbaum, Crosby, & Gliner, 2001).

Many countries also have their own apprenticeship systems to teach skills and crafts. In China, for instance, apprentices are often influenced by their master's thoughts, which are based on Confucianism's emphasis on fulfilling social duties. Germany's vocational education and training system is also based on apprenticeships. Students receive mentorship-based training from professionals in the workplace and theoretical education from schools that integrate practical learning. This approach combines theoretical knowledge with hands-on experience. Japan cultivates a "craftsman spirit" in specific fields, which demands an almost perfect and meticulous approach to their industries, products, and services, and requires the inheritance through the master teaching the apprentice. By teaching, the unique culture, characteristics, or spirit of their industries or services are passed down, and it takes over ten years of complete technical training for an apprentice to become independent (Tsai Qingmei, 2020). Apprenticeship systems in certain countries have evolved over time and remain as critical channels for developing professional and technical personnel today.

Apprenticeship education is still widely used in modern society. For example, in the medical field, many doctors pass on their skills and experiences to young interns to help them grow and progress continually in their careers. (Tuomikoski, Ruotsalainen, Mikkonen, Miettunen, & Kääriäinen, 2018). Apprenticeship education is also widely used in the fields of vocational education and technical training. It enables students to learn practical skills and knowledge, and gradually master their abilities. (Zhao, Watson, & Chen, 2018). (Huang Meiping, 2011) found that the implementation of the apprenticeship system led to improvements in students' learning motivation, academic achievement, self-perception, and academic adaptation abilities. This indicates that the apprenticeship system has a positive impact on students' learning and self-development. Li-Ching Sun, 2015 discovered that implementing the apprenticeship system can promote students' learning motivation, academic achievement, and academic adaptation abilities. Study also shows that, from the perspective of knowledge sharing, the apprenticeship system allows for the exchange of information and knowledge between masters and apprentices. Through the master's knowledge sharing and the apprentice's
learning and application of information and knowledge, the apprentice's abilities and performance in the workplace can be enhanced, promoting organizational growth and inspiring innovative behavior (Douglass, Smith, & Smith, 2013). Recent meta-analyses suggest that deep-level similarity positively affects the mentoring process and its outcomes, even more so than surface-level similarity (Eby et al. 2013).

2.3 Implementing the apprenticeship system in design education

According to literature, the apprenticeship system has been widely implemented in several occupational fields within school education, and has positive effects in improving students' learning outcomes, skills, and motivation. Apprenticeship is currently regarded as a highly effective teaching method in educational theories. A study conducted by (Zielhuis, Sleeswijk Visser, Andriessen, & Stappers, 2022) indicates that the apprenticeship system can enhance an individual's self-confidence and professional capabilities, improve work efficiency and satisfaction, and provide a personalized and practical learning experience. By interacting and communicating with their masters, students can gain a deeper understanding of the knowledge and skills they learn. Apprenticeship can also help students develop their self-confidence and independent thinking abilities (Kram, 1988). Previous studies have shown that students continuously improve their abilities and qualities by learning from and imitating their masters, engaging in practice and innovation in the actual learning process, thereby enhancing their self-confidence and independent thinking abilities (Spiekermann, Lyons, & Lawrence, 2020).

Previous research has shown that in modern design education, the apprenticeship system can offer a valuable learning experience. By working with experienced mentors, students can better comprehend and apply theoretical knowledge, as well as enhance their skills and creativity. This approach enables students to acquire their mentors' professional skills and work experience and put their knowledge into practice. Additionally, this educational method contributes to the transmission of design culture and values, promoting the growth and development of a new generation of designers (Yalman & Yavuzcan, 2015).

Apprenticeships can also help students establish close relationships with their mentors, which helps build students' confidence and sense of self-worth (Dorst & Cross, 2001). Students can build confidence and self-worth through interaction with their mentors, as well as quickly master design skills and further enhance their design capabilities. They can develop their professional attitudes and values, and hone their problem-solving abilities and creativity, ultimately becoming more creative and influential designers (Lahti & Seitamaa-Hakkarainen, 2005).

Overall, incorporating an apprenticeship system into design education can offer students valuable learning opportunities that foster skill development and creativity, while also promoting the preservation of design culture and values. To make the most of this approach in modern design education, schools should establish personalized mentorship pairings based on students' needs and professional characteristics, ensuring effective guidance and learning. By doing so, we believe that more talented designers can be cultivated, ultimately contributing greater value to society's development and talent cultivation.
3 Method

The purpose of this study is to integrate and define a mentorship-based educational model for design education through literature review and to understand its effectiveness. The first phase involves the practical application of the innovative design apprenticeship model in the educational setting. The second phase involves selecting students from the first phase and understanding the effectiveness of the mentorship-based educational model in the design education field through observation, interviews, and evaluation with scales.

