The Establishment of Supported Decision-making Model for Evaluation Teaches Professional Development Effects Based on Fuzzy Theory

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***Abstract*—A country's competitiveness depends on the performance of its national education. Meanwhile, the effects of national education rely on the professional aptitude of teachers. Facing the current knowledge economy, all countries are trying to use quality education to develop highly competitive citizens through educational reform. Therefore, inspiring self-awareness of teachers through internal and external power and further enhancing the profession both spontaneously and continuously is the only way to achieve quality education. This study adopts the group decision technique of the (Delphi method) to identify the following four review factors: course design and teaching, class operation and guidance, professional research and educational development, and professional dedication and attitude, as well as relevant content through a questionnaire survey, analysis, and construction. Furthermore, the quantification function of the fuzzy logic theory is applied to establish a scientific and highly objective "supported decision-making model for evaluating the professional development effects of teachers". In addition to providing evaluation for teaching self-assessment and the overall educational effects of the educational unit, our findings could be used as references for education and administrative departments to evaluate educational results.**

***Index Terms*—teacher's professional development, Delphi method, fuzzy logic theory, evaluation model**

I. Introduction

Education is a fundamental task crucial for generations to come, and schools are the places responsible for developing students' core competence. Educational performance has a bearing on a country's future competitiveness. Therefore, establishing a system with students as the subjects and teachers as the core is an urgent issue. The major purpose of all the major advanced countries in implementing teachers' professional development evaluation is to urge the continuous development of teachers' specialties and provide assistance to improve such specialties. Through an evaluation system, quality teachers may earn the recognition they deserve, while teachers who need improvement can be made aware of deficiencies, either actively or passively, through definite indicator verification. This is one of the motivations for this research. Psychologist "Abraham Maslow" emphasizes that demand is the origin of human value orientation and the inner motivation of acts [1]. The teachers' profession examination system and the reward and punishment may not only urge the improvement of the teacher profession, but also allow teachers to achieve satisfaction appropriate to the high level demand of humans. This is the second motivation for this research. To establish a definite and feasible profession development evaluation model for the self-assessment of teachers and mutual evaluation among peers to perceive personal professional improvement is the third research motivation.

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II. Literature Study

A. The Meaning and Purpose of Teaching Profession Development Evaluation

Stufflebeam indicated that "Educational evaluation is to improve rather to prove" [2]. Wen-Shih Cheng, Chih-Hsien Chen defined teaching evaluation as: "a successive journey of value judgment on teachers' performance and professional improvement" [3]. Meanwhile, Huan-Min Lin studied the purpose of teaching evaluation from the perspectives of teaching evaluation implemented by different countries. In addition to including performance assessment and handling incompetent teachers through evaluation purposes, the professional improvement of teachers is also the major purpose of evaluation [4]. Researchers arrange the differences of evaluation purposes in various countries via relevant literatures as shown in Table I, while the evaluation indicators of elementary and junior high schools in different countries are shown in Table II.

TABLE I. The Comparison of Teacher Evaluation Purposes of Different Countries

Evaluation Purposes	Country
Professional improvement	US, Canada, Australia, Austria, England, Germany, Belgium, Russia, France, Singapore, Japan, China, Taiwan
Performance assessment	US, Japan, Austria, Germany, Belgium, Russia, Singapore, China
Handling incompetent teachers	US, Austria, Germany, Belgium, Singapore, China

Source: [4], [5]; arranged by researcher

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TABLE II. THE COMPARISON OF TEACHER EVALUATION INDICATORS OF ELEMENTARY AND JUNIOR HIGH SCHOOLS IN DIFFERENT COUNTRIES

Country	Evaluation indicator→ evaluation dimensions
US	(1)Education (2)Proof of student achievement (3)Management/organization (4) Learning atmosphere (5) Professional degree
England	(1)Educational profession efficacy (2)Student discipline, inspiration, and guidance (3) Organizational performance (4) Proper use of educational resources (5) Expectations for reformation and promotion of reformation sources
France	(1)Exercise social responsibilities (2)Be familiar with mother language (3) Be proficient in professional knowledge and quality teaching ability (4)Class management and ability to teach students in accordance with their aptitude (5) Ability of self-study, advance study, and innovation
Australia	(1)The content of teaching and teaching instructions (2)Teaching activities (3) Student learning evaluation and score report (4)School and community interaction (5)Professional requirements
Japan	(1)Intention (2) Ability (3) Performance
Singapore	(1)Core competence (2)Knowledge development (3) Mind winning (4)Cooperation with others
China	(1)Politics through performance (2) Cultural profession knowledge (3)Teaching ability (4) Work performance (5)Duty performance status
Taiwan	(1)Course design and teaching (2)Class management and guidance (3) Research development and advance study (4) Professional dedication spirit and attitude

