



# A Fuzzy Comprehensive Model to Evaluate PAD Class Teaching Quality Quantitatively and Qualitatively

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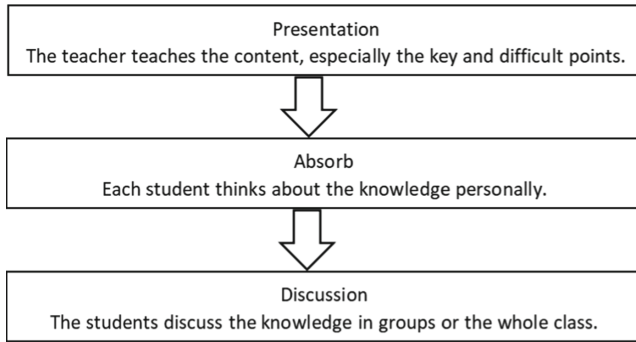
**Abstract.** PAD Class is carried out in the form of teacher's presentation and students' discussions, but the way to evaluate its teaching quality is the same as lecturing class currently. To address this problem, the paper provides a 2-level fuzzy comprehensive evaluation model for PAD Class specially. It takes teaching content, teaching organization, teaching literacy and teaching result as 1-level indexes, and 17 2-level indexes such as necessity, time allotment etc. It quantifies some unclear indexes to values by membership functions and then gets a qualitative conclusion according to the value. In this model the evaluation indexes focus on the teacher's ability to make discuss efficiently, and it lets fuzzy factors more accurate by quantifying. Through practical applications, the teachers' recognition of the evaluation conclusions reaches 93.3%, which is 13.3% higher than that in previous evaluation way.

**Keywords:** PAD Class · Fuzzy Comprehensive Evaluation · Evaluation Index · Membership Function

## 1 Introduction

PAD Class is a new teaching form to fit for the new teaching ideas in China, which is provided by professor XueXin ZHANG in Fudan University [1]. It divides the time into two parts, one is for teacher's presentation and the other is for students' discussions. There's a gap time between discussion and presentation, in which the students absorb the knowledge personally [2]. The teaching process of PAD Class is shown in Fig. 1.

PAD Class is carried out in the form of teacher's presentation and students' discussions. Obviously It's different from traditional lecturing class in organizing and controlling teaching. But in fact, the way to evaluate PAD Class teaching quality is fuzzy comprehensive evaluation, which is the same as that to lecturing class. When evaluating, there are 4 evaluation indexes, teaching content, teaching method, basic skill for teaching and teaching result. It qualitatively evaluate each index by evaluation matrix [3, 4].



**Fig. 1.** The teaching stage of PAD Class

To address this problem, the paper provides a Fuzzy comprehensive evaluation model for PAD Class, takes teaching content, teaching organization, teaching literacy and teaching result as evaluation indexes, and designs membership functions to quantify some unclear indexes.

## 2 Evaluation Indexes

The most important thing for class is to impart knowledge, that is teaching and learning. No matter what teaching form used in class, we need to pay attention to what the teacher teaches and how the student learns. This is also fit for PAD Class. When evaluating the teaching quality of PAD Class, we need to evaluate what knowledge the teacher teaches, whether the content is in the course and exactly is in the class according to the course schedule, how the teacher explain the difficult points. From the perspective of learning, we need to evaluate whether the students learn actively, whether they can answer the related questions correctly or not, or if they can ask some valuable questions. So we get two evaluation indexes, teaching content and teaching result.

At the same time, we need to see the speciality of PAD Class. The main difference between PAD Class and traditional class is discussion. When we try to evaluate a discussion class, we should pay attention to whether the teacher guides the discussion efficiently, and if there are some effective ways to motivate students to discuss when they're inactively. So we get the other two evaluation indexes, teaching organization and teaching literacy.

The 4 1-level indexes, teaching content, teaching organization, teaching literacy and teaching result and the meaning of their 2-level indexes are shown in Table 1.

