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SELECTING MANAGERIAL STRATEGIES BY USING FUZZY LOGICS FOR KINDERGARTEN UNDER THE DECREASING BIRTH RATE

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Abstract. *Kindergartens in Taiwan now have crisis owing to the declining birth rate. Thus, this study aimed to examine kindergarten management perception gaps between parents and faculty in New Taipei City, Taiwan. Fuzzy questionnaire method was employed and 112 valid copies were from the parents while 19 valid copies were from the faculty. Fuzzy statistics was used to examine the gaps in terms of using fuzzy distance to determine the gaps. Positive and negative managerial strategies for kindergarten were developed in this study. The results reveal that positive strategies are having foreign teachers, participating in new experimental courses, and increasing indoor activity space. Negative managerial strategies suggest stopping offering after-school, winter and summer vocations child-care services.*
Keywords: Kindergarten, Management strategy, Fuzzy statistics, Fuzzy distance

1. **Introduction.** Declining birth rate has been a severe problem in Taiwan. According to the international standard, each woman should have 2.1 children in order to maintain the ideal population replacement. However, the total fertility in Taiwan has begun to decline since 1950. In 1984, it fell below 2.1 children and dropped to 1.05 in 2008. In 2010, it even dropped to 0.89, which made Taiwan's birth rate the lowest in the world [1]. As the first stage of school education, early childhood education is sure to be the first to be affected. The total number of kindergartens in Taiwan is 6,310 in 2017, with 6,222 in operation and 88 closed [2,3]. These figures show that kindergartens in Taiwan are now faced a fierce competition with the falling birth rate. The fewer children are there in a family, the more efforts and money their parents will put on them. Parents surely tend to have more expectations on their children. It can be concluded that parents' expectations should be emphasized in kindergarten management so that right strategies will be adopted to fulfill customers' needs. In this regard, a kindergarten manager should not only realize the parents' concern, but develop suitable strategies to attract more kids to enroll in the competitive market. This study aims to explore the better strategies for kindergarten management in the declining birth rate era.

Previous studies indicated parents will consider in choosing kindergartens [4-10]. In parents' kindergarten choice-making processes, kindergarten's service quality and management have been taken into account [11-16]. Moreover, whether English or art classes, safe environment and facilities are provided in a kindergarten is often valued. Taiwan parents expect that children-care service time and tuition fees will meet their needs. They anticipate that the school emphasizes its performance and service quality. They also make choices depending on the reputation and characteristics of a kindergarten. Related findings show that faculty is the key to kindergarten's quality assurance. Therefore, it

TABLE 1. Analysis of kindergarten management strategies

No.	Management strategy
1	Advance teachers' qualification
2	Emphasize teaching quality
3	Provide English and art classes
4	Provide safe environment and facilities
5	Child-care service time meets parents' needs.
6	Tuition fees meet parents' economic standing.
7	Enhance school performance
8	Implement assessments
9	Improve service quality
10	Promote its public image and reputation
11	Create the kindergarten's characteristics

is crucial to bring faculty's perspective into this study. Only both perspectives are considered, can the perception gaps be detected and be bridged [15,16]. This study adopted questionnaire method to examine the kindergarten management strategy perceptions of parents and faculty. Fuzzy logic was used to examine the gaps, and thus suggested management strategies were developed. The kindergarten management strategies in previous studies have been presented in Table 1.

The structure of this study begins with the problem statement in the introduction section. Then, the method section addresses the research framework, fuzzy questionnaire, and fuzzy statistics conducted in this study. Third, the result section will report the positive strategies derived from fuzzy mean, defuzzification, and fuzzy distance. Finally, we provide suggestions for kindergartens to enhance their management strategies.

2. Methods.

2.1. **Research framework.** Figure 1 shows this research framework of kindergarten management strategies due to the fuzzy distance between self-perception of the kindergarten faculty and customer-perception of student' parent.