3.1 Innovative design apprenticeship model

The traditional apprenticeship system is a method in which a senior professional (master) instructs apprentices in learning and practicing skills in a one-on-one or one-to-many manner. Past studies have shown that students' learning outcomes can be significantly improved when they receive apprenticeship training in the workplace and participate in school-industry collaboration internship mechanisms in related vocational fields. Therefore, this study aims to integrate the advantages of traditional apprenticeship systems and contemporary workplace training, introduce the concept of industry mentor, and propose a 1+1 dual-mentor apprenticeship model: Innovative Design Apprenticeship Model, as shown in Figure 3, and usually involves involve the following steps, which includes 2 extra step compare to traditional apprenticeship, as shown in Figure 4:

1. Recruit Student: Recruiting interested students
2. Guiding students: Guide students on how to perform specific tasks, learn professional knowledge, and skills.
3. Introduce Industry Mentor: Introduce a mentor who practices in the industry, and students learn under the long-term interactive guidance of two masters to master professional knowledge and skills, while cultivating comprehensive qualities.
4. Practice: Students practice under the supervision of experts or mentors while also receiving practical experience guidance from a second industry mentor.
5. Evaluation: 2 Mentors evaluate student performance and provide feedback and suggestions.
6. Assistance: When students pass the assessment and gain recognition, they can become assistants, helping mentors guide new apprentices (junior students). Through teaching (imparting techniques and knowledge), they further refine their own skills and cultivate a stronger sense of responsibility and role identification.
7. Inheritance: Upon graduation, they have the necessary qualifications to quickly enter the industry and pass on their skills and knowledge to future generations.
This education model emphasizes close interaction between teachers and students, allowing students to not only master professional knowledge and skills under the long-term guidance of two mentors but also develop comprehensive qualities such as teamwork, problem-solving, and adaptability. By combining the practically experienced second mentor, students’ practical skills can be enhanced. The possible knowledge and field deficiencies relying solely on a single mentor’s instruction can also be addressed. After gaining recognition, students are assigned the role of an assistant, allowing them to help the mentors with professional projects as well as participate in interactions with other new apprentices. This not only further enhances the students' professional expertise but also promotes a sense of responsibility and role identification, laying a solid foundation for their future career development. The innovative design apprenticeship model integrates the essence of traditional education.
apprenticeship systems and modern industry workplace training, providing students with a more comprehensive and practical learning environment through the complementary teaching of two mentors, helping to cultivate outstanding talents with professional knowledge, skills, and comprehensive qualities.

3.2 Experiment design

3.2.1 Phase 1: application of the innovative design apprenticeship model
This phase involves the application of the innovative design apprenticeship model in design education. A newly-appointed product design professor (mentor) from a college in Taiwan recruits students (apprentices) to form teams and conduct long-term apprenticeship-based teaching. The scope of the experiment in this study is limited to the teacher leading team members to participate separately in the Kymco Design Competition, with all participating teams having no prior experience in this competition. The Kymco Design Competition is the largest transportation design competition in Taiwan, held annually and divided into three stages: preliminary, semi-final, and final rounds, with a competition timeline of approximately 9 months.

3.2.2 Phase 2: questionnaire survey and interview review
The objective of this phase is to gather the students' (apprentices') subjective thoughts regarding the innovative education model of apprenticeship. Four participants were selected from the first phase of the experiment and agreed to be interviewed. The experiment began with an online questionnaire to collect preliminary information and investigate the participants from the first phase. The individuals who were primarily responsible for the product appearance design during the first phase experiment were then chosen for one-on-one interviews.

3.3 Participants
This study investigates the educational application of the innovative design apprenticeship model, divided into two stages. In the first stage, this model is used to guide student teams in completing design competitions. Four teams with a total of 14 design major students, aged between 19-23 years old, participate in this stage.

In the second stage, interviewees were selected from the first-stage participants, with a total of 4 students meeting the eligibility criteria. The selection criteria were based on apprentices who were mainly responsible for product styling design in the teams. The interviews was conducted in a private office with natural light and controlled lighting that was stable, and with a temperature set at 26°C (78.8°F). All participants understood the experiment and agreed to participate. They were also required to sign a consent form.

