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FUZZY DETECTION OF LEADERSHIP FOR LEARNING PERCEIVED BY PRINCIPALS AND TEACHERS

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Abstract. *This study aims to determine different perspectives on leadership for learning (LL) in current education settings. A total of 51 participants voluntarily joined this study, including 23 (45.1%) principals and 28 (54%) teachers from elementary schools in Taiwan. Of all the participants, 45.1% (n = 23) were male and 54.9% (n = 28) were female. Using the self-designed fuzzy questionnaire, we employed means and Wilcoxon rank-sum test (WRST) to evaluate principals' and teachers' different perceptions of leadership for learning. The findings reveal that principals had higher perceptions of LL, compared with teachers, while the gender did not display significant difference with WRST. The specific dimension differences have been tested. This study suggests that teachers should be encouraged to enhance their knowledge of leadership for learning and engage in school activities enthusiastically.*
Keywords: Elementary school, Fuzzy statistics, Leadership, Leadership for leaning, School management

1. **Introduction.** With the concept of student-centered learning and the emphasis on student learning outcomes, leadership for learning (LL) seems to provide more effective approaches for school improvement and educational development [1,2]. Regarding the term "instructional leadership" with emphasis on the role of principals, LL conceptualizes on "school leadership" and incorporates both a wider range of leadership resources and additional focus on actions [1-3]. Under LL, related factors should be taken into account in schools that may affect student learning, like principal leadership, teacher leadership, school management, teacher profession, classroom activities, and supportive resources. This concern provides more wide concept to deal with the content of LL.

1.1. **Problem statement.** Better learning performance has been expected in schools for years; therefore focusing on the new leadership model for better learning outcome has become basic requirement for school leaders in Taiwan. Nevertheless, the effect of LL is hard to be estimated in elementary schools widely.

1.2. **Purpose of study.** This study aims to evaluate the existing different perspectives on LL in current teaching settings. Given this purpose, we apply the self-designed fuzzy questionnaire and small group testing technique efficiently and effectively to tackle the problems.

1.3. **Research process.** First, related LL theories were used to construct the research framework. Second, the research design and method were discussed. Third, the results were discussed based on the fuzzy statistics. Finally, based on the findings, suggestions for LL in educational practices and academic were provided.

2. **Theoretical Framework.** Dempster argued that purpose, context, and human agency account for three fundamental elements at the heart of effective organizational leadership and lie at the center of LL [4]. Therefore, the LL has been viewed as a distinct form of educational practice [5]. The LL related activities for school leaders include collaborating to build visions and share goals [6,7], focusing on student learning and learning outcomes [6-9], promoting and participating in teacher professional development [8-10], shaping student learning culture [11,12], sharing leadership and accountability [8,13,14], ensuring an orderly and supportive environment [8,9,15], and encouraging parent and community to support learning activities in schools [6,10,16-18].

According to the LL suggested by the researchers, this study considered five dimensions in LL as its theoretical framework (that is, D1 to D5). Specifically, D1 is "building visions and setting goals with expectations", D2 is "focusing on student learning and learning outcomes", D3 is "promoting and participating in teacher professional development", and D4 is "shaping student learning culture", D5 refers to "sharing leadership and accountability". The fuzzy questionnaire design was based on these five domains to develop the related indicators for collecting data. This study assumes there is no significant difference between the principals and teachers in implementing leadership for learning in schools. If there is difference, which dimension of LL might be a gap?

3. **Method.** To verify our assumption, the fuzzy questionnaire and fuzzy statistics were used to collect and transform the interval data. The following section addressed how the fuzzy interval data were collected, transformed, and conducted under the Wilcoxon rank-sum test (WRST) in order to test the differences between these two groups. In this study, the designed logics for verifying the fuzzy data were presented as Figure 1.

