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FUZZY CORRELATION AMONG STUDENT ENGAGEMENT AND INTERPERSONAL INTERACTIONS

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Abstract. *Student engagement has become a hot issue in education settings. Previous studies have provided a profound knowledge to tackle this issue from different perspectives. While engagement or not is an ambiguous question for student learning, it is not easy to reflect on a crisp answer in a traditional way. Similarly, the students' interpersonal interactions among the teachers, classmates, and parents have shown uncertainly relationship with their engagement. This study aims to explore the issues by using self-designed fuzzy questionnaire as an example for high school teachers. Fuzzy means, centroids, variances, and fuzzy correlations have been transformed. The results reveal some indicators have negative tendency fuzzy relationships. The fuzzy correlation coefficients did not display their significant differences in this case study. This study has demonstrated that the fuzzy statistics can provide an example to tackle the similar issue on a class basis in education settings.*

Keywords: Fuzzy correlation, Fuzzy questionnaire, Interpersonal interactions, Student engagement, High school students

1. **Introduction.** Previous studies indicated that college students' time and energy devoted to purpose activities in campus have become one of the best predictors to explain their learning and personal development [1-4]. Student engagement is not conceptualized as an attribute of the student, but rather a state of being that is highly influenced by contextual factors, like home, school, and peers, which will provide consistent support for student learning [5]. The related literature supports that student engagement is defined as a concept that requires psychological connections within the academic environment (e.g., positive relationships between adults and students and among peers) in addition to student's active behavior (e.g., attendance, effort, and behavior). Effective interventions have also addressed student engagement comprehensively, not only focusing on academic or behavioral skill deficits, but also on the social, interpersonal aspects of schooling, particularly the need for supportive connections to other adults and peers [6]. For example, a process model focusing on students' motivational resources was used to frame a study examining whether engagement in the classroom shapes students' academic coping, and whether coping in turn contributes to subsequent persistence on challenging tasks and learning, which then feed back into ongoing engagement [7]. Various studies agreed that student engagement refers to a relevant and multidimensional construction that integrates students' thoughts, feelings, and behaviors [8,9]. Based on previous studies, researchers have incorporated a three-part typology emphasizing affective, behavioral, and cognitive

dimensions of engagement [1-3,8]. In this study, the conceptual framework of student engagement extended that students demonstrate their levels of engagement through a variety of emotional cognitive and behavioral engagement.

Surveys play a prominent role in assessment and institutional research in this field. For example, the NSSE College Student Report is one of the most popular surveys of enrolled undergraduates in the United States [10]. While engagement related studies in high school level is relatively neglected in current educational settings. Moreover, students live in a digital society, where the information technology related devices have become necessary tools in their daily life. This study argues the interpersonal interaction pattern might have changed in the young generations because they are over depended smartphones or laptops and lack of "face to face" with people. Therefore, realizing the relationships between student engagement and interpersonal interactions has become emergent issue in schools. For most of teachers, it is not possible to tackle the issues based on a larger scale survey, and then developing a small and practical way to realize the issue in their class is needed. Given this purpose, this study explores the status of student engagement and interpersonal interaction as an example in a selected class. This case study focuses on the relationship between student engagement and interpersonal interaction to develop an alternative way to tackle the issue.

This study begins with introduction to address the problem statement and purpose of research. Then, this study displays the logics of data transformation with fuzzy statistics. The third section will report the result of fuzzy data transformation. Finally, we make a conclusion and provide some suggestions for enriching knowledge in the fields.

2. Algorithm for Fuzzy Solution.

The engagement issue includes theoretical concepts and practical activities. This study reviews the related engagement literature and selects the target group in higher school level. The logic of fuzzy solution has been presented as follows.

1) Decide a research framework: We select two different concepts, student engagement and interpersonal interactions, in the research framework. Since the study focuses on fuzzy correlation solution, the related demographic variables will be neglected in this model. The concept of student engagement has been defined as emotion engagement, cognitive engagement, and behavioral engagement.

2) Design a fuzzy questionnaire: The self-designed fuzzy questionnaire for student engagement includes 19 indicators, in which eight indicators belong to behavioral engagement, six indicators belong to emotional engagement, and the other five belong to active cognitive engagement. The interpersonal interaction refers to the relationships that students are interactive with teachers, classmates, and family. The selected indicators have been verified by the invited five experts in this field. Each indicator of the questionnaire has been designed by using 1 (minimum weight) to 5 (maximum weight) scale to fit the fuzzy interval data format. For example, if N student's cognitive engagement is from 2 to 4, s/he needs to circle 2 and 4 to represent the range of perception based on the scale of the questionnaire.