3.4 Guidelines for developing measurement survey
This study collects and summarizes recent relevant literature as shown in Table 3-1, classifies the apprenticeship-specific measurement scales based on functional theory, and modifies them accordingly. The categories are as follows: (1) career development; (2) social-psychological support; (3) role modeling, with the aim to explore the impact of mentor functions on apprentice performance, effectiveness, and organizational development. The table 3-1 below presents the design directions of this questionnaire.
Table 1. Questionnaire Guide

<table>
<thead>
<tr>
<th>Questionnaire Aspect</th>
<th>Definition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career Development</td>
<td>Career development aims to enhance the apprentice's job capabilities in the relationship and assist in their career progression. It can positively impact job satisfaction, work performance and effectiveness, organizational citizenship, interpersonal relationships, etc., for those with less experience.</td>
<td>Kram, 1985; Scandura, 1992 Murphy, 2012</td>
</tr>
<tr>
<td>Social Psychosocial Support</td>
<td>Social-psychological support can help apprentices improve their job capabilities and attitudes in the workplace, identify with their work role, and fully engage in their work. It can also enhance their self-efficacy in demonstrating their ideas and performance, and even increase the opportunities to explore undiscovered skills.</td>
<td>Hoffman et al, 2016 Form et al, 2017 Crowther, Hann &amp; Andrews, 2002</td>
</tr>
<tr>
<td>Role Modeling</td>
<td>Role modeling refers to the apprentice observing the mentor as a subject, learning and imitating the mentor's attitudes and performance at work, and integrating and applying these aspects into the apprentice's work.</td>
<td>Chen, 2013 Murphy, 2012</td>
</tr>
</tbody>
</table>

3.5 Experimental space and equipment

The study's participants were all students from a college in Taiwan. To conduct the first phase of the experiment, we utilized the specialized research and teaching space provided by the school's teachers.

For the second phase's in-depth interview, we selected a clean room with a comfortable temperature as the experimental venue. Our priority in choosing the venue was the participants' comfort during the interview process, as well as the availability of natural light and ventilation to ensure the site's practicality and comfort. Additionally, we used a professional microphone to record the interview. The microphone has high sensitivity and low noise characteristics, allowing it to accurately capture the participants' voices and ensuring the interview's accuracy and completeness.

3.5.1 Questionnaire design

Based on the table 3-1, The questionnaire consists of 35 questions using a Likert 5-point scale as the response format, as shown in Figure 5. Participants read the question content and choose a number and corresponding option based on their feelings. The options are as follows: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree," with scores ranging from 5 to 1.
3.5.2 Interview outline

The interview questions were designed based on the results of the first questionnaire, as shown in Figure 6, and took approximately 30 to 50 minutes to complete.

The interview consists of three stages:

1. Evaluate the results that participants provide upon finishing the innovative design apprenticeship model program.
2. Explore how participants have applied the apprenticeship model in the design field and their related experiences.
3. Gather participants' feedback and thoughts about the apprenticeship model.
4. Understand the impact of increasing the apprenticeship model with industry mentor on learning.

Figure 6. Interview Outline

4 Result

4.1 Analysis of questionnaire result

The result shows the average scores for the most questions are above 4.0, as shown in Table 2. The survey is based on Likert 5 points scale, therefore indicating an average 4.0 score is a relatively high level of satisfaction among students towards their mentors and the training process. In summary, in career development dimension: most apprentices(students) believe that it is necessary to collect effective data for analysis and propose solutions during training or work, clearly express their thoughts and understand others' narratives, and continuously seek learning resources to improve themselves. Apprentices and mentors can quickly understand the situation within the team and adopt effective management measures to achieve goals while actively learning self-management and team management, and being responsible for themselves. Apprentices also believe that it is necessary to
demonstrate their work capabilities in important occasions, quickly adjust to situations to complete tasks, and actively learn and accept guidance when being supervised and receiving feedback from others. In social psychological support dimension: apprentices indicated that apprentices and mentors would listen to each other, understand each other's thoughts, feelings, and considerations, and share experiences and personal journeys in work through open consultations and discussions to address work-related issues. When apprentices show progress, mentors provide support and praise. Apprentices can also understand the mentors' position and express recognition and respect. In private occasions, apprentices and mentors have opportunities for mutual interaction and consider each other as friends. They can collaborate on tasks together, and apprentices can clearly express their thoughts and understand the other party's narratives. In role model dimension: Positive evaluations were obtained for aspects such as proactively learning to imitate the mentors' performance and attitude, mentors encouraging apprentices to independently complete tasks, hoping apprentices surpass themselves, trusting mentors and believing in their words and deeds, respecting mentors' training, considering mentors as respectable in their work, examining one's performance with extremely high standards, reaching consensus, specifically expressing suggestions and goals, encouraging apprentices to propose new ideas, and being willing to accept new challenges.