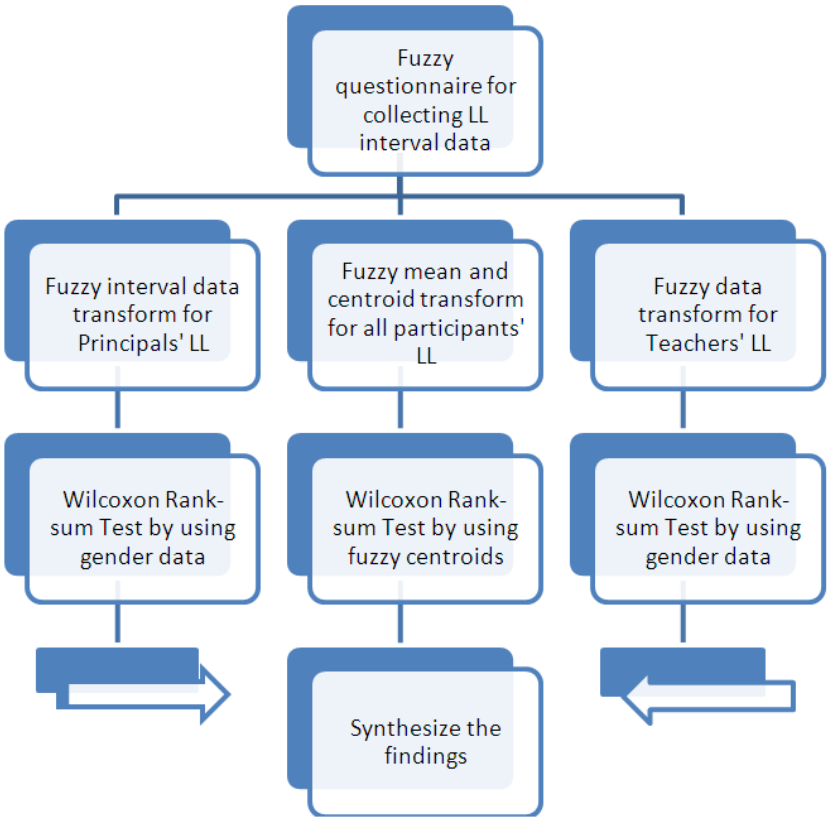

FIGURE 1. The logic of fuzzy data transformation

3.1. **Data collection.** The self-designed fuzzy questionnaire was used to collect data from the target groups in December 2016. Each item of the questionnaire was designed by using 1 (minimum weight) to 5 (maximum weight) scale to fit the fuzzy interval data format. For example, if N teacher's perception of LL is from 2 to 4, s/he needs to circle 2 and 4 to represent the range of perception based on the scale. The example of fuzzy questionnaire has been demonstrated in Figure 2.

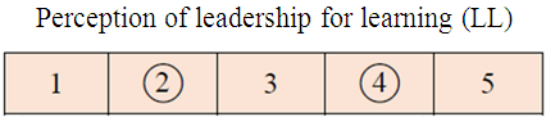

FIGURE 2. An example of self-designed fuzzy questionnaire

In this study, we successfully recruited 51 principals and teachers based on voluntary participation from elementary schools in Taiwan. The school scale differences (large, medium, and small) and school location (in urban, suburban district and in remote area) were taken into recruitment consideration. A total of 23 (45.1%) were principals and 28 (54.9%) were teachers. Among all the participants, 23 were male and 28 were female.

3.2. **Fuzzy data transformation.** In general, interval fuzzy data can be defined as a well-distributed membership function that uses fuzzy numbers. The symbol [ ] denotes a closed interval set. If $a, b \in R$ and $a < b$, $[a, b]$ is an interval fuzzy number. We considered a to be the lower bound of $[a, b]$ and b to be the upper bound of $[a, b]$. If $a = b$, $[a, b] = [a, a] = [b, b] = a = b$ and a (or b) are real numbers. Similarly, a real number k can be defined as $[k, k]$ for a special case [19-21].

Definition 3.1. *Fuzzy means (data with interval values) [22]:*
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 mean is then defined as $F\bar{x} = \left[\frac{1}{n}\sum_{i=1}^{n} a_i, \frac{1}{n}\sum_{i=1}^{n} b_i\right]$.