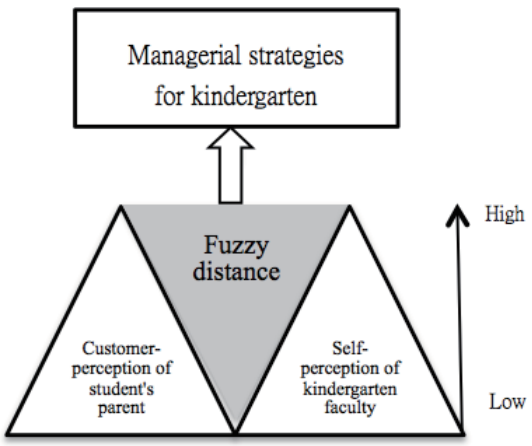

FIGURE 1. Research framework

2.2. **Instrument design.** After thorough literature review, factors which parents consider when choosing a kindergarten and kindergarten marketing and service quality strategies were selected. Later, through expert interview, several management strategies were carefully chosen for the self-designed questionnaire. After two rounds of Delphi and three

TABLE 2. Categories of kindergarten management strategies

Category	Indicator	Management strategy	Suggested by previous studies
Teaching staff	C1-1	High proportion of qualified teachers	1
	C1-2	Teachers with professional skills	2
	C1-3	In-school foreign teachers	(3)
Service time	C2-1	Service time meets parents' need.	5
	C2-2	After-school child-care service	
	C2-3	Child-care service in winter and summer vacations	
School facilities	C3-1	New buildings and facilities	
	C3-2	Sufficient indoor activity space	4
	C3-3	Sufficient outdoor activity space	4
	C3-4	Sufficient recreational facilities	4
Tuition fees	C4-1	Reasonable tuition fees or monthly fees	6
	C4-2	No extra charge (6)	
	C4-3	Reasonable after-school child-care service fees	
Kindergarten characteristics	C5-1	Good reputation	10
	C5-2	Significant teaching characteristics	11
	C5-3	Evaluated good by government	8, 9
	C5-4	The kindergarten or its teachers are often awarded.	
	C5-5	Participating in new experimental courses	7

experts' suggestions, the content of the questionnaires was finally developed, including five categories and 18 indicators. Table 2 shows the selected indicators in which the numbers listed in the right column are also proposed by previous studies as Table 1.

There are 112 parents and 19 faculty members participating in this study on a voluntary basis. The participants were asked to fill the questionnaire as our fuzzy format. The example is listed as follows:

Direction: The following questions are related to management strategies of a kindergarten. We need your opinions on the kindergarten management strategies. If you feel the important level of management strategy is 3-6 on the scale of 1-7, please circle the number 3 and 6 for representing your opinion.

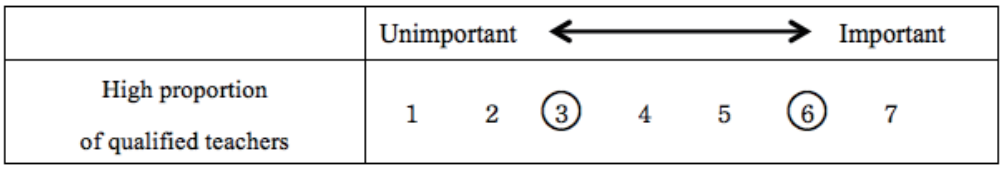

FIGURE 2. Sample of fuzzy questionnaire

2.3. **Fuzzy statistics.** This study employs fuzzy means, defuzzification and fuzzy distance to analyze the data from the perceptions on kindergarten management strategies. The gaps between kindergarten faculty and parents have been determined by using fuzzy statistics. The data transformation processes have been addressed as follows.

Definition 2.1. *Fuzzy sample means (data with interval values) [17-19].*

Let U be the universal set and $\{Fx_i = [a_i, b_i], a_i, b_i \in R, i = 1, \ldots, n\}$ be a sequence of random fuzzy samples on U. The fuzzy sample mean is then defined as follows:

$$F\overline{x} = \left[\frac{1}{n}\sum_{i=1}^{n} a_i, \frac{1}{n}\sum_{i=1}^{n} b_i\right]$$

Example 2.1. *Let $x_1 = [1, 3]$, $x_2 = [2, 5]$, $x_3 = [2, 6]$, $x_4 = [3, 7]$, $x_5 = [5, 7]$ be the self-perception of the kindergarten faulty with fuzzy interval scale. Thus, the fuzzy mean for the evaluation is*

$$F\overline{x} = \left[\frac{1+2+2+3+5}{5}, \frac{3+5+6+7+7}{5}\right] = [2.4, 5.6]$$

