

Article

# An Application of the Fuzzy Delphi Method and Fuzzy AHP on the Discussion of Training Indicators for the Regional Competition, Taiwan National Skills Competition, in the Trade of Joinery

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Received: 20 April 2020; Accepted: 21 May 2020; Published: 24 May 2020



**Abstract:** The importance of vocational training and capacity assessment has grown since the 1980s. Vocational education is an important foundation for societal and economic development. Therefore, it is crucial to develop vocational training and education that meet the demands of the labor market. Modern industrial structure is different from that of the past, creating an imbalance in the supply and demand of the labor force. The purpose of the Skills Competition (the collective term for the regional competition under the Taiwan National Skills Competition in this research) is to encourage the young generation to participate in vocational education and training, thereby further improving the effect and efficiency of learning and training. In order to develop suitable indicators for the joinery trade of the regional competition, Taiwan National Skills Competition (hereinafter referred to as the Regional Competition), we first identify the level of importance of each indicator. Firstly, this study formed a hierarchical structure via the fuzzy Delphi method (FDM) with six training indicators (drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials), and 27 sub-indicators were developed on the basis of these six major indicators. Secondly, in order to develop suitable training indicators for the joinery trade of the Regional Competition, the fuzzy analytic hierarchy process (fuzzy AHP) was adopted to seek the relative weight value of each indicator by assessing subjects through a paired-comparison. The results show that, among the six indicators, the relative weight value of measurements was the highest, followed by finishing and appearance and drawings. The indicators with higher relative weight value, such as measurement and finishing and appearance, should be paid more attention during the training processes. It is hoped that these results be presented to the trainers or instructors of training institutions or vocational schools as a reference to improve their training models, strategies, and quality.

**Keywords:** skills competition; vocational education and training (VET); fuzzy Delphi method (FDM); fuzzy AHP (FAHP); joinery

## 1. Introduction

### 1.1. Background

The main purpose of vocational education is to establish practical abilities for talents to meet the demands of the employment market. The significance of capacity assessment in vocational education and training has been growing since the 1980s. Developing and shaping vocational education and training to match the demands of the employment market [1–3] has been one of the most important issues in this field. The essence of assessment for vocational education and training is to select proper teaching, learning, and training models based on the designed frameworks and goals and to adjust the goals after assessing the level of achievement. Hence, the goals for teaching, learning, and assessing are intertwined [4].

An assessment strategy for school education is the foundation for improving the development and competitiveness of a country and is crucial in deciding the development and direction of young talents (for the purposes of this research, in order to reflect the qualification for the participation of the National Skills Competition, “young talents” means those who are under 21 and are capable of working). Hence, an appropriate assessment strategy is one of the main goals of capacity development [5–8]. In the past, many employees in rank-and-file positions were cultivated under the vocational training system in Taiwan. With the changes in society and upgrades to industry, the public has shown more attention to the reformation and quality of education in the hopes of improving the learning efficiency and achievement of young talents. In other words, basic education and training, the cultivation of professional knowledge, and capacity assessment for vocational education and training are crucial to the development of one’s skills and future career [9–11].

By participating in the Skills Competition (the collective term for the Regional Competition, Taiwan National Skills Competition, and the WorldSkills Competition in this research), young talents are encouraged to set up goals and to join vocational training. Solid and highly professional foundations in skills can be built during the training process. Further, the designs of a test project (the content and design which competitors shall follow during the Skills Competition) for the Skills Competition held regionally, domestically, and internationally have followed the trends in industry that are conducive to the career development of young people. The ultimate goal is to cultivate young talents with both professional knowledge and skills to devote to the development of the country. The National and Regional Skills Competitions seeks to establish correct and forward-looking skill values for young people in Taiwan and to encourage them to participate in vocational education and training.

### 1.2. Skills Competition

The Taiwan National Skills Competition was first held in 1968. With the booming economy in Taiwan at the time, the demand for the labor force was stronger than ever. In response to the demands of the labor market, the number of participating trades in the Skills Competition in Taiwan has grown from 14 trades in the beginning to 47 trades at present. This event is held once a year, and the participating competitors are nominated by vocational training centers, vocational schools, and industrial groups [10]. The participating trades are classified into six major categories: Social and Personal Services, Construction and Building Technology, Manufacturing and Engineering Technology, Transportation and Logistics, Information and Communication Technology, and Creative Arts and Fashion [11].

The purpose of the Skills Competition is to promote vocational training and education by providing an opportunity and space for all participating members to improve their skills and share their information/experiences. The qualifications to participate in the National Skills Competition are as follows: (1) The ages of the competitors must be below 21; and (2) competitors must be one of the top five competitors for each trade in the Regional Competition or one of the top three competitors of a related trade in the National High School Skills Competition [12]. The final goal of all competitors is to win the qualification to participate in the biennial international event of vocational skills at the

WorldSkills Competition. In brief, before winning the qualification to participate in the National Skills Competition and further the qualification to participate in the WorldSkills Competition, the competitors must win the Regional Competition as a threshold.

The purpose of this research is to discuss and analyze the training indicators of the Joinery Trade under the category of Construction and Building Technology in the Regional Skills Competition to establish training strategies and standards for this trade to improve the skill level of competitors so that they will have higher chances to be selected as champions to represent Taiwan in the WorldSkills Competition.

### Joinery

“Joinery” is a term used in the WorldSkills Competition, the National Skills Competition in Taiwan, and the Regional Skills Competition. The works made from the test project of Joinery include doors, windows, stairs, tables, and shelves. Generally speaking, the works made from Joinery contain delicate structures formed by joints and tenons of various types and are required to be processed by professional machines and hand tools. The producer/competitor must be the one to finish the work from drawings, interpretations of the test project, planning, cutting to making joints and tenons and assembling and installing the various components [13].

The training period may be as long as 3 to 5 years, so the competitors of the National Skills Competition need to be highly patient and stress-resistant. It is also challenging to find suitable competitors who meet the necessary qualifications [14]. In the early days, Joinery in Taiwan focused on the ability to use hand tools and recognize drawings and space. Under this approach, the competitors with good skills in hand processing were able to finish the test project in a very short period of time with a high precision level. However, the focus of the WorldSkills Competition shifted from hand processing to machine processing (it now mainly relies on machine processing and is supplemented by hand processing). This change not only improved the efficiency of processing but precipitated a reform for woodwork processing. For this reason, in response to changes in the regulations of the WorldSkills Competition, the trainers and competitors in Taiwan must have thorough strategies and assessment standards.

The test project of the Regional Skills Competition was a single-model type (Figure 1), and the competition time ranged from 5 to 6 h (depending on the judgment of the chief expert of the trade). In the past, the scoring criteria included a subjective score and an objective score. The subjective score ranged from 1 to 10, and the final score was taken from the average of the scores given by the three experts. However, in response to the trends adopted in the international competition field, since the 49th Regional Skills Competition held in 2019, the scoring criteria were changed to a judgment (subjective) score and a measurement (objective) score, with the judgment score ranging from 0 to 3. For competitors, the shrinking scoring range of judgment requires higher precision levels of detail for each criterion.

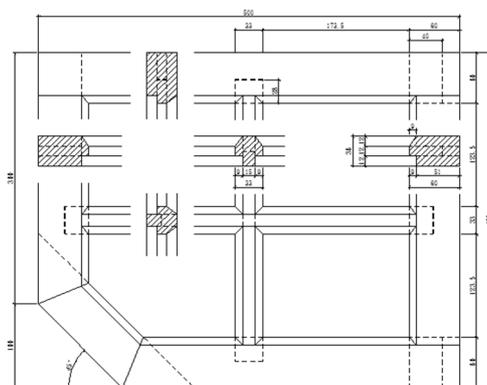


Figure 1. Single-model type test project of Joinery.