Source: [6]-[10]; arranged by the researchers

B. Delphi Method

The "Delphi method" was developed by the "Rand Corporation" in 1948. The Delphi method is considered an expert opinion method, which is a forecast method that uses intuitive judgment, as well as a structured group communication process. With a series of systematic and purposive questions, a group of experts and scholars in relevant fields were invited to fully express their opinions and views about what each person valued. After several rounds of circular questions with repeated feedback, deviating opinions among all experts are minimized to seek the group consensus on complicated issues.

C. The Application of Fuzzy Logic Theory

Fuzzy theory was proposed by Zadeh of "U.C. Berkeley" in 1965. Fuzzy theory makes approximate quantification aimed at the subjective idea of humans based on general information. It is a quite rigorous theory that actively admits many confuse conditions in daily life and tries to simplify complications via strict discussion and analysis through a mathematic model. It is one of the best methods for solving many issues with a subjective consciousness and indefinite boundary [11]. Since fuzzy logic theory can be used to handle indefinite events, e.g., the gradually extensive application of the unclear meanings of adjectives that are difficult to measure could be a tool for conversion from qualification to quantification. The fuzzy logic theory construction can be divided into continuous output and non-continuous output based on different presentations of quantification output. However, it is indifferent in practical application. Since fuzzy logic may accept uncertain and ambiguous information and differentiates from traditional definite logic between 0 and 1, fuzzy logic theory is very appropriate for handling ambiguous, non-specific, not easily quantified, and highly complicated issues [12].

Sung-Lin Hsueh, Sun Yue, and Min-Ren Yan found the following in their study: Fuzzy logic theory entails the calculation of ambiguous semantics of humans. In the quantification procedure of fuzzy logic, the fuzzy sets, a membership function, and the quantified interval values of each criterion must first be constructed. After the fuzzy logic inference system (FLIS) is constructed, the FLIS exhibits the functions of inference and an algorithm. The quantitative evaluation algorithm of the FLIS can be separated into four procedures: (1) an input value, which can be quantified values or ambiguous semantics of different units; (2) a fuzzifier; (3) rule-based inferences to the defuzzifier; and (4) output value quantification. The FLIS is a scientific artificial algorithm that can accept different units, scales, and non-quantified and unclear semantics. Therefore, this type of algorithm cannot be replaced by normal mathematical equations. Fuzzy logic theory is a methodology, first proposed by Zadeh in 1965, that is widely applied in various domains today. For example, it has been applied in the following domains: corporate sustainable performance assessment, groundwater contamination estimation, hydrothermal process assessment, habitat ecological integrity and environmental impact assessment, renewable energy system assessment, and agricultural soil dynamic quality index assessment. Comparison between the difference between traditional logic and fuzzy logic (see Table III) [13]

TABLE III. COMPARISON BETWEEN THE DIFFERENCE BETWEEN TRADITIONAL LOGIC AND FUZZY LOGIC

The difference	Traditional logic	Fuzzy logic
Differences in collections	(0, 1) composed of two elements	0-1 consists of infinite continuous elements
Function difference	Characteristic Function	Membership function
Quantitative scale	Same unit of measure	Can handle many different units of measurement at the same time
Data differences	The presentation of the data is unambiguous, Such as: 0 or 1; positive or negative value	The presentation of data is a continuity of multiple representations, such as: (a). Very good, good, medium, bad, very bad (b). Very tall, tall, medium build, low, very low
Information differences	Must be the correct value	Acceptable uncertainty, vague human language

Source: [13]

III. Research Design and Implementation

A. Study of Preliminary Review Factor

Regarding the teacher development evaluation methods, purposes, and relevant evaluation of various countries and Taiwan mentioned above, the researcher has preliminarily summarized the factors affecting teaching professional development effects from four general dimensions: course design and teaching, class operation and guidance, professional research and educational development, and professional dedication and attitude, with 21 potential factors.