Definition 2.2. *Let $\chi = [a, b]$ $(a \neq b)$ be an interval fuzzy number on U, then the defuzzification number R_χ of $[a, b]$ is defined as follows [17,19]:*

$$R_\chi = \frac{a+b}{2} + \left(1 - \frac{\ln(1+|b-a|)}{|b-a|}\right)$$

Example 2.2. *Let $\chi = [3, 6]$, then $R_\chi = \frac{3+6}{2} + \left(1 - \frac{\ln(1+|6-3|)}{|6-3|}\right) = 5.04$.*

Definition 2.3. *Distance between samples of interval-valued data [18,19].*

Membership function can be used to explain the idea of the triangular fuzzy numbers. Let us display two triangular fuzzy numbers, one is $[1, 2, 3]$ and the other is $[2, 3.5, 5]$. We can use the idea of membership function to determine their centroids. In the fuzzy measurement, the centroid represents 1.0 in terms of its membership function is 100% to fit. We can use the centroids to determine the weights of fuzzy means.

Let U be the universe of discourse. Let $\{\chi_i = (a, b, c), i = 1, 2, 3\}$ be three samples from U, with the center $C_i = \frac{a_i+b_i+c_i}{3}$, $h_i = 1$, and area $A_i = \frac{(c_i-a_i)*h_i}{2}$.

The distance between the triangle samples χ_1 and χ_2 are defined as $\chi_1 \to [C_1, A_1]$, and $\chi_2 \to [C_2, A_2]$. Therefore,

$$d(\chi_1, \chi_2) = |C_i - C_j| + \left|\frac{\ln(1+|A_i|)}{|A_i|} - \frac{\ln(1+|A_j|)}{|A_j|}\right|$$

Example 2.3. *Let $\chi_1 = [1, 2, 3]$ be the self-perception of the kindergarten faulty and $\chi_2 = [2, 3.5, 5]$ be the customer-perception of student' parent; therefore two sets of interval data should be $\chi_1 = [(1+2+3)/3, (3-1)*1/2] = [2, 1]$, $\chi_2 = [(2+3.5+5)/3, (5-2)/2] = [3.5, 1.5]$. The fuzzy distance is shown as the following:*

$$d(\chi_1, \chi_2) = |2 - 3.4| + \left|\frac{\ln(1+2)}{2} - \frac{\ln(1+1.5)}{1.5}\right| = 2.02$$

3. **Results.**

3.1. **Ranking management strategies based on defuzzification.** Table 3 displays each strategy was ranked in its own category based on defuzzification with parents' and the faculty's group. The result reveals they have similar rankings in the "faculty" category. However, the different rankings have been shown in other categories.

In the category of faculty, both groups ranked C1-1 as the first, C1-2 as the second and C1-3 as the last. In the category of service time, C2-1 was considered the most important in the parents' group but ranked at the least in the faculty's group. On the other hand, C2-2 was considered the most important in the faculty's group but the least in the parents' group.

As for the category of school facilities, they both ranked C3-3 as the most important strategy. However, the faculty ranked C3-4 as the second while the second important

TABLE 3. Fuzzy means, defuzzification, and ranking of kindergarten management strategies