Definition 3.2. *If $[a, b]$ is an interval fuzzy set, then $c_o = \frac{a+b}{2}$ and $s_o = \frac{b-a}{2}$ represent the center and radius respectively [19,20].*

3.3. **Testing the differences.** The Wilcoxon rank-sum test is a nonparametric alternative to the two sample t-test which is based solely on the order in which the observations from the two samples fall [23,24]. We consider the fuzzy centroids of perceptions on LL are crucial points that can be used to compare the group's differences. In this study, the WRST was used to determine the different perceptions on LL between principals and teachers. By way of the ranking of each fuzzy centroid, the Z score was calculated by following WRST's formula, see Formula (1). The differences between male and female on LL will be verified with the similar process. The null hypothesis (H_0) is: principals' perception on LL (A) = teachers' perception on LL (B), whereas the alternative hypothesis is principals' perception on LL (A) $\neq$ teachers' perception on LL (B). Similarly, the hypotheses for gender difference and specific domains are listed with the same pattern. The assumption has been presented as Figure 3 [23]. If the result shows p-value $> Z$, then we should accept the null hypothesis. The formula for Z has been presented as follows:

$$Z = \frac{T - \frac{n(N+1)}{2}}{\sqrt{\frac{mn(N+1)}{12}}} \tag{1}$$

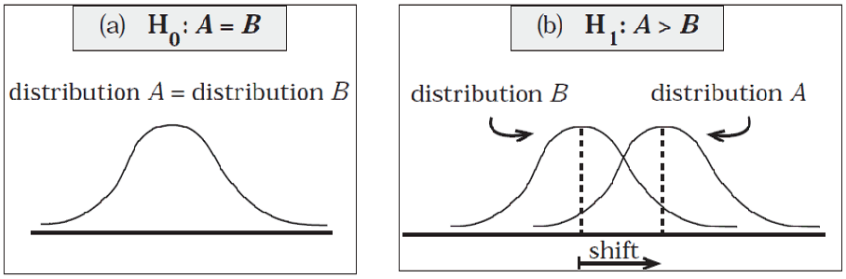

FIGURE 3. Illustration of H_0: $A = B$ versus H_1: $A > B$

TABLE 1. Transformation of fuzzy interval data by using fuzzy mean and centroid

Classify	All participants		Principals		Teachers	
	Fuzzy means	Centroid	Fuzzy means	Centroid	Fuzzy means	Centroid
TLL	[3.05, 4.28]	[3.67]	[3.47, 4.69]	[4.08]	[2.71, 3.90]	[3.31]
D1	[2.87, 4.18]	[3.53]	[3.29, 4.48]	[3.89]	[2.52, 3.80]	[3.16]
D2	[3.01, 4.19]	[3.60]	[3.57, 4.72]	[4.15]	[2.55, 3.75]	[3.15]
D3	[3.11, 4.33]	[3.72]	[3.45, 4.71]	[4.08]	[2.83, 4.02]	[3.43]
D4	[3.24, 4.39]	[3.82]	[3.67, 4.78]	[4.23]	[2.88, 4.06]	[3.47]
D5	[3.04, 4.29]	[3.67]	[3.38, 4.78]	[4.08]	[2.76, 3.88]	[3.32]

TABLE 2. Gender's fuzzy mean classified by different groups

Classify	Total	Male	Female	Male/ Principals	Female/ Principals	Male/ Teachers	Female/ Teachers
D1	[2.87, 4.18]	[2.86, 4.14]	[2.88, 4.06]	[3.31, 4.69]	[3.27, 4.60]	[2.27, 3.87]	[2.67, 3.76]
D2	[3.01, 4.19]	[2.88, 4.04]	[3.11, 4.31]	[3.46, 4.67]	[3.70, 4.80]	[2.13, 3.23]	[2.78, 4.04]
D3	[3.11, 4.33]	[2.94, 4.20]	[3.25, 4.44]	[3.36, 4.69]	[3.57, 4.73]	[2.40, 3.57]	[3.07, 4.28]
D4	[3.24, 4.39]	[3.12, 4.25]	[3.33, 4.50]	[3.59, 4.77]	[3.77, 4.80]	[2.50, 3.57]	[3.09, 4.33]
D5	[3.04, 4.29]	[3.13, 4.39]	[3.11, 4.38]	[3.03, 4.36]	[3.53, 4.83]	[2.57.3.43]	[2.87, 4.13]

4. **Results.** This study demonstrates the fuzzy statistics and WSRT that can be used to determine the differences between selected small groups. Table 1 displays the fuzzy interval data transformation including fuzzy mean and fuzzy centroid by calculating the total leadership for learning (TLL) and the other five domains with all participants, principals, and teachers, respectively. Comparing the fuzzy centroids, the principals had higher perceptions than teachers did, but the details of differences needed to verify by WRST. The gender's fuzzy interval data have been presented in Table 2. The fuzzy mean can be used to transform the fuzzy centroid following Definition 3.2.