### Table 2. Analysis of survey results

<table>
<thead>
<tr>
<th>Problem type</th>
<th>Explanation</th>
<th>M</th>
<th>Mdn</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Career development</td>
<td>Career development includes vital aspects such as data analysis, communication, learning, team management, task execution, self-adjustment, accepting feedback, responsibility, and knowledge acquisition.</td>
<td>4.38</td>
<td>4.5</td>
<td>0.65</td>
</tr>
<tr>
<td>2 Social psychosocial support</td>
<td>The social and psychological support dimension includes communication and understanding between master and apprentice, sharing experiences, discussing issues openly, supporting progress, showing respect and companionship, fostering friendships, collaborating on tasks, and understanding and expressing oneself clearly.</td>
<td>4.27</td>
<td>4.27</td>
<td>0.74</td>
</tr>
<tr>
<td>3 Role modelling</td>
<td>The role model dimension includes the apprentice learning to imitate the master's behavior and attitude, the master encouraging the apprentice to complete tasks independently, trust, respect, training and advice between the master and apprentice, and the individual's initiative to embrace challenges.</td>
<td>4.49</td>
<td>4.54</td>
<td>0.59</td>
</tr>
</tbody>
</table>

### 4.2 Analysis of interview results

Four participants were invited for this study, and in-depth interviews were conducted to explore the changes in students' works and ideas through the innovative design apprenticeship model. Interviews and feedbacks being collected in all formats was based on Chinese. The results of the interviews, categorized according to the interview themes, are being translated and shown in Table 4-2.
### Table 4.2 Integrated Sharing Table of Participant C’s Learning Process

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Early Progress</th>
<th>Midterm Progress</th>
<th>After Mentor Teaching</th>
<th>Effect Explanation</th>
<th>Apprentice Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brainstorming</strong></td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
<td><img src="image3" alt="Image" /></td>
<td>With the guidance of the mentor, the topic direction gradually became clear and focused, from initial rapid ideation to mid-term data investigation and subsequent integration stage.</td>
<td>&quot;I think if it were not for the mentors' guidance, the early ideation and research may not have been so complete, and may have led to greater difficulties in executing the design later on.&quot;</td>
</tr>
<tr>
<td><strong>Sketch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Drawing</strong></td>
<td><img src="image4" alt="Image" /></td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
<td>After the mentors' guidance, the proportion of the model gradually became reasonable, and the motorcycle's functions and details were gradually completed.</td>
<td>&quot;The mentors gave us suggestions on the concept of motorcycle styling, such as analyzing the structure and styling vocabulary of motorcycles in real life, so that we could consider them when drawing sketches and constructing 3D models.&quot;</td>
</tr>
<tr>
<td><strong>3D Modeling</strong></td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
<td><img src="image9" alt="Image" /></td>
<td>After the mentors provided suggestions on 3D modeling, there were significant changes in the modeling adjustments. Additionally, we began to execute the paint details on the surface of the motorcycle.</td>
<td>&quot;This stage involved the most discussions and modifications with the mentors, and also took the most time, but gradually became complete with each week's discussion, suggestions,</td>
</tr>
</tbody>
</table>
and modifications in the overall styling and proportions."

<table>
<thead>
<tr>
<th>Material Rendering and Detail Processing</th>
<th>Following the mentors' suggestions, we entered post-production in Photoshop, such as adjusting shadow details, adding light rays from lighting, etc., to make the motorcycle more realistic.</th>
</tr>
</thead>
</table>
| "In addition to learning rendering skills in this stage, we also learned how to use Photoshop to match the motorcycle graphics to increase detail presentation."