Category	Indicator	Fuzzy means (Parent)	R	Ranking	Fuzzy means (Teaching staff)	R	Ranking
Teaching staff	C1-1	[4.97,6.74]	6.27	1	[4.63,6.37]	5.91	1
	C1-2	[4.93,6.71]	6.23	2	[4.21,6.11]	5.58	2
	C1-3	[3.04,4.87]	4.37	3	[1.42,2.95]	2.55	3
Service time	C2-1	[4.40,6.17]	5.70	1	[4.37,6.00]	5.58	3
	C2-2	[4.15,5.85]	5.40	3	[4.89,6.53]	6.11	1
	C2-3	[4.15,5.90]	5.43	2	[4.47,6.21]	5.75	2
School facilities	C3-1	[4.40,6.21]	5.73	4	[3.58,5.63]	5.04	4
	C3-2	[4.97,6.74]	6.27	2	[4.05,5.79]	5.32	3
	C3-3	[5.09,6.86]	6.39	1	[4.53,6.21]	5.77	1
	C3-4	[4.69,6.49]	6.01	3	[4.37,6.11]	5.64	2
Tuition fees	C4-1	[4.95,6.65]	6.20	1	[5.16,6.74]	6.33	1
	C4-2	[4.64,6.35]	5.90	2	[4.68,6.42]	5.96	3
	C4-3	[4.57,6.22]	5.79	3	[5.00,6.63]	6.21	2
Kindergarten characteristics	C5-1	[4.56,6.40]	5.90	3	[4.89,6.63]	6.17	1
	C5-2	[4.72,6.53]	6.04	1	[4.26,6.05]	5.58	2
	C5-3	[4.63,6.38]	5.92	2	[3.79,5.79]	5.22	3
	C5-4	[3.77,5.73]	5.18	5	[2.84,4.89]	4.30	4
	C5-5	[3.91,5.73]	5.24	4	[2.47,4.47]	3.90	5

strategy in the parents was C3-2. As for the category of tuition fees, both groups ranked C4-1 as the most important strategy.

In the category of kindergarten characteristics, the parents' rankings can be seen divided into two sub-groups by defuzzification: high-score group ($R = [5.90, 6.04]$) and low-score group ($R = [5.18, 5.24]$). C5-1, C5-2 and C5-3 were in the high-score group. C5-4 and C5-5 were in the low-score group. The faculty's rankings are also seen separated into a high-score group ($R = [5.22, 6.17]$) and a low-score group ($R = [3.90, 4.30]$). Although parents and faculty have different rankings in high-score and low-score groups they all thought that kindergarten characteristics can be recognized by parents and government is important, but it is less important whether a kindergarten conducts innovative teaching or whether its teachers are personally awarded.

The results reveal that parents and faculty had consistency in the categories of faculty, school facilities and tuition fees. In the category of kindergarten characteristics, they also had similar rankings. However, in the category of service time, they had great inconsistency: the strategy ranked the most important by parents, but in the least important by the faculty.

3.2. **Ranking management strategies by fuzzy distance.** In Table 4, each item was ranked in its own category or in all categories by fuzzy distance. In the category of faculty, the fuzzy distance of C1-3 is the greatest (1.80). The second is C1-2 (0.67) and the last is C1-1 (0.36). In the category of service time, C2-3 has the largest fuzzy distance (0.32), but it is still lower than all items' in the category of faculty. In the category of school facilities, C3-2 is the item in which parents and faculty had the largest gap (0.94). The second largest is C3-1 and the last one is C3-4. In the category of tuition fees, the fuzzy distance of C4-3 is the largest while that of C4-2 is the smallest. In the category of

TABLE 4. Fuzzy distance and ranking of kindergarten management strategies

Category	Indicator	Management strategy	Fuzzy distance	Ranking in category	Ranking
Teaching staff	C1-1	High proportion of qualified teachers	0.36	3	11
	C1-2	Teachers with professional skills	0.67	2	7
	C1-3	In-school foreign teachers	1.80	1	1
Service time	C2-1	Service time meets parents' need.	0.12	3	17
	C2-2	After-school child-care service	0.19	2	15
	C2-3	Child-care service in winter and summer vocations	0.32	1	13
School facilities	C3-1	New buildings and facilities	0.73	2	6
	C3-2	Sufficient indoor activity space	0.94	1	3
	C3-3	Sufficient outdoor activity space	0.61	3	8
	C3-4	Sufficient recreational facilities	0.36	4	12
Tuition fees	C4-1	Reasonable tuition fees or monthly fees	0.16	2	16
	C4-2	No extra charge	0.06	3	18
	C4-3	Reasonable after-school child-care service fees	0.42	1	10
Kindergarten characteristics	C5-1	Good reputation	0.29	5	14
	C5-2	Significant teaching characteristics	0.44	4	9
	C5-3	Evaluated good by government	0.74	3	5
	C5-4	The kindergarten or its teachers are often awarded.	0.89	2	4
	C5-5	Participating in new experimental courses	1.37	1	2

kindergarten characteristics, C5-5 has the largest fuzzy distance (1.37). Also in the low-score group in terms of defuzzification, the fuzzy distance of C5-4 is the second largest, followed by C5-3, C5-2 and C5-1. C5-3, C5-2 and C5-1 are in the high-score group in terms of defuzzification.