### 1.3. Motivation

Taiwan's Joinery champions won many medals in the WorldSkills Competition in its early days. From 1977 to 2019, the Joinery champions of Taiwan won six gold medals, six silver medals, one bronze medal, and seven medals of excellence. However, the performance of Taiwan's Joinery champions faced challenges when this trade was removed from the list of national teams representing Taiwan to attend the 37th WorldSkills Competition held in 2003 due to budget cuts initiated by the Taiwan government. At the time, the inheritance of this skill and related experiences in Taiwan was interrupted, causing many years of underperformance after the government put Joinery back onto the list of national teams in the 38th WorldSkills Competition. Furthermore, with the significant improvement of skills in emerging countries, the competition of this trade in the international event has become more and more intense. To improve and maintain Taiwan's performance in the WorldSkills Competition in this trade, it is important to study and discuss the conditions of the competitors at an early stage to find suitable training standards and indicators, especially the Regional Competition, the fundamental threshold. The research was performed to provide a scientific, simple, and objective method for training institutions and schools to follow during their training processes.

### 1.4. Research Questions

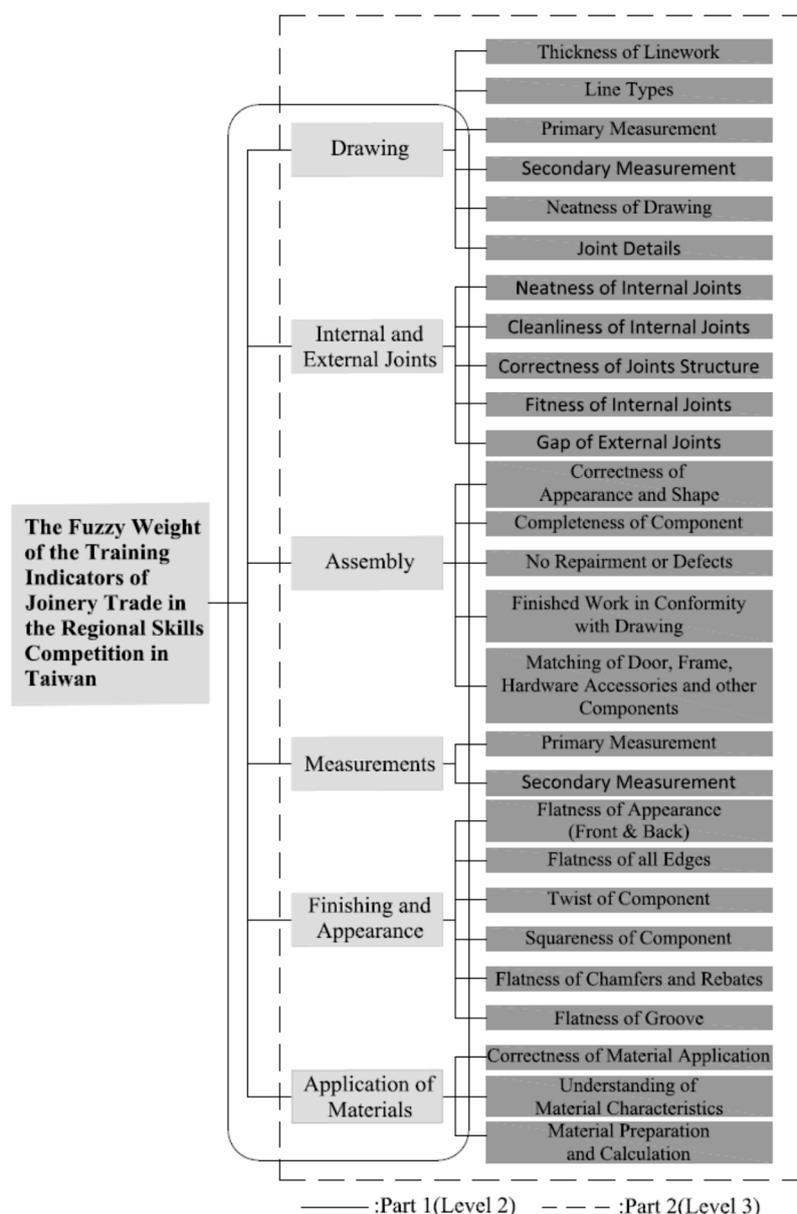
This research attempts to address the above-mentioned drawbacks and, specifically, answer the following two main questions:

- (a) Are the six major indicators and the 27 sub-indicators suitable to be the assessing standard?
- (b) Among the six major indicators, which one of them is the most important? Additionally, among the 27 sub-indicators, which one of them is the most important?

Therefore, the purpose of this research is to find in this paper. The study is organized into five sections. For the remainder of the paper, Section 2 presents the materials and methods adopted by the research, including the data collection process and analysis. Section 3 discusses the results. Section 4 is about the discussion and implications, and Section 5 is the conclusion.

## 2. Materials and Methods

With the technical description of the 45th WorldSkills Competition as the foundation, the present research aims to discuss the criteria of the training indicators for Joinery at the Regional Skills Competition [13]. The technical description is the guidance manual that announced before the event for all participants to follow, and it includes information such as scoring standards, timetable, and materials and equipment. When each WorldSkills Competition is over, the representative experts among all participating members discuss and adjust the content of the technical description. Therefore, the regulations listed in the technical description reflect the consensus of the experts from all participating countries, just like the decision-making model of the expert meeting method. Furthermore, this research compares the technical description of the 45th WorldSkills Competition with the standards specification, the scoring criterion listed in the technical description of the 44th WorldSkills Competition, ultimately yielding the six aforementioned training indicators for Joinery (Figure 2): drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials. A total of 27 sub-indicators were developed based on these six major indicators.



**Figure 2.** Structure of the hierarchy of the fuzzy weight of the training indicators for Joinery in the Regional Skills Competition in Taiwan.

In order to ensure the appropriateness of the developed training indicators, this research collected and analyzed the opinions from woodworking experts through the fuzzy Delphi method (FDM). Since it is difficult to use the traditional analytic hierarchy process (AHP) approach to determine the weight value on a fuzzy matrix due to its lower precision level, fuzzy AHP, an approach combining traditional AHP and fuzzy theory, was adopted to seek the weight value of each indicator [15]. In this process, a fuzzy number was used to solve the fuzziness created during the process of criterion assessment and judgment. The relative level of importance was expressed in a trapezoidal fuzzy number to form a fuzzy matrix. Further, the fuzzy weight in the fuzzy matrix was calculated through the geometric mean, obtaining the corresponding fuzzy weight to express the allocation of the weight of the training indicators. In this way, the criterion of the training indicators and weight system was established based on the level of weight. It is hoped that this formula and weight system derived from fuzzy theory will be used as assessment references and criteria for training institutions and schools.

The data collection of this research consisted of two stages. In the first stage, FDM was adopted to collect the opinions of woodworking-related experts through a survey (FDM survey). After determining the consensus of the participating experts, representative training indicators were retained or removed based on their level of suitability. In the second stage, a survey based on fuzzy AHP (fuzzy AHP survey) was developed and delivered to the participants. Then, defuzzification was performed to seek the relative weight value of each criterion to decide the sequence of the weight value and the importance level of each indicator.