## 3 A Model Evaluating Quantitatively and Qualitatively

### 3.1 Fuzzy Comprehensive Evaluation

When evaluating a thing or a phenomenon, fuzzy comprehensive evaluation is needed if there are too many evaluation indexes, or index should be divided into many levels, or indexes are unclear. Fuzzy comprehensive evaluation is used to evaluate a thing or

**Table 1.** The evaluation INDEXES for PAD Class teaching quality evaluation

<b>L1 index</b>	<b>index meaning</b>	<b>L2 index</b>	<b>index meaning</b>
teaching content	ability to teach knowledge and technique	necessity	The content is in the course outline.
		scheduling	The content is fit for the course schedule.
		accuracy	The content has no scientific error.
		the way to presentation	The lecturing way is easy to know and clearly and logically.
teaching organization	ability to control PAD Class	grouping	The number of the members and their abilities are rational in each group.
		software using	The teacher can use duifene frequently.
		time allotment	The teacher can divide time to present and discuss reasonably.
		motivation way	The teacher motivates the students to participate discussion actively.
		controlling ability	The teacher can control the process of discussion and communication.
teaching literacy	basic skill to teach and ability to make and use digital resources	IT ability	The teacher is able to make digital resources.
		teaching manner	The teacher's manner is natural.
		language	The teacher speaks mandarin and clearly.
		usage of teaching material	The teacher uses teaching material reasonably and effectively.

*(continued)*

**Table 1.** (continued)

<b>L1 index</b>	<b>index meaning</b>	<b>L2 index</b>	<b>index meaning</b>
teaching result	the students' enthusiasm to learn	discussion times	How many discussion times are there in the class?
		interaction times	How many interaction times are there in the class between students and teachers?
		times and number of persons who communicate	How many communication times and how many persons participate in the communication are there in the class?
		classroom atmosphere	The students participate in the communication actively.

a phenomenon influenced by many factors. It evaluate things comprehensively with principle of fuzzy transformation and maximum membership, considering every factor that is related to the thing evaluated [5].

Fuzzy comprehensive evaluation model includes 1-level model and multi-level model. PAD Class evaluation indexes shown in Table 1 include 4 1-level indexes and 17 2-level indexes. Thus we can use 2-level evaluation model [6]. It evaluates 4 1-level indexes by the 2nd model, and evaluates teaching quality as a whole by the 1st evaluation model.

### 3.2 Evaluate 4 1-Level Indexes by the 2nd Evaluation Model

#### 1) Build evaluation indexes union.

Evaluation indexes union is a union of main factors that influence the thing. Each evaluation factor union of 4 1-level index is:

$$U_1 = \{\text{necessity; scheduling; accuracy; the way to presentation}\}$$

$$U_2 = \left\{ \begin{array}{l} \text{grouping; software using; time allotment;} \\ \text{motivation way; controlling ability} \end{array} \right\}$$

$$U_3 = \left\{ \begin{array}{l} \text{IT ability; teaching manner; language;} \\ \text{using of teaching material} \end{array} \right\}$$

$$U_4 = \left\{ \begin{array}{l} \text{discussion times; interaction times; classroom atmosphere;} \\ \text{times and number of person who communicates} \end{array} \right\}$$

**2) Determine weight of each factor.**

Because the importance of each factor in  $U_i$  is different, each of them should have different weight. Consulting related statistical documents or rating by experts can be used to determine the weights usually. The 2-level indexes of 4 1-level indexes interact with each other, and they have no clear limit and don't need to calculate accurate [7]. By consulting 5 statistical documents, we get the weight of each 1-level index.

$$A_1 = \{0.3; 0.2; 0.3; 0.2\}, \quad A_2 = \{0.1; 0.1; 0.2; 0.3; 0.3\},$$

$$A_3 = \{0.3; 0.2; 0.2; 0.3\}, \quad A_4 = \{0.2; 0.3; 0.3; 0.2\}.$$

**3) Determine membership function of each index.**

Membership functions quantify the fuzzy factors to values, then we can analysis the fuzzy factors with mathematics accurately. Membership function is the key to describe fuzzy factor. It can show the transition between different features, and it's an approach from fuzziness to accuracy [8].