4.2.1 Interview results of the outcome sharing after implementing the innovative design apprenticeship model

The results show that the innovative design apprenticeship model offers students the opportunity to gain valuable practical experience and skills. Test-takers from different grades all stably produced excellent positive results and achieved outstanding results in the design competitions of the year. The strict and patient guidance of the mentors enable students to better cope with various challenges and problems, and to continuously improve and grow in practice. By leading apprentices to participate in complete projects, such as the KYMCO Design Competition being tested this study, apprentices not only learn a lot of knowledge and skills in the process, but also gain a sense of accomplishment and prestige from their remarkable achievements. The mentors provided numerous recommendations, especially for optimizing product design, user experience, and human-centered design. The advice and guidance of the mentors have a very significant impact on the team's effectiveness, making the design outcome more fits with user needs and improving the team's design capabilities and creative thinking.

4.2.2 Interview results of the application of the innovative design apprenticeship model in the design field

The application of the innovative design apprenticeship model in the design field can help apprentices to acquire a deeper understanding of knowledge and skills that are beyond what is typically taught in a regular classroom setting. This approach can enhance their abilities and self-confidence. By maintaining a close and long-term relationship, mentors can effectively understand the potential problems that each individual apprentice may encounter during the learning process, providing timely and appropriate assistance and guidance. With the guidance of their mentors, apprentices can better understand design requirements, develop solutions, and put them into practice in actual projects.

The apprenticeship innovation education model can also inspire apprentices' perspectives and thinking, encouraging them to independently develop designs. With the guidance of their mentors, apprentices can continuously improve their skills and receive valuable feedback.
4.2.3 Analysis of interview results on the evaluation of the innovative design apprenticeship model

According to the interview results, the innovative design apprenticeship model is viewed positively as an approach to education, particularly suitable for specific fields such as handicrafts, technology, and design. Compared to traditional teaching methods, the innovative design apprenticeship model offers several advantages, including close relationships between apprentices (students) and mentors, direct observation and guidance, and personalized instruction. The greatest strength of the innovative design apprenticeship model is that students can gain practical experience and skills from their mentors, while also developing positive attitudes and a sense of responsibility when interacting with others and handling various situations. Additionally, apprentices can establish meaningful relationships with their mentors and receive continuous guidance and opportunities for self-improvement.

The relationship between mentors and apprentices is more personal and collaborative, like partners in mutual learning and growth. This fosters a deeper understanding and mastery of the knowledge and skills being learned. However, there are also some drawbacks to this model, including the need for apprentices to adjust their mindset and reconsider their approach, limitations on time and location to follow around mentors’ training location that may restrict their ability to learn, and the potential for mentor bias to affect the learning process, which may require some adjustments before learning can proceed smoothly.

4.2.4 Interview results of the impact of introducing industry mentor

Results from the interviews showed that participants reflected on the assistance and impact of industry mentor on students' learning in the design field. Apprentices generally believe that industry mentor provide abundant professional knowledge and experience, helping them better understand design practices and details, making their works more mature and complete. The industry mentor can also guide apprentices to master various design thinking approaches, enhancing creativity and market competitiveness in their designs. During the learning process, the guidance and suggestions from industry mentor allow apprentices to more fully express their work, and apprentices also learn self-discipline and time management from the mentors' attitudes and habits. Industry mentor can also provide valuable advice and guidance, helping apprentices overcome difficulties such as lack of knowledge, process challenges, and misunderstandings of design concepts. Although the learning difficulty has increased, the help from industry mentor enables apprentices to learn the design field more comprehensively and deeply, and better cope with future workplace challenges.

4.3 Summary of the interviews

In this study, four participants were invited from the team to conduct in-depth interviews, sharing the impact on apprentices at different design stages under the joint guidance of school mentor and industry mentor through the innovative design apprenticeship model. The results, as shown in Table 4-3, take 3D model construction as an example. All four teams were participating in this competition for the first time and had no previous transportation design training experience. The result shows that, regardless of grade or age differences, after receiving training through this education model for varying periods of 1 to 1.5 years (time differences mainly stem from recruitment and competition
durations), all four competition projects achieved excellent results in competition. Winning bronze award 2019, Gold award 2020, bronze & honorable mention awards 2021 respectively.

From the images shared by the apprentices, there were significant improvements in the level of detail, completeness, and rationality of their work after receiving guidance from the mentors. This is consistent with the feedback from the apprentices in the interviews, stating that they initially faced challenges such as grasping proportions, lacking a sense of three-dimensionality, and focusing on color matching when creating 3D drawings. However, under the mentors’ guidance, they were able to improve and achieve better results, such as capturing overall proportions, refining the design, and adding shadow details.