### 2.1. Fuzzy Delphi Method

In 1948, the Rand Corporation developed a decision analysis method called the Delphi method or Delphi technique. This method (a kind of expert investigation method) depends on professional knowledge and the experience and judgment of participants. Since experts of certain fields are equipped with abundant knowledge, practical experience, and subjective judgments, the answers obtained from them are practical and effective. Furthermore, using this method, the answers are organized in a scientific way, allowing a consensus to be reached for complicated issues. Participants are allowed to fully express their opinions, and all of the opinions are treated equally [16–19].

FDM is a method that combines the Delphi method and fuzzy theory. FDM mainly focuses on uncertainties and linguistic variables. The triangular fuzzy number (of fuzzy theory) is adopted to improve the drawbacks of the traditional Delphi method, which may only provide 50% of the required information. In order to determine the suitability of indicators, this research integrates and organizes the opinions of experts under the FDM by establishing a fuzzy preference relation and seeking the best preference relation for the group based on the preferences of each participating expert. By adopting FDM, the time spent on data collection is reduced, and the membership function is either 0 or 1. The logistic analysis of the two values allows us to neglect the other 50% of important information. In comparison with the Delphi method, FDM is less complicated and less time-consuming [20]. The advantages of FDM include the following: The rounds used in FDM are many fewer than those used in the Delphi method; moreover, FDM precisely expresses the implication of a linguistic structure. In general, FDM is a simple and systematic method to solve multi-attribute issues. In addition, the reliability and validity of a fuzzy linguistic scale are higher than that of a traditional scale [16,21–28]. The drawback of the Delphi method's group decision-making model, however, needs to be addressed. FDM was used to set up the level of fuzzy preferences based on the professional opinions of the participating experts to obtain consistent preferences.

#### 2.1.1. Development and Delivery of FDM Survey

FDM survey was designed and developed by the authors, and we referred to a survey with similar forms of other literature to build the structure. We compared the technical description of Joinery of the 45th WorldSkills Competition [13] and the standards specification of the 44th WorldSkills Competition to form the major content of the survey: the six indicators and the 27 sub-indicators.

After introducing the background information and the content of the survey, it requested the participants to fill in their personal information (such as age, affiliation and years of experience), to choose the suitability of the six major indicators and to select the suitability of the 27 sub-indicators based on their opinions. In addition, all participants were welcome to write down their ideas and opinions about each item.

The number of samples required by FDM is 10 to 15 participants; if more than 10, the reliability would increase. There were 14 participants who accept the survey, and they are experts in the woodworking field from the UK, Malaysia, China, and Taiwan. Eight of the participants are instructors of the woodworking field in colleges, and they are experienced in teaching and research in the field; six of the participants are experienced in practical teaching and training in the woodworking field, and they are experts, instructors, and champions who are related to the Skills Competition.

2.1.2. The Steps for Performing FDM

1. Collecting opinions from decision-making groups, including (1) forming the preliminary hierarchical structure by comparing the Joinery Technical Description of the 45th WorldSkills Competition with the Joinery Standards Specification of the 44th WorldSkills Competition, and (2) preparing the content of the survey.
2. Selecting a suitable preference scale: Obtaining the level of suitability for each training indicator from the participants.
3. Setting up the triangular fuzzy number: Converting the linguistic variable to a triangular fuzzy number to integrate the opinions of participating experts. The algorithms for the triangular fuzzy number, including fuzzy addition (Formula (1)), fuzzy subtraction (Formula (2)), fuzzy multiplication (Formula (3)), and fuzzy division (Formula (4)). The triangular fuzzy number remained a triangular fuzzy number after applying the algorithm [29]. In brief, the level of suitability for each level of structure in this research was calculated based on the mean of the triangular fuzzy number (Formula (5)).

Assume that  $u_{A1}^{\sim}(x) = (l_1, m_1, u_1)$ ;  $u_{A2}^{\sim}(x) = (l_2, m_2, u_2)$ .  
 Fuzzy Addition :  $u_{A1}^{\sim} \oplus u_{A2}^{\sim} = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$ . (1)

Fuzzy Subtraction :  $u_{A1}^{\sim} \ominus u_{A2}^{\sim} = (l_1, m_1, u_1) \ominus (l_2, m_2, u_2) = (l_1 - l_2, m_1 - m_2, u_1 - u_2)$ . (2)

Fuzzy Multiplication :  $u_{A1}^{\sim} \otimes u_{A2}^{\sim} = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$ . (3)

Fuzzy Division :  $u_{A1}^{\sim} \oslash u_{A2}^{\sim} = (l_1, m_1, u_1) \oslash (l_2, m_2, u_2) = (l_1 \div l_2, m_1 \div m_2, u_1 \div u_2)$ . (4)

Assume that the mean of the triangular fuzzy number is  $A_{ij}^{\sim} = (l_{ij}, m_{ij}, u_{ij})$ ,  $j = 1, 2, 3, \dots, n$ .  
 $l_{ij} = \frac{l_{ij} + l_{ij} + \dots + l_{ij}}{N}$ ,  $i = 1, 2, 3, \dots, n$ :  $l_{ij}$  is the mean of the triangular fuzzy number at the left end;  $N$  is the total number of samples;  
 $m_{ij} = \frac{m_{ij} + m_{ij} + \dots + m_{ij}}{N}$ ,  $i = 1, 2, 3, \dots, n$ :  $m_{ij}$  is the mean of the triangular fuzzy number in the middle;  $N$  is the total number of samples;  
 $u_{ij} = \frac{u_{ij} + u_{ij} + \dots + u_{ij}}{N}$ ,  $i = 1, 2, 3, \dots, n$ :  $u_{ij}$  is the mean of the triangular fuzzy number at the right end;  $N$  is the total number of samples. (5)

4. Defuzzification: (1) Applying the center of gravity method to perform defuzzification of the fuzzy weight  $A_{ij}^{\sim} = (l_{ij}, m_{ij}, u_{ij})$  for each assessing subject (Formula (6)) and (2) converting it into a specific figure to sequence the fuzzy number.

$$DF = \frac{(l_{ij} + m_{ij} + u_{ij})}{3} \tag{6}$$

5. Retaining the representative training indicators: (1) Studying the total value of triangular fuzzy numbers for each indicator, which represents the consensus of the participating experts towards the assessment scale for the indicators; and (2) using this research’s threshold set to decide whether to retain the indicator. If the weight value of a training indicator is greater than or equal to the threshold value, this indicator is retained as the training indicator of the Regional Skills Competition in Joinery; if the weight value of a training indicator is less than the threshold value, this indicator is removed.

To assess the suitability of the indicators, this research adopted a 5-point Likert-type linguistic scale: Very Suitable, Suitable, Acceptable, Unsuitable, and Very Unsuitable. Each of the 5 elements of the linguistic scale corresponded to 5 points, 4 points, 3 points, 2 points, and 1 point, and the linguistic variables of each scale were expressed as a triangular fuzzy number. Linguistic variables were the variables of the terms or phrases used in natural language, representing the level, function,

or features of certain data. Within the range of a linguistic scale, the number of linguistic variables was an odd number; the more linguistic variables that were present, the more detailed the scale was. In addition, fuzzy theory was further applied to convert the linguistic variables to fuzzy numbers, and the quantitative data are called fuzzy linguistic variables. The linguistic variable scale was expressed as a triangular fuzzy number. In this research, the  $r$  fuzzy number ranges from 1 to 0 (in the linguistic variables, from Very Suitable to Very Unsuitable);  $\alpha$ ,  $\beta$ , and  $\gamma$  represent the triangular fuzzy numbers of the variables for certain linguistic terms; 0.8, 0.9, and 1 are the linguistic values for Very Suitable; and 0.9 was the maximum degree of satisfaction. The tolerance range was from 0.8 to 1, as shown in Table 1.