To evaluate classroom teaching quality, it should evaluate 4 1-level indexes by membership first. Each of 4 1-level indexes takes 2-level indexes as influenced factors. The 4 membership functions are shown below:

- membership function of teaching content:

$$S_1 = \frac{3}{10}S_{11} + \frac{2}{10}S_{12} + \frac{3}{10}S_{13} + \frac{2}{10}S_{14} \tag{1}$$

$$S_{11} = \begin{cases} 0 & \text{(The content isn't in the course outline.)} \\ 0.5 & \text{(The content is in the course outline partly.)} \\ 1 & \text{(The content is in the course outline completely.)} \end{cases} \tag{2}$$

$$S_{12} = \begin{cases} 0 & \text{(The content doesn't match the course schedule.)} \\ 0.5 & \text{(The content matches the course schedule partly.)} \\ 1 & \text{(The content matches the course schedule completely.)} \end{cases} \tag{3}$$

$$S_{13} = \begin{cases} 0 & \text{(The content has scientific errors.)} \\ 1 & \text{(The content has no scientific error.)} \end{cases} \tag{4}$$

$$S_{14} = \begin{cases} 0 & \text{(Only reading the teaching metaterials.)} \\ 0.5 & \text{(The lecturing way is relatively easy to know.)} \\ 1 & \text{(The lecturing way is easy to know and clearly.)} \end{cases} \tag{5}$$

- membership functions of teaching organization:

$$S_2 = \frac{1}{10}S_{21} + \frac{1}{10}S_{22} + \frac{2}{10}S_{23} + \frac{3}{10}S_{24} + \frac{3}{10}S_{25} \tag{6}$$

$$S_{21} = \begin{cases} 0 & \text{(The number and ability of the member are not rational )} \\ 0.5 & \text{(The number and ability of the member are rational relatively .)} \\ 1 & \text{(The number and abiliy of the member are rational.)} \end{cases} \tag{7}$$

$$S_{22} = \begin{cases} 0 & \text{(The teacher can not use Duifene.)} \\ 0.5 & \text{(The teacher can use Duifene.)} \\ 1 & \text{(The teacher can use Duifene frequently.)} \end{cases} \quad (8)$$

$$S_{23} = \begin{cases} 0 & \text{(The time of presentation and discussion is reasonably.)} \\ 0.5 & \text{(The time of presentation and discussion is reasonably relatively.)} \\ 1 & \text{(The time of presentation and discussion is reasonably.)} \end{cases} \quad (9)$$

$$S_{24} = \begin{cases} 0 & \text{(There is no motivation way.)} \\ 0.5 & \text{(There are motivation ways, the students discuss inactively.)} \\ 1 & \text{(There are motivation ways, the students discuss actively.)} \end{cases} \quad (10)$$

$$S_{25} = \begin{cases} 0 & \text{(The teacher can not control teaching process.)} \\ 0.5 & \text{(The teacher can basically control teaching process.)} \\ 1 & \text{(The teacher can control teaching process.)} \end{cases} \quad (11)$$

- membership functions of teaching literacy:

$$S_3 = \frac{3}{10}S_{31} + \frac{2}{10}S_{32} + \frac{2}{10}S_{33} + \frac{3}{10}S_{34} \quad (12)$$

$$S_{31} = \begin{cases} 0 & \text{(The teacher made no digital resources.)} \\ 0.5 & \text{(The teacher made normal digital resources.)} \\ 1 & \text{(The teacher made good digital resources.)} \end{cases} \quad (13)$$

$$S_{32} = \begin{cases} 0 & \text{(The teacher/s manner is overcautious.)} \\ 0.5 & \text{(The teacher/s manner is natural.)} \\ 1 & \text{(The teacher/s manner is kind.)} \end{cases} \quad (14)$$

$$S_{33} = \begin{cases} 0 & \text{(The teacher doesn't speak in mandarin.)} \\ 1 & \text{(The teacher speaks in mandarin and clearly.)} \end{cases} \quad (15)$$

$$S_{34} = \begin{cases} 0 & \text{(The teaching materials are ineffectively.)} \\ 0.5 & \text{(The teaching materials are relatively effectively.)} \\ 1 & \text{(The teaching materials are effectively.)} \end{cases} \quad (16)$$