B. The Identification of Evaluation Factors

The research is assisted by ten scholars and experts with more than 15 years of experience, including an educational administrative officer, a professor of an educational department of a university, and principals and teachers of tertiary schools under high school. After undergoing opinions' revision and the integration of Delphi method research procedures, one expert interview, two Delphi method questionnaire survey for four months, the four dimensions, and relevant content were consistently reached by experts to identify the important factors of teaching professional development effects and the fuzzy logic model (see Table IV).

TABLE IV. Evaluation Factors and Relevant Content as Required by the Research

Research dimension	Content
Course design and teaching	(1)Course design (2)Teaching strategy (3) Effective teaching (4)Diversified evaluation
Class management and guidance	(1)Class rules, (2)Teacher and student interaction (3) Parents and teacher cooperation (4)Knowledge guidance
Professional research and educational development	(1)Teaching research (2) Innovative education,(3)Advance study (4)Teaching reflection
Professional dedication spirit and attitude	(1)Campus ethics (2) Professional attitude (3)Peer relationship

IV. Research Results and Discussion

A. Introduction to Establishing the Fuzzy Logic Evaluation Model

This research consists of a total of four evaluation factors, and each evaluation factor has evaluation semantics in three scales, i.e., course design and teaching (very good, average, not good); class management and guidance (very good, average, not good), professional research and educational development (good, average, bad); and professional dedication and attitude (very good, average, not good). Since every factor has three evaluation conditions, this study thus has a total of 3*3*3*3 = 81 evaluation conditions among four evaluation factors. Each evaluation condition is converted to quantitative output via fuzzy system. Meanwhile, the research adopts function attributed to triangle and trapezoid, as well as a continuous output model to establish the fuzzy logic evaluation model.

The Establishment of Functions Attributed to Evaluation Factors

The fuzzy semantics of course design and teaching are (very good, average, and not good), and the fuzzy quantification scale is defined as 0-10. The higher the quantification value, the more diversified and better the course design and teaching methods are, instead of a single and unchanging teaching model. (see Fig. 1).

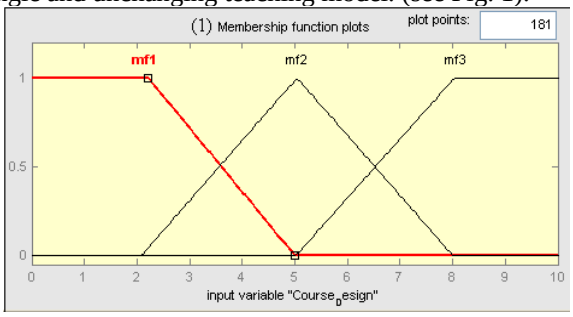

Figure 1. The relationship of function definition for course design and teaching

The fuzzy semantics of class management guidance are (very good, average, and not good), and the fuzzy quantification scale is defined as 0-15 hours, which refers to the fixed time every week spent on class management and guidance as appropriate. The average is 7-8 hours per week, and the more time scheduled, the better. (see Fig. 2).

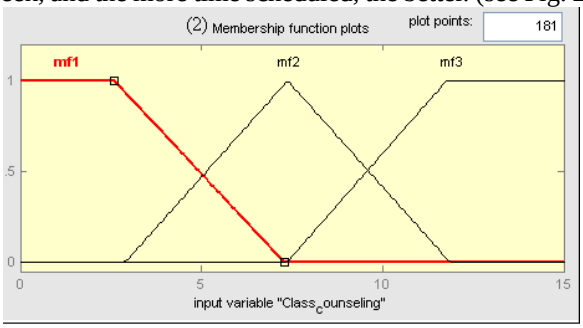

Figure 2. The relationship of function definition for class management and guidance

The fuzzy semantics of professional research and educational development are (good, average, and bad), and the fuzzy quantification scale is defined as 0-6. Among them, a higher quantification value means better professional research, but is the scale goes up to six items because education work is the top consideration of teachers. Meanwhile, (see Fig. 3).