**Table 1.** Definition of the scale of fuzzy numbers.

Linguistic Variable	Fuzzy Number			
	Maximum Degree of Satisfaction	Tolerance Range		
Very Suitable	0.9	0.8	1	
Suitable	0.7	0.6	0.8	
Acceptable	0.5	0.4	0.6	
Unsuitable	0.3	0.2	0.4	
Very Unsuitable	0.1	0	0.2	

## 2.2. Fuzzy AHP

Saaty [30] indicated that AHP can solve strategic issues using multiple criteria. AHP simplifies a complicated system, separating it into several groups and making it a simpler hierarchical structure. Each group is divided into several sub-groups. Then, opinions from the experts and decision-makers of all levels are collected. Due to the lower precision level of traditional AHP, fuzzy AHP, which combines fuzzy theory and AHP, is mainly used in uncertain conditions and for strategic issues that involve multiple criteria. In fuzzy AHP, a pairwise comparison assessment among factors is performed on a nominal scale. The five variables of the nominal scale are Extremely More Important, Very Strong More Important, Strongly More Important, Moderately More Important, and Equally Important, and their assessment values are 1, 3, 5, 7, and 9, respectively. The assessment values indicate the level of the relative weight that may be referenced by decision-makers when making decisions [31]. In addition, fuzzy theory was adopted to address the fuzziness created during the process of criterion assessment and judgment. In this research, the relative level of importance was expressed as a trapezoidal fuzzy number to form the fuzzy matrix. Further, the fuzzy weight in the fuzzy matrix was calculated through the geometric means, thereby obtaining the corresponding fuzzy weight to express the allocation of the weight of the training indicators. By obtaining the weight values, the sequence of the elements in each hierarchy was settled, and consistent ideas were converted into a fuzzy matrix [15]. The criteria for the training indicators and weight system were then established based on the level of weight. The formulas and weight systems derived from fuzzy theory could be used as assessment references and criteria for training institutions and schools.

We address the defects of a pairwise comparison matrix in traditional AHP (such as being subjective, lacking accuracy, and fuzziness), using the concept of triangular fuzzy numbers. Since the participants may be subjective or uncertain during the surveying process, fuzzy AHP was adopted to express the possible consensus of all types of participants. The linguistic scales were converted into triangular fuzzy numbers, as shown in Table 2.

**Table 2.** The definition of scale for fuzzy numbers (by applying fuzzy AHP).

Scale	Linguistic Variables	Triangular Fuzzy Number	Triangular Fuzzy Number Reciprocal
1	Equally Important	(1,1,1)	(1,1,1)
3	Moderately More Important	(2,3,4)	(1/4,1/3,1/2)
5	Strongly More Important	(4,5,6)	(1/6,1/5,1/4)
7	Very Strong More Important	(7,8,9)	(1/8,1/7,1/6)
9	Extremely More Important	(8,9,10)	(1/10,1/9,1/8)

### 2.2.1. Development and Delivery of Fuzzy AHP Survey

A survey based on fuzzy AHP was designed and developed by the author (fuzzy AHP survey). The content and structure of the fuzzy AHP survey are on the basis of the aforementioned FDM survey.

After introducing the background information and the content of the survey, it requested the participants to fill in their personal information (such as age, affiliation and years of experience), to determine the relativity of importance of the six major indicators (cross-comparison of each one) and to select the relativity of importance of the 27 sub-indicators (cross-comparison of each one) based on their opinions. In addition, all participants were welcome to write down their ideas and opinions about each item.

The survey related to group-decision requires 5 to 15 participants. There were 15 participants who accept the fuzzy AHP survey, and they are experts in the woodworking field from Japan, Malaysia, Hong Kong, and Taiwan. Three of them are from industry, six are from governmental institutions, three are from academia, and three from other areas. The purpose of this survey is to seek the relative weight of training indicators of the Regional Skills Competition in Joinery.

### 2.2.2. The Steps for Performing Fuzzy AHP

1. Setting up a hierarchical structure for each criterion based on the training indicators retained through the FDM;
2. Designing the content of the fuzzy AHP survey: The structure of the survey was based on the pairwise comparison method using five linguistic variables—Extremely More Important, Very Strong More Important, Strongly More Important, Moderately More Important, and Equally Important. The participating experts decided the scale of the related criteria through their opinions. The relative level of importance among criteria was based on the subjective judgments of the participating experts, and the fuzziness introduced by these judgments was addressed by converting the linguistic variables into triangular fuzzy numbers, as shown in Table 2.
3. Establishing triangular fuzzy numbers for the training indicators of each level: (1) performing a statistical analysis on the survey conducted by all participating experts; (2) then, applying an algorithm by converting the linguistic variables. The formula is shown below as Formula (7).

$$\widetilde{A}_{ij}^E = (l_{ij}^E, m_{ij}^E, u_{ij}^E)$$

where  $l_{ij}^E = \text{Min}\{l_{ij}^T\} \forall T \in E$  is the minimum value on the left end,

and  $m_{ij}^E = \left\{m_{ij}^T\right\}^{\frac{1}{n}} \forall T \in E$  is the geometric mean of the median of all triangular Fuzzy Numbers;

$u_{ij}^E = \text{Max}\{u_{ij}^T\} \forall T \in E$  is the minimum value on the right end.

$\widetilde{A}_{ij}^E$ : the value obtained after multiple comparisons of the opinions of experts in relation to the  $i$ th assessing element and the  $j$ th assessing element;

$T$ : the  $T$ th expert.

(7)

- Setting up a fuzzy pairwise comparison matrix [30]: This involves placing the triangular fuzzy number into pairwise comparison matrix  $A = [a_{ij}]$  to form a fuzzy pairwise comparison matrix  $\tilde{A} = [\tilde{a}_{ij}]$ , which addresses the fuzziness created during the assessment process. In the pairwise comparison matrix A, the value at the bottom left corner indicates the reciprocal of the value at the upper right corner (Formula (8)).

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{21}} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix}$$

$$\tilde{A} = [\tilde{a}_{ij}]$$

$$\tilde{a}_{ij} = \begin{cases} (1, 1, 1) & \text{if } i = j \\ (a_{ijl}, a_{ijm}, a_{iju}) & \text{if } j > i \\ \left(\frac{1}{a_{iju}}, \frac{1}{a_{ijm}}, \frac{1}{a_{ijl}}\right) & \text{if } j < i \end{cases}$$
(8)

- Calculating the relative fuzzy weight value through normalization of the row average [28] to obtain the fuzzy weight value from the fuzzy pairwise comparison matrix. The formula is shown below as Formula (9).

$$W_i = \frac{(\prod_{j=1}^n a_{ij})^{\frac{1}{n}}}{\sum_{i=1}^n (\prod_{j=1}^n a_{ij})^{\frac{1}{n}}} \quad i, j = 1 \sim n$$

$a_{ij}$  : the Triangular Fuzzy Number located at row  $i$  and column  $j$  in the pairwise comparison matrix;

$W_i$  : the fuzzy weight of row  $i$ .

(9)

2 Steps :

Step 1 :  $Z_i = \left[\prod_{j=1}^n \tilde{a}_{ij}\right]^{\frac{1}{n}}, \forall i$

Step 2 :  $W_i = \frac{(\prod_{j=1}^n \tilde{a}_{ij})^{\frac{1}{n}}}{\sum_{i=1}^n (\prod_{j=1}^n \tilde{a}_{ij})^{\frac{1}{n}}} = Z_i \oplus (Z_1 \oplus \dots \oplus Z_n)^{-1}$ .