- membership functions of teaching result:

$$S_4 = \frac{2}{10}S_{41} + \frac{3}{10}S_{42} + \frac{3}{10}S_{43} + \frac{2}{10}S_{44} \quad (17)$$

$$S_{41}(x) = \begin{cases} 0.2xx \leq 5 \\ 1x > 5 \end{cases} \quad (x \text{ is the total times of dicussions.}) \quad (18)$$

$$S_{42}(x) = \begin{cases} 0.05xx \leq 20 \\ 1x > 20 \end{cases} \quad (x \text{ is the total times of interactions between T - S.}) \quad (19)$$

$$S_{43}(x, y) = \begin{cases} 1 & x \geq \frac{y}{2} \\ \frac{20x}{y} \frac{y}{5} \leq x < \frac{y}{2} \\ 0 & x < \frac{y}{5} \end{cases} \quad \left( \begin{array}{l} x \text{ is the number of whom communicates} \\ y \text{ is the total number of students.} \end{array} \right) \quad (20)$$

$$S_{44}(x) = \begin{cases} 0.05x & x \leq 20 \\ 1 & x > 20 \end{cases} \quad (x \text{ is the times of handing up.}) \quad (21)$$

We can quantity 4 1-level indexes with these membership functions above.

### 3.3 Evaluate the Classroom Teaching Quality as a Whole by the 1st Model

#### 1) Build evaluation indexes union $U'$ .

It takes 4 2nd evaluation conclusions as the 1st model indexes, those are:

$$U' = \left\{ \begin{array}{l} \text{teaching content; teaching organization;} \\ \text{teaching literacy; teaching result} \end{array} \right\}$$

#### 3) Build evaluation conclusion union $V'$ .

The evaluation conclusion union is a union of conclusion when evaluating the thing, to the teaching quality, the evaluation conclusion can be:

$$V' = \{ \textit{excellent}; \textit{good}; \textit{medium}; \textit{poor} \}$$

#### 4) Determine the weight of each factor.

Rating by the experts, the weight of teaching content, teaching organization, teaching literacy, teaching result is  $A' = \{0.3; 0.2; 0.2; 0.3\}$  [9].

#### 5) Determine membership function of teaching quality.

$$S = 100 \times \left( \frac{3}{10}S_1 + \frac{2}{10}S_2 + \frac{2}{10}S_3 + \frac{3}{10}S_4 \right) \quad (22)$$

get the evaluation *conclusion*

It evaluates teaching quality qualitatively according to the membership degree, the function is shown below:

$$B = \left\{ \begin{array}{ll} \text{excellent} & S \geq 85 \\ \text{good} & 75 \leq S < 85 \\ \text{medium} & 50 \leq S < 75 \\ \text{poor} & S < 50 \end{array} \right\} \text{ (S is the membership degree)} \quad (23)$$

## 4 Model Application and Analysis in Compared with the Previous Evaluation Model

### 4.1 Collecting Evaluation Data

#### 1) Information Technology needed.

There are two methods of IT needed to collect evaluation data. One is an online survey such as [www.wjx.cn](http://www.wjx.cn) and [wj.qq.com](http://wj.qq.com). A special survey is designed before each evaluation to a teacher.

### Evaluate Teaching Quality

Teacher Name: ShaoJie Du  
 Course Name: C# Programming  
 Date and Time: 2022-9-11 9:30am

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\* 1. Necessity of the Content

The content isn't in the course outline.  
 The content is in the course outline partly.  
 The content is in the course outline wholly.