Table 3 reveals principals' and teachers' different perceptions of LL based on Wilcoxon rank-sum test. According to the Wilcoxon rank-sum test, $Z = 3.56$, $p < .05$. Because $Z = 3.56 > Z_{0.05} = 1.645$, we should reject H_0. The differences exist in the groups. The result of WRST demonstrates that the principals had higher perceptions of LL, compared with teachers.

$$\text{Since } T = 786, m = 28, n = 23, N = 51,$$
$$\text{then } Z = \frac{T - \frac{n(N+1)}{2}}{\sqrt{\frac{mn(N+1)}{12}}} = \frac{786 - \frac{23(51+1)}{2}}{\sqrt{\frac{28\times 23\times (51+1)}{12}}} = 3.56,\ p < .05$$
$$(Z = 3.56 > Z_{0.05} = 1.645, \text{reject } H_0).$$

Table 3. Different perceptions on LL between principals and teachers tested by WRST

Position	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Centroids	3.33	3.50	3.53	3.57	3.80	3.87	4.10	4.10	4.10	4.10	4.10	4.13	4.20	4.30	4.37	4.37	4.37
Rank	10.5	15	16.5	18	23	25	32	32	32	32	32	35	38	39	43.5	43.5	43.5
Position	P	P	P	P	P	P	T	T	T	T	T	T	T	T	T	T	T
Centroids	4.37	4.37	4.37	4.43	4.43	4.50	1.33	1.47	1.70	1.83	1.93	2.50	2.70	2.93	2.97	3.33	3.43
Rank	43.5	43.5	43.5	47.5	47.5	49.5	1	2	3	4	5	6	7	8	9	10.5	13
Position	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Centroids	3.43	3.43	3.53	3.60	3.67	3.67	3.77	3.87	3.87	3.90	4.00	4.00	4.17	4.17	4.33	4.50	4.53
Rank	13	13	16.5	19	20.5	20.5	22	25	25	27	28.5	28.5	36.5	36.5	40	49.5	51

Note. P = principals' centroids of perceptions, T = teachers' centroids of perceptions

Table 4. Gender differences of perceptions on LL tested by WRST

Gender	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Centroids	1.33	1.47	1.83	1.93	3.33	3.43	3.43	3.53	3.57	3.80	4.00	4.10	4.10	4.10	4.10	4.17	4.17
Rank	1	2	4	5	10.5	13	13	16.5	18	23	28.5	32	32	32	32	36.5	36.5
Gender	M	M	M	M	M	M	F	F	F	F	F	F	F	F	F	F	F
Centroids	4.20	4.30	4.37	4.37	4.43	4.50	1.70	2.50	2.70	2.93	2.97	3.43	3.50	3.53	3.60	3.67	3.67
Rank	38	39	43.5	43.5	47.5	49.5	3	6	7	8	9	13	15	16.5	19	20.5	20.5
Gender	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Centroids	3.77	3.87	3.87	3.87	3.90	4.00	4.10	4.10	4.13	4.33	4.37	4.37	4.37	4.37	4.43	4.50	4.53
Rank	22	25	25	25	27	28.5	32	32	35	40	43.5	43.5	43.5	43.5	47.5	49.5	51

Note. M = males' centroids of perceptions, F = females' centroids of perceptions

According to the fuzzy mean, the medium of males' fuzzy centroid of LL was 3.59, the females' was 3.74. Table 4 presented the result of gender differences of perceptions by WRST. The males' and females' fuzzy centroids have been calculated as Table 4, then we ranked the centroids and gave the rank number for them from small (1) to the largest (51). Following the formula, we got the calculated $T = 597$, $m = 28$, $n = 23$, and $N = 51$. The different perceptions on LL between males and females have been determined by Wilcoxon rank-sum test. According to the rank-sum, we got the calculated $Z = -0.019$, $p > .05$. Because $Z = -0.019 > -Z_{0.05} = -1.645$, so we should accept H_0. The differences did not exist in gender in this study.