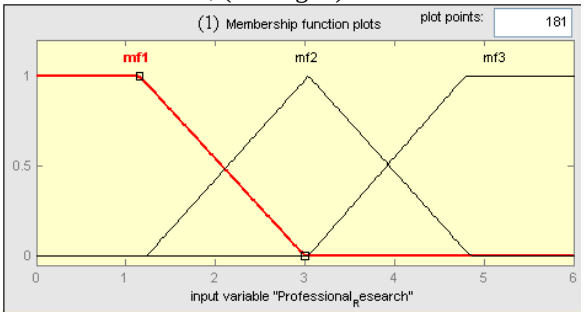

Figure 3. The relationship of function definition for professional research educational development

The fuzzy semantics of professional dedication spirit and attitude are (very good, average, and not good), and the fuzzy quantification scale is defined as 0-100%. Among them, the lower the ratio, the worse the professional spirit and attitude are (see Fig. 4).

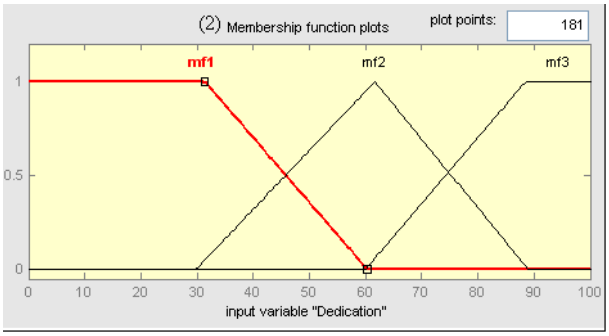

Figure 4. The relationship of function definition for professional dedication spirit and attitude

The definition of functions attributed to the four input evaluation factors indicate different units and definitions for each quantification scale. However, after fuzzy logic calculation, the quantitative value for comparison could be found [14]. This creates a difficult problem that cannot be calculated and handled by general traditional mathematic formulas [15]. The calculation result of this research shows that the best evaluation is 89.8 points, the average evaluation value is 62.3 points, and the lowest evaluation value is 21 points (see Table V).

TABLE V. THE QUANTIFICATION SCALE OF FUZZY SETS AND OUTPUT, INPUT VALUE DEFINITION OF EVALUATION FACTORS

Input			Output
Evaluation Factor	Quantification Scale	Fuzzy Set Semantics	Fuzzy Sets
Course design and teaching	0-10	Very good, average, not good	Quantification output Best 89.8 Average 62.3 Worst 21
Class management and guidance	0-15	Very good, average, not good	
Professional research and educational development	0-6	Good, average, bad	
Professional dedication spirit and attitude	0-100%	Very good, average, not good	

B. 3D Output of the Evaluation Model

The input of the model constructed has four evaluation factors, and each evaluation factor has three input conditions, for a total of 81 evaluation conditions. Each evaluation condition input is converted into a quantitative output value for comparison via the fuzzy system. The relationship between input and output, as shown in Fig. 5-Fig. 7 3D relationship between input and output, is a complicated mapping relationship.