\* 2. Scheduling of the Course

The content doesn't match the course schedule.  
 The content doesn't match the course schedule partly.  
 The content doesn't match the course schedule completely.

**Fig. 2.** An example of online survey.

The other is an education application, such as Duifene and Cloud Class, which is used throughout the class to report the teaching process, especially the activities between teacher and student.

## 2) Data from online survey.

The model includes 4 1-level indexes and 17 2-level indexes. When evaluating teaching quality with the model, some evaluation data is manually judged by evaluator, such as necessity of teaching content, time allotment of teaching organization, teaching manner of teaching literacy. The evaluator observes the whole class of evaluatee, and gives his conclusion of each 2-level indexes through the survey, then the evaluation system gets their numerical values according to the membership functions.

An example of online survey is shown in Fig. 2.

## 3) Data from education application.

The evaluation data of 5 2-level indexes of teaching result is from Duifene application, such as discussion times, interaction times, handing times. The data can be exported from the application in an Excel sheet, which is shown in Fig. 3.

## 4.2 Evaluate in Practice with the Model

5 experts are chosen to observe 20 teachers who teach with PAD Class. They evaluate 2-level indexes with special survey for PAD Class and traditional survey for lectured class. Then according to the evaluation data, it gets 2 groups of conclusions by this model and by previous way. The 2 groups of conclusion are shown in Fig. 4.

Comparing the 2 groups data, it can be known that there are 6 same conclusions accounting for 40%, 9 different conclusions accounting for 60%. 14 teachers agree to



No.	Teaching Activities in Class					
	hands up-1 (total and picked)	hands up-2 (total and picked)	pick at random-1	hands up-3 (total and picked)	hands up-4 (total and picked)	pick at random-2
202111020101	1	1			1	
202111020102	1				1	
202111020103	1	1	1	1	1	
202111020104	1	1				
202111020105	1			1	1	1
202111020106	1			1	1	
202111020107	1	1			1	
202111020108	1	1			1	
202111020109	1					
202111020110	1	1		1	1	

Fig. 3. Interaction data from Duifene application

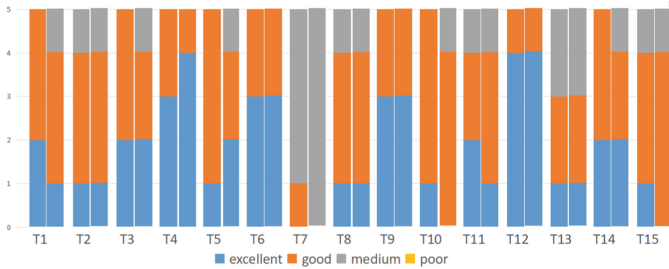


Fig. 4. 2 Groups of evaluation conclusion

the conclusions with PAD Class model, accounting for 93.3%. 12 teachers agree to the conclusions with previous way, accounting for 80%. The special evaluation is more scientific and reasonable, and the model in the article is practical.

### 5 Conclusions

As a new teaching mode, PAD Class highlights the primary role of the students in class, the evaluation way should be changed meanwhile. The 4 1-level evaluation indexes focuses on teaching and learning, at the same time it focuses on evaluating teachers' ability to control the class, such as whether time divided for lecturing and discussion is reasonably or not, whether the motivation is efficient, etc. All of these make the evaluation fit for PAD Class more.

Of the evaluation data, some are from education application Duifene, such as discussion times, handing times. Others are from experts' judgement. Some researchers have applied pattern recognition, BP neural network and other AI technique to evaluate some subjective evaluation indexes automatically [10, 11], the authors need to do more research about it.

With the wide application of PAD Class, it's meaningful to evaluate PAD Class teaching quality scientifically and reasonably. It can evaluate whether the teacher can teach with PAD efficiently, then push the teacher grasp the key of PAD Class gradually, and make teachers take part in teaching reform actively. Except for expanding application of PAD Class, it provides a reference to others discussion teaching mode at the same time.

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