$$Z = \frac{T - \frac{n(N+1)}{2}}{\sqrt{\frac{mn(N+1)}{12}}} = \frac{597 - \frac{23(51+1)}{2}}{\sqrt{\frac{28\times23\times(51+1)}{12}}} = -0.019,\ p > .05$$

$$Z = -0.019 > -Z_{0.05} = -1.645$$

A figure was drawn up based on the perceptual centroids among principals, teachers, males, and females. Figure 4 displays the differences among the centroids with the LL and specific domains (D1 to D5). In Figure 4, D1 is "building visions and setting goals with expectations", D2 is "focusing on student learning and learning outcomes", D3 is "promoting and participating in teacher professional development", D4 is "shaping student learning culture", and D5 refers to "sharing leadership and accountability". The differences testing by WRST were displayed in Table 5.

Based on our WRST, there is no gender difference in D1, while there are differences between males and females from D2 to D5. The results reveal that males are inferior in these specific domains. Male and female teachers have shown different perceptions in D3 and D4. However, teachers and principals have shown different perceptions in all the five domains. The listed information related to the hypothesis can be used to weight which strategy should be selected in the decision-making.

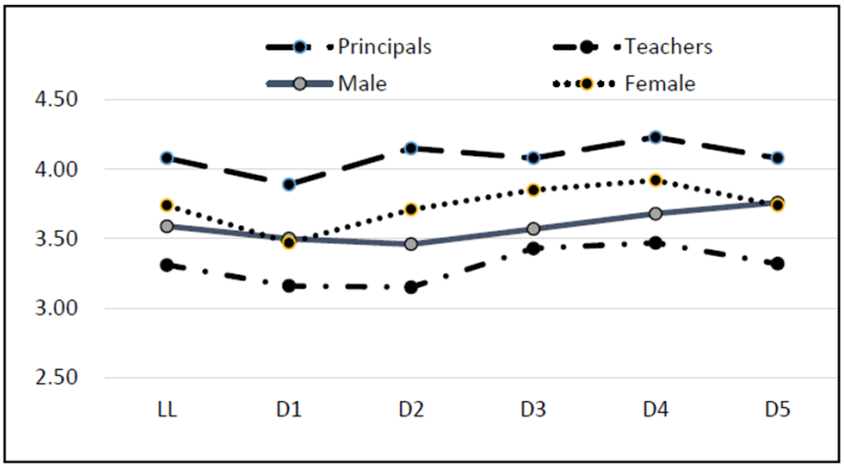

FIGURE 4. The different centroids in LL and specific domains

TABLE 5. Hypothesis testing for LL and different domains

Classify	Principal vs. Teacher	Male vs. Female	Principal Male vs. Female	Teacher Male vs. Female
D1	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	$H_0 Accept$	$H_0 Accept$
D2	$\boldsymbol{H_0 Reject}$	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	$H_0 Accept$
D3	$\boldsymbol{H_0 Reject}$	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	$\boldsymbol{H_0 Reject}$
D4	$\boldsymbol{H_0 Reject}$	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	$\boldsymbol{H_0 Reject}$
D5	$\boldsymbol{H_0 Reject}$	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	$H_0 Accept$
LL	$\boldsymbol{H_0 Reject}$	$H_0 Accept$	–	–

5. **Conclusions.** There was a significant difference between principals' and teachers' perceptions of LL in this specific setting. Principals had higher perception, compared with teachers'. However, gender did not affect participants' perception of LL. Based on the WRST in different domains, five suggestions were made. First, teachers' knowledge should be enhanced in building visions and setting goals with expectation (D1). Second, males' and teachers' leadership for student learning and learning outcomes should be focused (D2). Third, teachers should be encouraged to participate in their professional development (D3), particularly among male teachers. Next, teachers should be equipped with knowledge on shaping student-learning culture (D4), especially among male teachers. Moreover, teachers should be equipped with knowledge on sharing leadership and accountability (D5), particularly among male teachers.

From a practical perspective, this study demonstrates the LL in wider educational settings quickly. The self-designed fuzzy questionnaire can be used to collect interval data effectively and the fuzzy interval data can be transformed easily with a readable format. In order to save time and money, the nonparametric statistics is effective in testifying the gaps between groups with small samples. The study may provide an example for further studies in different settings.

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