Moreover, each item was ranked in all categories based on its fuzzy distance. C1-3 is ranked the first, the second is C5-5, and the third is C3-2. C4-2 is ranked the last one, the second last is C2-1 and the third last is C4-1.

The ranking of the five categories is displayed in Table 5. Teaching staff comes first, followed by kindergarten characteristics, school facilities, tuition fees and service time. It is found that parents and faculty have the greatest gap in the category of faculty, especially their great inconsistency in C1-3. However, similar perception in the category of service time reflects that the related strategies needed modifications.

TABLE 5. Fuzzy distance and ranking of kindergarten management strategy categories

Category	Fuzzy distance	Ranking
Teaching staff	0.94	1
Service time	0.21	5
School facilities	0.66	3
Tuition fees	0.21	4
Kindergarten characteristics	0.74	2

TABLE 6. Ranking of positive and negative management strategies

Indicator	Positive management strategy	Ranking	Indicator	Negative management strategy	Ranking
C1-3	In-school foreign teachers	1	C2-2	After-school child-care service	1
C5-5	Participating in new experimental courses	2	C4-3	Reasonable after-school child-care service fees	2
C3-2	Sufficient indoor activity space	3	C2-3	Child-care service in winter and summer vacations	3
C5-4	The kindergarten or its teachers are often awarded.	4	C5-1	Good reputation	4
C5-3	Evaluated good by government	5	C4-1	Reasonable tuition fees or monthly fees	5
C3-1	New buildings and facilities	6	C4-2	No extra charge	6
C1-2	Teachers with professional skills	7			
C3-3	Sufficient outdoor activity space	8			
C5-2	Significant teaching characteristics	9			
C3-4	Sufficient recreational facilities	10			
C1-1	High proportion of qualified teachers	11			
C2-1	Service time meets parents' need.	12			

3.3. **Positive and negative strategies by defuzzification and fuzzy distance.** Positive and negative managerial strategies are developed in this study by the defuzzification, see Table 6. A positive managerial strategy means the parents' defuzzification is larger than the faculty's. On the other hand, a negative managerial strategy means that the parents' defuzzification is smaller than the faculty's. Managers in kindergartens are advised to avoid taking in order not to waste resources.

Among the 18 strategies, there are 12 positive managerial strategies in our findings. The top three are C1-3, C5-5, and C3-2. There are six negative managerial strategies. The top three are C2-2, C4-3 and C2-3.

4. **Conclusions.** With the severe impact of the declining birth rate in Taiwan, various kindergartens are closed because of poor management or low enrollment. This is partly because of the gap between kindergarten management and parents' expectations in the competitive settings. As the frontline personnel, faculty understands parents' needs most. Thus, this study investigated both parents and faculty as the research subjects to explore their kindergarten management strategy perception. Fuzzy statistics has been conducted to determine the perception gaps between faculty and parents. Positive and negative managerial strategies for kindergartens were developed and ranked through fuzzy logics in this study.

In this study, the most distinguished one is whether any foreign teacher in a kindergarten. In parents' view, in-school foreign teacher is a crucial factor with great influence on their choice. This strategy has been proposed by previous studies. Moreover, a manager should devote more resources in positive managerial strategies, such as participating in new experimental courses and increasing indoor activity space to improve the quality of kindergarten. These strategies are similar to the suggestions in previous studies. On the other hand, negative managerial strategies should be avoided in practices. For example, stop providing after-school child-care services, unreasonable after-school child-care service fees, and stop child-care in winter and summer vacations. The findings reveal that the parents have extended their needs in child-care services.

This study provides a practical fuzzy thinking to explore perception gaps between kindergarten faculty and parents under uncertain environment. Both positive and negative strategies provide useful knowledge to adopt or avoid in kindergarten management. For further studies, this study suggests extending the faculty's participating in the survey. Furthermore, the differences between city and urban areas are needed to reflect the specific issues.

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