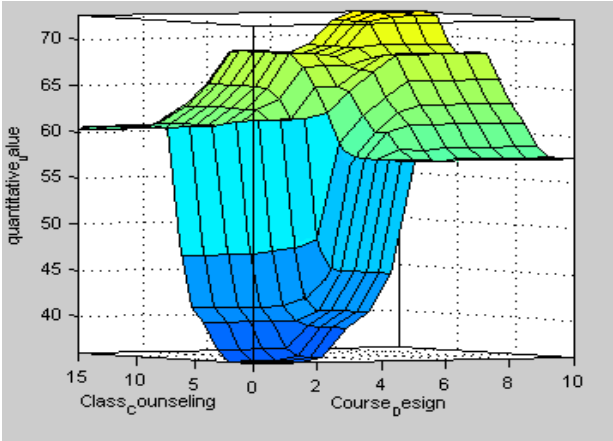

Figure 5. 3D relationship between input and output 1

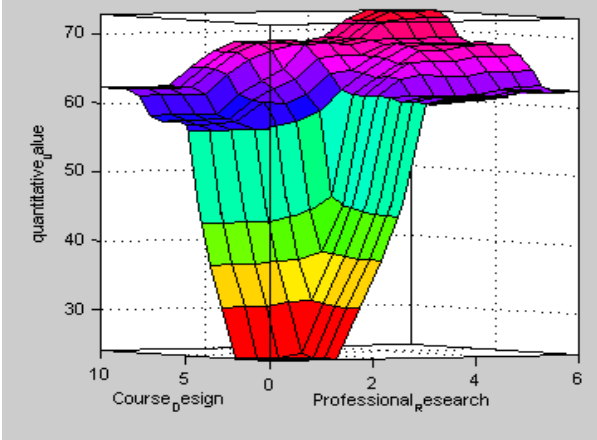

Figure 6. 3D relationship between input and output2

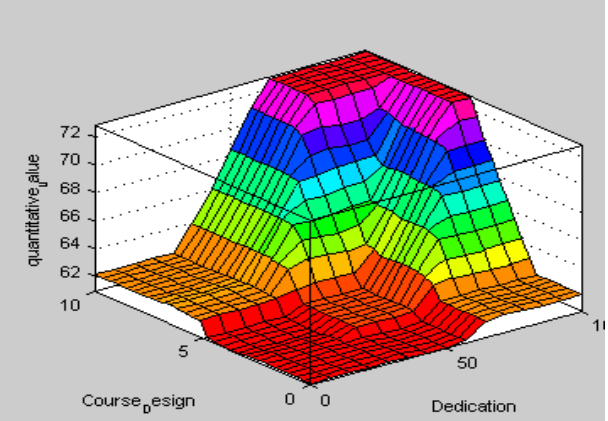

Figure 7. 3D relationship between input and output 3

C. Description of the Best and Worst Evaluation Values

Figures 8 to 10 show that the best evaluation is 89.8 points, the general evaluation value is 62.3 points, and the lowest evaluation value is 21 points. (see Table VI). The four input evaluation factors in this study are known by the definition of the membership function. There are different units and quantization interval definition values, but after fuzzy logic operations, comparatively large quantization values can be obtained, which is a difficult problem that cannot be calculated and handled by traditional mathematical formulas [14].