- Defuzzification: This research adopted the simple center of gravity method to calculate the geometric gravity of each fuzzy member's function. The calculated gravity was based on a specific figure of the fuzzy number. Assuming that  $A_{ij} = (l_{ij}, m_{ij}, u_{ij})$ , the formula for defuzzification can be obtained as Formula (10) below.

$$F_{ij} = \frac{(l_{ij}^E + m_{ij}^E + u_{ij}^E)}{3}$$
(10)

- Normalizing the triangular fuzzy number of each training indicator (Formula (11)): To make the result more rigorous, before defuzzification (to seek the final relative weight value), the triangular fuzzy number was normalized [32].

$$HW_i = \frac{F_{ij}}{\sum_{j=1}^n F_{ij}}$$
(11)

- Applying a hierarchical series and a sequence of training indicators: (1) Seek the weight value  $HW_i$  of dimension I in Level 1, the weight value  $HW_{ij}$  of criterion j in Level 2 under the i dimension in Level 1, and the weight value  $HW_{ijk}$  of sub-criterion k in Level 3 under dimension j of Level 2;

(2) seek the weight value  $HW_k$  (Formula (12)) of sub-criterion k in Level 3 under the target level. This research performed a level series; (3) after performing a hierarchical series, the absolute weight value of each sub-criterion against the overall assessment level was obtained; (4) lastly, sequence each sub-criterion to obtain the level of importance:

$$HW_k = HW_i \times HW_{ij} \times HW_{ijk}. \quad (12)$$

### 3. Results

The training indicators for the Regional Skills Competition in Joinery developed in this research were based on the Joinery Technical Description of the 45th WorldSkills Competition and the Joinery Standard Specification of the 44th WorldSkills Competition. In order to ensure the consistency of the indicators, this research adopted FDM to select indicators within the range and sequenced the relative weight values of the sub-indicators of each level through fuzzy AHP to determine their level of importance.

#### 3.1. Establishing a Hierarchical Structure for the Training Indicators for Joinery at the Regional Skills Competition

This research integrated and analyzed the content and answers obtained from an FDM-based survey, which we designed and delivered to 14 experts from the UK, Malaysia, China, and Taiwan to discuss the suitability of the training indicators. However, the participating experts held different opinions about the suitability of the fuzzy weight value of the Joinery indicators for the Regional Competition. In order to obtain objective and consistent answers, we converted the triangular fuzzy number of each training indicator to a single value to sequence the level of suitability. In Table 3, the highest weight value among the level two indicator was measurements, followed by internal and external joints. The indicator with the lowest weight value was the application of materials. The sequence of the weight values of the level 3 indicators is listed in Table 4.

**Table 3.** The sequence of Level 2 training indicators.

Level 2 Training Indicators	Indicator Weight (Center of Gravity Method)	Sequence
Drawings	0.81	4
Internal and External Joints	0.84	2
Assembly	0.83	3
Measurements	0.86	1
Finishing and Appearance	0.79	5
Application of Materials	0.71	6

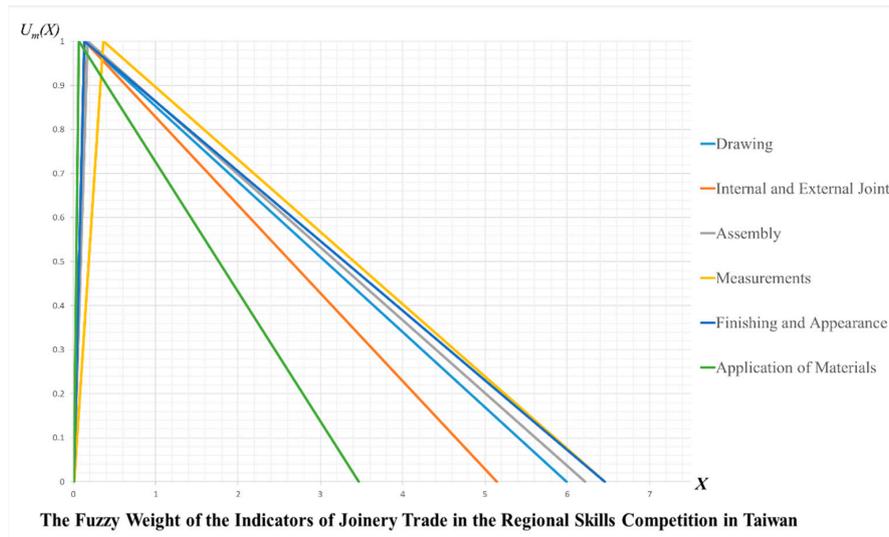
Our fuzzy Delphi method survey included an open opinion section that invited the participating experts to write down their opinions for each training indicator. After considering the advice and opinions of the participating experts, we designed the fuzzy AHP survey. The threshold set by this research was suitable, with a total weight value of 0.7. Therefore, any criterion whose total value was lower than 0.7 was removed. The results show that our training indicators for Joinery in the Regional Skills Competition were all higher than 0.7, as shown in Table 3, so all indicators were retained. The weight values of the sub-indicators for all training indicators (drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials) were above 0.7, as shown in Table 4. All sub-indicators were, therefore, preserved. As a result, there were six training indicators chosen for Joinery in the Regional Skills Competition: drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials. A total of 27 sub-indicators were developed from these six indicators.

**Table 4.** The sequence of Level 3 training indicators.

Level 2 Training Indicators	Level 3 Training Indicators	Indicator Weight (Center of Gravity Method)	Sequence
Drawings	Thickness of Linework	0.73	5
	Line Types	0.77	4
	Primary Measurements	0.87	1
	Secondary Measurements	0.84	2
	Neatness of Drawings	0.77	4
Internal and External Joints	Joint Details	0.81	3
	Neatness of Internal Joints	0.7	4
	Cleanliness of Internal Joints	0.74	2
	Correctness of Joint Structure	0.73	3
	Fitness of Internal Joints	0.81	1
Assembly	Gap of External Joints	0.81	1
	Correctness of Appearance and Shape	0.84	1
	Completeness of Components	0.77	3
	No Repairs or Defects	0.7	4
	Finished Work in Conformity with the drawings	0.8	2
Measurements	Fitness of Door, Frame, Hardware Accessories, and Other Components	0.8	2
	Primary measurement	0.89	1
Finishing and Appearance	Secondary measurement	0.8	2
	Flatness of Appearance (Front and Back)	0.79	1
	Flatness of all Edges	0.79	1
	Twist of Components	0.76	3
	Squareness of Components	0.77	2
	Flatness of Chamfers and Rebates	0.71	4
Application of Materials	Flatness of Groove	0.7	5
	Correctness of Material Application	0.87	1
	Understanding of Material Characteristics	0.7	3
	Material Preparation and Calculation	0.8	2