Interviewees generally believed that this educational model could help them gain more in-depth practical experience and skills, enhance their confidence and independent thinking abilities. By closely interacting with their mentors over an extended period, the mentors can effectively understand the potential problems each apprentice may encounter during the learning process and provide timely and appropriate assistance and guidance. The involvement of industry mentor significantly increases the intensity and difficulty of the training, but also provides clear and practical suggestions for design rationalization, significantly benefiting the completeness of the apprentices’ works. As apprentices are required to meet the training and requirements of two different mentors simultaneously, this has a significant impact on enhancing their technical and communication skills through self-imposed demands.

Table 4-3 Case studies of experimental results - 3D model construction

<table>
<thead>
<tr>
<th></th>
<th>Participant A</th>
<th>Participant B</th>
<th>Participant C</th>
<th>Participant D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td><strong>Age for first competition</strong></td>
<td>19</td>
<td>23</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Grade level for first competition</strong></td>
<td>Sophomore year</td>
<td>Second year master</td>
<td>Junior year</td>
<td>Junior year</td>
</tr>
<tr>
<td><strong>Year of following the mentor</strong></td>
<td>Freshman year of college</td>
<td>First year master</td>
<td>Sophomore year of college</td>
<td>Freshman year of college</td>
</tr>
<tr>
<td><strong>Major responsibilities in the team</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Project Name</strong></td>
<td>3D Modeling</td>
<td>3D Modeling</td>
<td>3D Modeling</td>
<td>3D Modeling</td>
</tr>
<tr>
<td><strong>Competition Year</strong></td>
<td>Mobile Media</td>
<td>Cozy Mama</td>
<td>Pet-Amb</td>
<td>Mount-Aid</td>
</tr>
<tr>
<td><strong>Early 3D Modeling</strong></td>
<td><img src="image1.png" alt="1" /></td>
<td><img src="image2.png" alt="2" /></td>
<td><img src="image3.png" alt="3" /></td>
<td><img src="image4.png" alt="4" /></td>
</tr>
</tbody>
</table>
5 Discussion and future suggestion

The purpose of this study is to propose an innovative design apprenticeship model and to understand the effectiveness in the field of design education. The study was conducted through the recruitment of teams by a teacher from a technological university in Taiwan. The study found that mentors’ work attitude greatly influences apprentices, and mentors’ work attitude can enhance their self-discipline and self-motivation. It is consistent with previous research where apprentices learn not only skills and knowledge from their masters but also behavioral norms, life philosophies, and moral concepts (Chan & Luo, 2020). The apprenticeship education method not only preserves traditional culture and skills but also cultivates students’ character and ideological quality, making it an education method with unique value (Tenenbaum, Crosby, & Gliner, 2001).

By introducing a new educational model with industry mentor, apprentices’ learning efficiency, practical experience, and design capabilities can be significantly improved, resulting in higher-quality outcomes. This is similar to previous studies on Germany’s dual-track vocational education and training system. As in the medical field, many doctors pass on their skills and experiences to young interns, helping them continuously grow and advance in the medical field (Tuomikoski, Ruotsalainen, Mikkonen, Miettunen, & Kääriäinen, 2018).

The research results also point out that the mentors is both an symbol as an enemy and a friend to the apprentices, with the apprentice aiming to surpass the mentors. This is consistent with previous research that indicates students can build confidence and self-worth through interaction with their mentors, as well as quickly master design skills and further enhance their design capabilities. They can develop their professional attitudes and values, and hone their problem-solving abilities and creativity, ultimately becoming more creative and influential designers (Lahti & Seitamaa-Hakkarainen, 2005). In summary, the study demonstrates that the innovative design apprenticeship model is a positive, and effective design education training model that provides apprentices with rich learning experiences. Through the cooperation of two mentors (1+1), apprentices can simultaneously strengthening their theoretical and practical abilities, and helping them develop design techniques and creativity.

However, there are some limitations in the research process. First, due to time constraints, the sample size of this study is relatively small, including only four competition cases from four teams and four in-
depth interviews with students, focusing solely on apprentices in the product design field, without considering other design disciplines within the team, such as graphic design and animation design. As a result, the generalizability and representativeness of the research results may be limited. Second, this study mainly collects data through interviews, which may be influenced by the subjective factors of the interviewees. Future research is suggested to implement the result and consider to expand the sample scope, applying this model to various competitions and design projects with apprentices, and trying to use diversified data collection methods, such as third-party objective evaluations, to obtain more comprehensive and objective results. It is hoped that through the application and exploration of more examples in the future, a systematic educational model for design education can be provided.

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