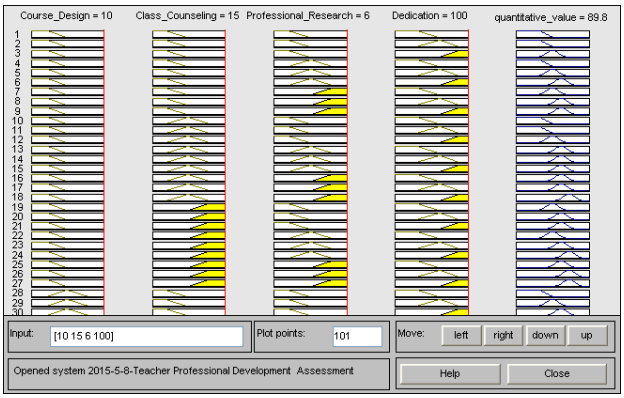

Figure 8. The best evaluation is 89.8 points

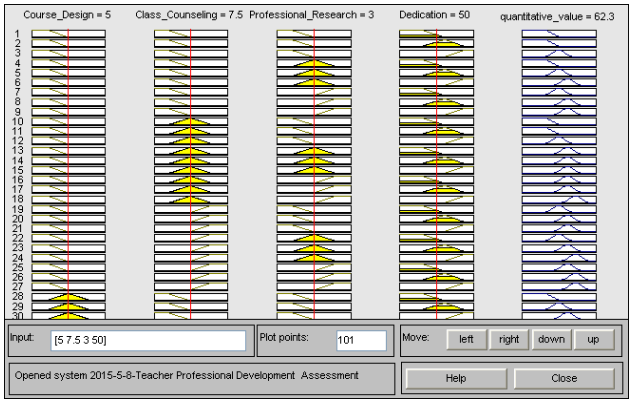

Figure 9. The general evaluation value is 62.3 points

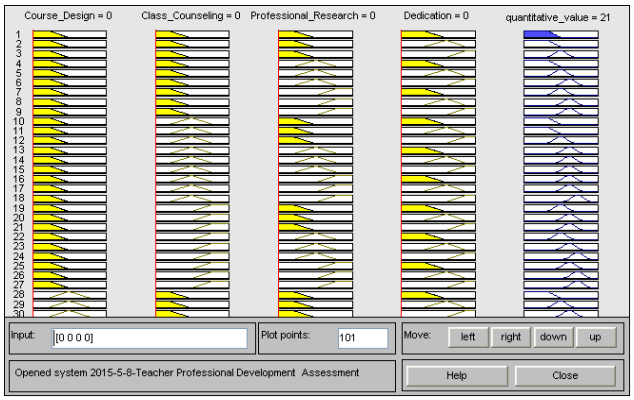

Figure 10. The lowest evaluation value is 21 points

TABLE VI. DESCRIPTION OF THE BEST AND WORST EVALUATION VALUES

Input				
Evaluation factor	Quantification scale	Best	General	lowes
Course design and teaching	0-10	10	5	0
Class management and guidance	0-15	15	7.5	0
Professional research and educational development	0-6	6	3	0
Professional dedication spirit and attitude	0-100%	100	50	0
Output		89.8	62.3	21

D. *Case Study*

According to the evaluation case results aimed at the performances of two teachers (see Fig. 11-Fig. 12): case 1 is 79.9 points, and case 2 is 68.6 points. The scores of the three evaluation factors of "course design and teaching, professional research and educational development, professional dedication spirit and attitude" are the same. Regarding the evaluation factor of class management and guidance, the score of case one is "good", while the score of case two is "average". The results of the fuzzy evaluation score show that even case two performs good at course design and teaching, professional research and educational development, and professional dedication spirit and attitude, but the class management and guidance factor score is only average. Therefore, the overall evaluation result is 68.6% and attributed to average effects.

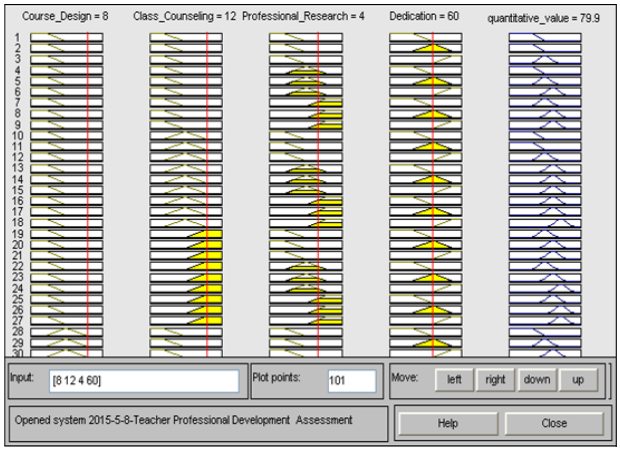

Figure 11. The evaluation output of case 1

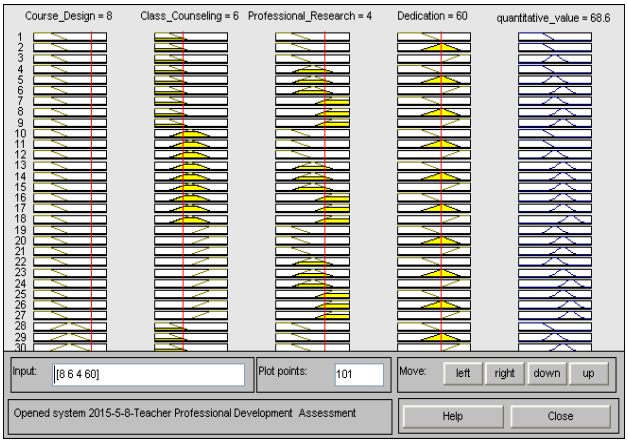

Figure 12. The evaluation output of case 2

This indicates that fuzzy logic not only has a quantification function, but can also perform overall evaluation of multiple properties (see Table VII).

TABLE VII. RESULTS OF CASE STUDY

Input				Output	
Evaluation factor	Quantification scale	Case 1	Case 2	Case 1	Case 2
Course design and teaching	0-10	8	8	79.9	68.6

Class management and guidance	0-15	12	6		
Professional research and educational development	0-6	4	4		
Professional dedication spirit and attitude	0-100%	60	60		

V. Summary

"UNESCO" specifically indicated in its 'Recommendation Concerning the Status of Teacher' in 1996 that teacher should be considered a profession. Therefore, in this time of knowledge economy, teachers must have goals and continuously arrange and select courses that satisfy their personal needs to effectively improve the educational profession and become a professional teacher that keeps pace with the times. The studies of many scholars believe that urging teachers toward self-understanding and self-reflection through teacher evaluation may allow them to become learning professionals and further seek continuous professional development [16]-[18]. Through rigorous implementation experiences and common opinions of relevant scholars and experts, the study has constructed a quantitative evaluation model based on fuzzy logic theory and established a supported decision-making model for evaluating the professional development effects of teachers. It allows teachers who are willing to make self-advancement and self-awareness to open another feasible path other than the qualification evaluation model for implementing both self-assessment and peer assessment.