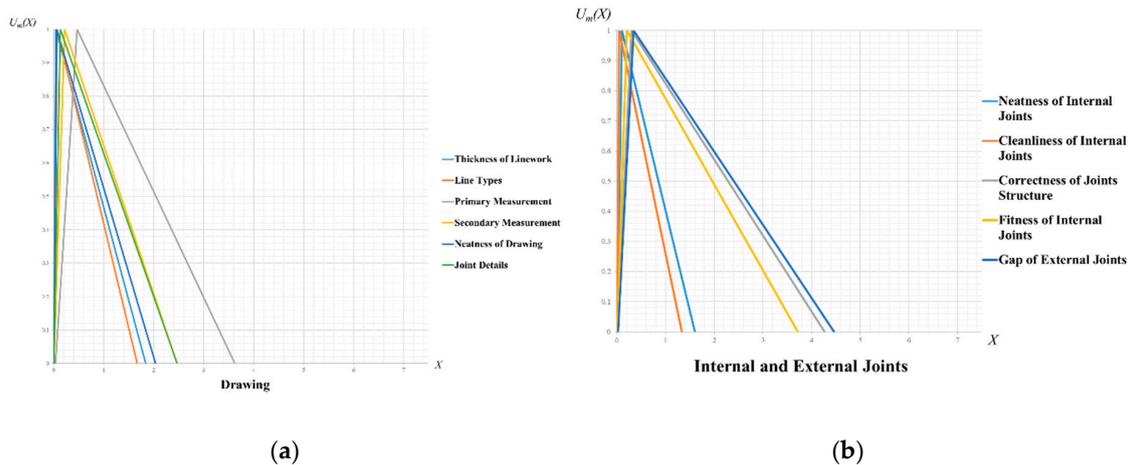
### 3.2. Analysis of the Fuzzy Weight Value for The Training Indicators of Joinery in the Regional Competition

Each participating expert held different ideas about the importance of each factor. In order to avoid deviations during the analysis process, we combined the content of the survey with the triangular fuzzy number and then performed defuzzification. The result shows that the fuzzy weight of measurements was the highest among all the training indicators for Joinery in the Regional Skills Competition, followed by finishing and appearance and assembly, as listed in Figure 3. This indicates that trainers or training instructors must set higher requirements for measurements of the project during the training process. In addition, during the scoring process, the scores of the measurements were objective scores. In the competition, all the points for each criterion are lost if the results show a slight deviation from the required measurements (smaller or bigger). Therefore, each competitor must pay great attention to the measurements of the parts that are under a high scoring weight. The scores for finishing and appearance and assembly are mainly based on subjective judgment. The scores ranged from 0 to 3, and the final score was the mean of the scores given by all experts. Hence, the competitors need to be very precise during the manufacturing process and avoid any unnecessary mistakes.

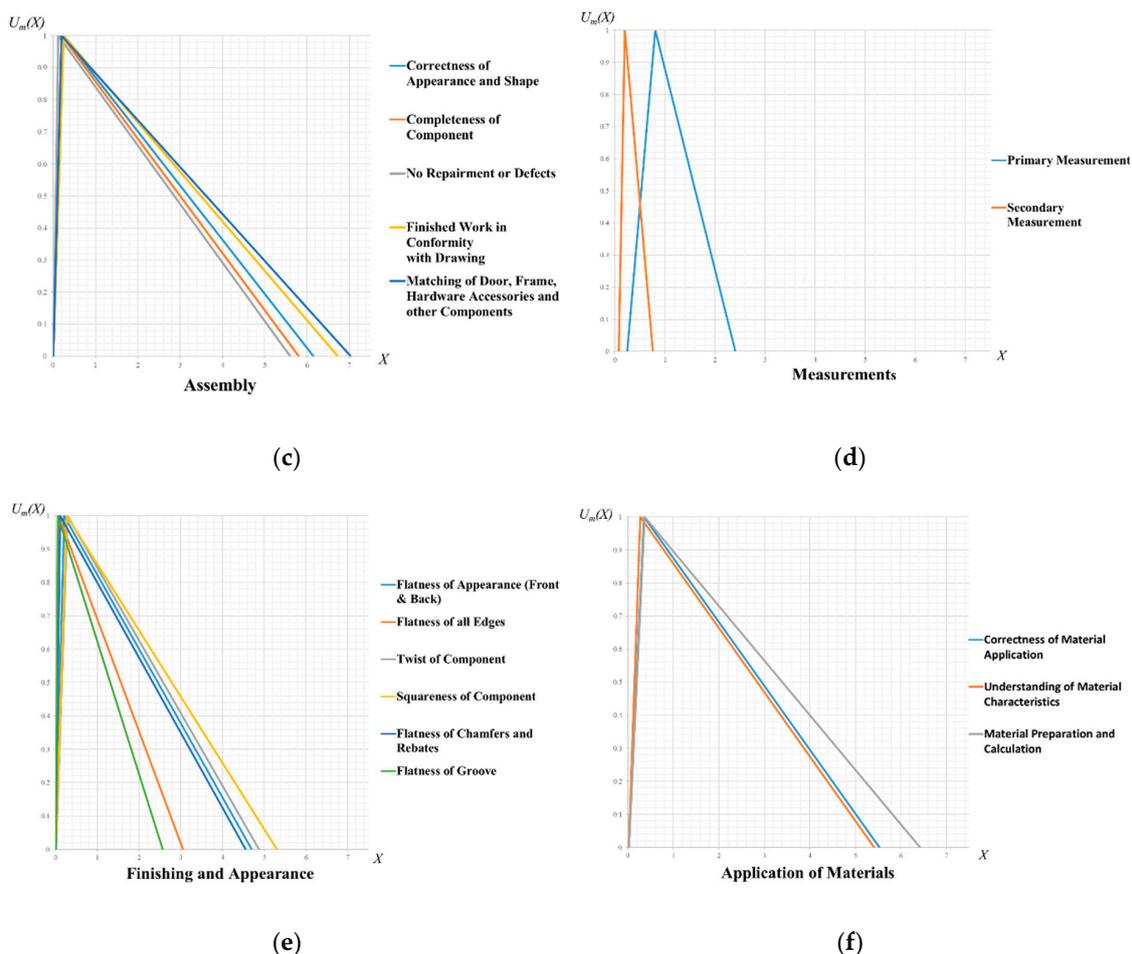


**Figure 3.** Triangular fuzzy number of Level 2 training indicators of Joinery in the Regional Skills Competition.

As shown in Figure 4, among the sub-indicators of drawings, the fuzzy weight of primary measurement is the highest (Figure 4a); among the sub-indicators of internal and external joints, the fuzzy weight of the gap of external joints is the highest (Figure 4b); among the sub-indicators of assembly, the fuzzy weights for the matching of door, frame, hardware accessories, and other components are the highest (Figure 4c); among the sub-indicators of measurements, the fuzzy weight of primary measurements is the highest (Figure 4d); among the sub-indicators of finishing and appearance, the fuzzy weight of the squareness of components is the highest (Figure 4e); among the sub-indicators for application of materials, the fuzzy weight of material preparation and calculation is the highest (Figure 4f). Therefore, during the training process, the competitors and trainers must prepare training strategies that focus on the indicators–sub-indicators with the highest fuzzy weights.



**Figure 4. Cont.**



**Figure 4.** Triangular fuzzy numbers for the sub-indicators of Joinery in the Regional Competition: (a) drawing; (b) internal and external joints; (c) assembly; (d) measurements; (e) finishing and appearance; (f) application of materials.

### 3.3. Hierarchical Series and Sequences of Importance for Each Training Indicator

We adopted fuzzy AHP to calculate the weight values of the indicators and sub-indicators. Our fuzzy-AHP-based survey was delivered to 15 experts in Joinery-related fields from Japan, Hong Kong, Taiwan, and Malaysia. The answers obtained were integrated and analyzed. After the fuzzy weight of each indicator/sub-indicator was obtained, a hierarchical series was performed to show the weight value and sequence of importance for each indicator/sub-indicator (Table 5). The relative weight value of measurement was the highest, followed by finishing and appearance, while the application of materials was the lowest. The results show that the Level 2 indicators (drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials) were all important. Therefore, competitors must pay the most attention to these indicators/sub-indicators, which have higher weight values than other indicators. As shown in Table 5, the importance of the measurement score (objective) is the most significant; thus, it is very important for the competitors to focus on precise measurements. On the other hand, for the judgment score (subjective), the importance of finishing and appearance was more important. The fineness of the finishing and appearance of a work decide whether that work qualifies as fine art. In general, during the training process, trainers can refer to the level of importance of indicators/sub-indicators to adjust their training content. Also, the results allowed competitors to be clear about the level of importance of each indicator/sub-indicator.