Conflict of Interest

There are no conflicts of interest in this paper.

Author Contributions

This paper is the research result of the author Wen-Tang Liang, and the content has been reviewed and approved by three Sung-Lin Hsueh, Chun-Chih Chen, Chia-Hui Huang, Ming-Hong Lin professors

References

[1] Y. H. Yang, "The study of change in Maslow's hierarchy of needs," master's thesis Department of Educational Psychology and Counseling National Taiwan Normal University, 2009.

[2] Y. L. Wang, "The study of Stufflebeam's CIPP model development in education evaluation," *Educational Manpower and Professional Development*, vol. 29, 2012.

[3] W. S. Cheng and C. H. Chen, "Quality teacher reinvention: The implementation of teachers' professional evaluation," *Friend of Teacher*, vol. 48, pp. 93-100, 2007.

[4] H. M. Lin, "the study of teachers' professional evaluation promoted in the county – from perspective of policy analysis," *The Bi-monthly Journal of School Administrators*, vol. 62, pp. 98-119, 2009.

[5] M. Y. Jao, "The study of comparing evaluation of teachers in elementary and junior high schools between Taiwan and Singapor," Master's thesis Institute of Public Administration and Policy Nanhua University, 2013.

[6] Y. Y. Chang and C. W. Chang, "The comparison of professional development evaluation for physical education teachers in junior high schools- taking US France and Taiwan as example," *Quarterly of Chinese Physical Education*, vol. 27, pp. 187-194, 2013.

[7] S. H. Cheng and S. W. Yang, "the study of evaluation of teachers of elementary and junior high schools in Tokyo Japan," *Bulletin of Educational Research*, vol. 56, pp. 65-98, 2010.

[8] Y. L. Cheng, " the study of evaluation of teachers of elementary and junior high schools in Aomori Japan," *National Chiayi University Journal of the Educational Research*, pp. 69-97, 2012.

[9] F. Y. Weng and S. P. Lin, "The draft of evaluation indicator construction for professional development of elementary education teachers in Taiwan," *Chinese Journal of Science Education*, vol. 4, pp. 63-94, 2004.

[10] K. C. Lai, "Physical guidelines for advanced certification indicators of teachers' professional development evaluation," *Secondary Education*, vol. 64, pp. 162-170, 2013.

[11] M. H. Wu, "The study of applying fuzzy sets theory and item response theory in study e valuation," Master's thesis Department of Information Management, Chaoyang University of Technology, 2003.

[12] S. L. Hueh, "The construction of investment decision making model based on fuzzy logic theory-taking residence construction in coastal cities of China as example," Doctoral dissertation, NTUST Department of Architecture, 2006.

[13] S. L. Hsueh, Y. Sun, and M. R. Yan, "Conceptualization and development of a DFuzzy model for low-carbon Ecocities," *Sustainability*, vol. 5833, 2019.

[14] S. L. Hsueh, "Evaluation of community energy-saving effects using fuzzy logic model," *Environmental Engineering and Management Journal*, vol. 13, pp. 1207-1212, 2013.

[15] S. L. Hsueh, "A fuzzy utility-based multi-criteria model for evaluating households' energy conservation performance: A taiwanese case study," *Energies*, vol. 5, pp. 2818-2834, 2012.

[16] C. H. Wu, "Teachers' professional development evaluation: The theory and practices in three domains," Taipei City, Wunan, 2010.

[17] H. L. Pan, "The analysis of evaluation standards for foreign teachers," *Essay Released in Seminar of the Challenge Response and Outlook of Teacher Evaluation*, Taipei, 2007.

[18] K. L. Yen, "the basic concept of teacher evaluation, questions and measures," *Journal of Education Research*, vol. 112, 2003.

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