**Table 5.** Weight values of the training indicators and their sequence of importance.

Assessment for Training Indicators					
Level 2 Training Indicators	Weight Value	Sequence	Level 3 Training Indicators	Weight Value	Sequence
Drawings	17.6%	4	Thickness of Linework	2.2%	5
			Line Types	2.03%	6
			Primary Measurement	4.8%	1
			Secondary Measurement	3.13%	2
			Neatness of Drawings	2.5%	4
Internal and External Joints	15.2%	5	Joint Details	3.03%	3
			Neatness of Internal Joints	1.58%	4
			Cleanliness of Internal Joints	1.29%	5
			Correctness of Joint Structures	4.23%	2
			Fitness of Internal Joints	3.64%	3
Assembly	18.4%	3	Gap of External Joints	4.46%	1
			Correctness of Appearance and Shape	3.64%	3
			Completeness of Components	3.42%	4
			No Repairs or Defects	3.26%	5
			Finished Work in Conformity with drawings	3.97%	2
Measurements	19.6%	1	Fitness of Door, Frame, Hardware Accessories, and Other Components	4.12%	1
			Primary measurement	15.1%	1
Finishing and Appearance	18.9%	2	Secondary measurement	4.52%	2
			Flatness of Appearance (Front and Back)	3.57%	4
			Flatness of all Edges	2.28%	5
			Twist of Component	3.76%	2
			Squareness of Component	4.06%	1
			Flatness of Chamfers and Rebates	3.39%	3
Application of Materials	10.1%	6	Flatness of Grooves	1.91%	6
			Correctness of Material Application	3.26%	2
			Understanding of Material Characteristics	3.15%	3
Total	100%		Material Preparation and Calculations	3.76%	1
Total	100%		Total	100%	

#### 4. Suggestions and Discussion

By studying the assessment criteria for the training indicators of Joinery in the Regional Skills Competition through FDM and fuzzy AHP, we aim to upgrade the training quality and improve the training strategies and models of Joinery. In addition, holding a skills competition offers a means to attract and encourage young talents to join vocational education and training, which could be a future direction for their career development.

First, the six major indicators, drawings, internal and external joints, assembly, measurements, finishing and appearance, and application of materials, were developed by adopting FDM. The scoring criteria of the indicators are (1) for drawings, the competitor needs to follow the instructions in the test project and draw a technical diagram that is in a 1-to-1 scale compared to the finished work; (2) for internal and external joints, the measurements (including the length of tenons and the depth of the mortise) and location of the joints made by the competitor must be consistent with those of the test project; (3) for assembly, the finished work must match the drawing; (4) measurement includes primary measurements and secondary measurements; for primary measurements, the competitor wins a 100% score for the item if the tolerance between the test project and the final work is within 1 mm; a tolerance within 1.1 to 2 mm yields a score of 50%, and a tolerance of over 2 mm yields 0%. For secondary measurement, if the tolerance is within 1 mm, the competitor wins a 100% score for the item, while a tolerance over 1 mm yields a 0% score. (5) In finishing and appearance, the focuses are the flatness and correctness of appearance, grooves, chamfers, and rebates; (6) for the indicator of application of materials, the scoring benchmark relies upon whether the competitor requests different materials during the competition. Next, 27 sub-indicators were derived from the aforementioned six major indicators.

Fuzzy AHP was also adopted to analyze the relative weight. Based on the results of this research, vocational schools and training institutions could develop a strategic model that will be crucial in

cultivating talents in related fields. Meanwhile, these results could be used to review related courses in higher education. Besides the issues of a uni-directional educational system, an alternative method that could improve the flaws of traditional systems should also be discussed. We hoped that this method and content are broadly shared and applied. Furthermore, young talents must examine their own capacity to develop careers in related fields. By doing so, competitors of skills competitions will be able to apply their expertise in the future.

#### *4.1. Drawings*

According to the results of this research, the participating experts believed that drawings were the starting point for creating any work. If there are any mistakes in the drawings (e.g., incorrect measurements or joint structures), the assembly of the whole project is affected. Therefore, during the training process, competitors must establish correct drawings and graphics. They could start by focusing on the measurements, joint structures, and the neatness of the drawing.

#### *4.2. Internal and External Joint*

Internal and external joints are the foundation of woodworking and the basic requirement for woodworking techniques. They are also an important element in training competitors. The focuses for internal and external joints are the gap of the external joint, the correctness of the joint structure, and the fitness of internal joints. The training indicators developed in this study will enable competitors to understand different forms of joints, thereby making it easier to select suitable joint structures when manufacturing furniture or joints in the future. On the other hand, trainers could also enhance the processing ability (with hand tools or machines) of competitors.

#### *4.3. Assembly*

Assembly is the procedure that is performed after the processing of each component is finished. To complete this procedure, competitors must be equipped with various types of knowledge and abilities, such as drawing recognition, knowledge about different types of glue, and how to assemble hardware accessories. Therefore, assembly is a comprehensive indicator/standard that is involved with a broad range of knowledge and abilities. For this reason, trainers could put emphasis on the indicators of fitness of the frame, door, and hardware accessories and finished work in conformity with drawings when developing training strategies in this area.

#### *4.4. Measurement*

The results show that the weight value of measurements was the highest among the six training indicators, which indicates that the participating experts thought that measurement is the most important factor. Therefore, precise measurements must be the main focus of the training process.

#### *4.5. Finishing and Appearance*

Finishing and appearance is an important factor before a work is painted. Although painting was not included in the skills competition in Joinery, the competitors needed to understand the features of sandpaper of all types to control the quality of the appearance of the project. The weight value of finishing and appearance was the second highest. Since finishing and appearance is the last procedure in the woodworking process, many competitors do not have enough time to finish this procedure during the competition as a result of poor time control, which influences the fineness of the project and the score in the relevant criteria. Therefore, the control of time and the processing procedure must be the focus of the training process. Based on the analyzed results, trainers could further enhance strategies for the squareness of components, twists of components, and flatness of chamfers and rebates.

#### 4.6. Application of Materials

The weight value for the application of materials was the lowest among the six training indicators. This indicator focuses on the processing methods for different materials, recognizing the flaws in materials, examining materials, and making a material list. Although the weight value for the application of materials is low for the skills competition, it is relatively important in the preparatory process before the competition. The flaws in materials influence the processing methods, and the correctness of the material list provided by the hosting organization of the competition influences the precision of processing. Therefore, during the training process, trainers must discuss the preparation, calculation, and application of materials with the competitors to avoid competitors requesting different materials during the competition, which will lead to deductions of marks due to miscalculations.

### 5. Conclusions

The aim of this research is to apply FDM and fuzzy AHP to discuss the assessment criteria of the training indicators of the Regional Skills Competition. We hope that these results will be applied to the training model for the competitors of the Regional Skills Competition. The purpose of holding the skills competition is to encourage and attract young people to join vocational education and training, which may be a foundation for their future development. A training strategy that can train skills for young talents and develop their paths for future careers would be very lucrative and beneficial. The conclusions of this research are as follows:

1. Generally speaking, every training indicator is important and inter-connected with every other indicator. Thus, to improve the efficiency of competitors' skills and their professional techniques, competitors must pursue precision and perfection in every detail and reduce any unnecessary mistakes.
2. The assessment criteria developed in this research could be provided to trainers and instructors who participate in the training of Joinery competitors to improve their training models and strategies. It is hoped that the results of this research will allow such trainers to quickly understand the trends in the development of Joinery competitions.
3. Vocational training and education are key elements in the Skills Competition. We hope that the assessment criteria developed in this research will attract more teachers and instructors in vocational high school to join the training of competitors to participate in the Skills Competition. With more young people in the Skills Competition, the higher competitiveness would encourage all competitors to improve their skill levels and knowledge in the field.
4. Limitation of the Research Since studies on Joinery in the Skills Competition are limited, especially those using fuzzy theory to discuss assessment criteria, these assessment criteria must be more deeply studied and verified. We hope that the assessment criteria derived in this research serve as a foundation for future studies.
5. Future Research Directions

Because the subjects who accepted our survey are experts from different countries, and the number of experts from each country is uneven, their positions and opinions may be divergent, even though they all belong to the decision-making group. Thus, future research may consider the relative importance of subjects in a survey. In addition, this research did not include the number of competitors who participate in training. This is also another issue for future studies to discuss.

**Author Contributions:** All the authors contributed to the conceptualization, formal analysis, investigation, methodology, writing of the original draft, and writing—review and editing. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Clayton, B.; Blom, K.; Meyers, D.; Bateman, A. *Assessing and Certifying Generic Skills: What is Happening in Vocational Education and Training*; NCVER: Adelaide, Australia, 2003.
2. Craddock, D.; Mathias, H. Assessment options in higher education. *Assess. Eval. High. Educ.* **2009**, *34*, 127–140. [[CrossRef](#)]
3. Halliday-Wynes, S.; Misko, J. *Assessment Issues in VET: Minimising the Level of Risk*; NCVER: Adelaide, Australia, 2012.
4. Mak, P. *Assessing for Learning: Building a Sustainable Commitment Across the Institution*; Stylus Publishing: Herndon, VA, USA, 2010.
5. Taras, M. Using assessment for learning and learning from assessment. *Assess. Eval. High. Educ.* **2002**, *27*, 501–510. [[CrossRef](#)]
6. Billett, S.; Choy, S.; Dymock, D.; Smith, R.; Henderson, A.; Tyler, M.; Kelly, A. *Towards More Effective Continuing Education and Training for Australian Workers*; NCVER: Adelaide, Australia, 2015.
7. Asada, S. Educational research on forests and wood: Achievements and prospects. *Mokuzai Gakkaishi* **2015**, *61*, 117–122. [[CrossRef](#)]
8. Ministry of Education of Taiwan. *Vocational Education Reconstruction Project—Cultivating Quality Talents*; Ministry of Education of Taiwan: Taipei, Taiwan, 2010.
9. Wang, Y.C. On the shoulders of giants—introduction of WSI and WorldSkills International. *Employ. Saf. Half Year Publ.* **2014**, *13*, 96–104.
10. Ministry of Labor of Taiwan. *808 Competitors Competed in the National Skills Competition*; Ministry of Labor of Taiwan: Taiwan Labor e-Quarterly 19: Taipei, Taiwan, 2014; pp. 9–11.
11. Ministry of Labor of Taiwan. *The Manual of the 47th Regional Competition (Central Region), National Skills Competition*; Ministry of Labor of Taiwan, TCNR, Ministry of Labor: Taichung, Taiwan, 2017.
12. Chou, P.; Huang, Y.N. A study on the skill movement learning process for contestants in the National Skills Competition polymechanics/automation category. *J. Lib. Arts Soc. Sci. Chienkuo Technol. Univ.* **2015**, *34*, 15–32.
13. WorldSkills International Association. *Construction and Building Technology: Technical Description Joinery*; WorldSkills International Association: Amsterdam, The Netherlands, 2019; pp. 5–10.
14. Murry, T.J.; Pipino, L.L.; Van-Gigch, J.P. A pilot-study of fuzzy set modification of delphi. *Hum. Syst. Manag.* **1985**, *5*, 76–80. [[CrossRef](#)]
15. Chen, W.S. A Study of Visual Image Evaluation on Interior Wood Flooring Colors and Figures. Ph.D. Thesis, National Chiayi University, Chiayi, Taiwan, 2014; pp. 21–22.
16. Tsai, L.H. A Study on Construction of Meta-evaluation Standards and the Weight System of Teacher Evaluation in Elementary Schools. Ph.D. Thesis, National Taipei University of Education, Taipei, Taiwan, 2011; pp. 9–11, 122–129.
17. Chang, Y.H. Application of Fuzzy Theory in Judging Criteria of Science Fairs. Master's Thesis, National Taipei University of Education, Taipei, Taiwan, 2010; pp. 1–3, 7–11, 84–85.
18. Lin, Y.H. The Algorithm of Fuzzy Linguistic Numbers and Its Comparison of Scoring. *J. Natl. Taichung Univ. Educ.* **2003**, *17*, 279–304.
19. Wu, J.Z. Fuzzy Theory Applied in Site Selection of Thermal Power Plant. Master's Thesis, National Taipei University of Technology, Taipei, Taiwan, 2001; pp. 61–62, 64–69.
20. Chen, Z.H. Indexes of Competitive Power and Core Competence in Selecting Asia-Pacific Ports. *J. Chin. Inst. Transp.* **2001**, *13*, 1–25.
21. Jeng, T.B. Fuzzy Assessment Model for Maturity of Software Organization in Improving its Staff's Capability. Master's Thesis, National Taiwan University of Science and Technology, Taipei, Taiwan, 2001; pp. 1, 84.
22. Ishikawa, A.; Amagasa, T.; Tamizawa, G.; Totsuta, R.; Mieno, H. The max-mindelpi method and fuzzy delphi method via fuzzy integration. *Fuzzy Sets Syst.* **1993**, *55*, 241–253. [[CrossRef](#)]
23. Chen, S.J.; Hwang, C.L. *Fuzzy Multiple Attribute Decision Making—Methods and Applications*; Springer: Berlin, German, 1992.
24. Buckley, J.J. Fuzzy hierarchical analysis. *Fuzzy Sets Syst.* **1985**, *17*, 233–247. [[CrossRef](#)]
25. Linstone, H.A.; Turoff, M. *The Delphi Method: Techniques and Applications*; Addison-Wesley: Boston, MA, USA, 1975.

26. Huang, J.W. Identifying the Emerging Issues of National Forest Management in Taiwan. Master's Thesis, National Taiwan University, Taipei, Taiwan, 1995.
27. Wang, W.C. A Study on the Relationships between the Training Status of Taiwan Woodworking Contestants and the Learning Effectiveness of ADDIE Training Model. Master's Thesis, National Chiayi University, Chiayi, Taiwan, 2018; pp. 25–28.
28. Kaufmann, A.; Gupta, M.M. *Fuzzy Mathematical Models in Engineering and Management Science*; Elsevier Science: New York, NY, USA, 1988.
29. Saaty, T.L. *Analytic Hierarchy Process*; McGraw Hill: New York, NY, USA, 1980.
30. Duam, J.Y.; Tseng, K.F. The feature and application of AHP (I). *J. Chin. Stat. Assoc.* **1989**, *27*, 5–22.
31. Saaty, T.L.; Vargas, L.G. *Models, Methods, Concepts and Applications of the Analytic Hierarchy Process*; Springer: Boston, MA, USA, 2012.
32. Chang, P.T.; Lee, E.S. The Estimation of Normalized Fuzzy Weights. *Comput. Math Appl.* **1995**, *29*, 21–24. [[CrossRef](#)]



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