3) Select a target group: The target group has been selected from a high school as an example to verify the relationship with fuzzy formats. The samples are 46 high school students in this case study.

4) Transform fuzzy data: The fuzzy interval data were collected by using self-designed fuzzy questionnaire. The data were transformed by fuzzy mean, center, variance, and fuzzy correlation. The related definitions will be addressed in the fuzzy correlation coefficient transformation and calculation of the fuzzy correlation coefficient section.

5) Report the results and draw conclusions: In the stage, the fuzzy correlation coefficients will be displayed by using the rule to define the fuzzy relevant interval. The findings will be reported in this section.

3. Fuzzy Statistics.

3.1. **Fuzzy correlation coefficient transformation.** Each indicator of the fuzzy questionnaire was designed by using a scale of 1 (minima) to 5 (maxima) for collecting fuzzy interval data. For example, if the nth student believed that the weighting for the kth indicator was 2-4, the student would circle "2" and "4" on the scale. The data have been transformed by following fuzzy formats of student engagement and the interpersonal interactions. We judge the selected indicators by using fuzzy means their centers and variances. We assume the centers as the points that might take the highest fuzzy membership function with the students' opinions. Considered the existing information constraint, the interval fuzzy numbers have been defined as follows [11,12].

The concept of interval fuzzy data can be defined as a well-distributed membership function with fuzzy numbers. The symbol of "[ ]" means a closed interval. If $a, b \in R$ and $a < b$, then $[a, b]$ is interval fuzzy data. It can be named "a" as the lower bound of $[a, b]$ and "b" as the upper bound of $[a, b]$; if $a = b$, then $[a, b] = [a, a] = [b, b] = a = b$, and it is a real number a (or b). Similarly, a real number k can be defined as $[k, k]$. If $[a, b]$ is an interval fuzzy set, we can define $c_o = \frac{a+b}{2}$, $s_o = \frac{b-a}{2}$, and they represent the "center" and "radius" or "variance" respectively. This study also defined an interval fuzzy number as the following format:

$$[c_o; s_o] \Rightarrow [c_o + s_o, c_o - s_o] = [a, b]$$

In this case, the $\ell = b - a$ is the length of the fuzzy interval measurement. For example, when we consider (x_i, y_i) as the first i sample value, $i = 1, 2, \ldots, n$; x_i, y_i are interval fuzzy numbers; $\overline{x}$, $\overline{y}$ represent its sample mean respectively. If we deal with both variables x_i, y_i as fuzzy numbers, we will obtain interval fuzzy distribution between the two variables Ix_λ and Iy_λ. The idea of interval distribution has displayed as Figure 1 [12].

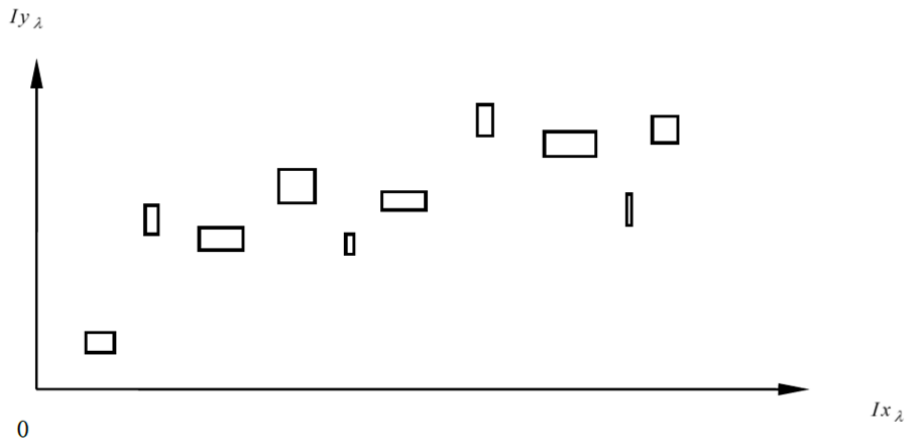

FIGURE 1. The distribution of x_i, y_i with fuzzy formats

3.2. **Calculation of the fuzzy correlation coefficient.** This study applied Formula (1) to calculating the upper bound correlation coefficient and used δ to adjust fuzzy correlation coefficient for a reasonable format [11-13]. Let l_{x_i} be the length of continuous interval sample x_i, l_{y_i} be the length of the sample interval y_i, and then the corrected length of correlation coefficient is

$$r_l = \frac{\sum_{i=1}^{n} \left(l_{x_i} - \bar{l}_x\right)\left(l_{y_i} - \bar{l}_y\right)}{\sqrt{\sum_{i=1}^{n} \left(l_{x_i} - \bar{l}_x\right)^2} \sqrt{\sum_{i=1}^{n} \left(l_{y_i} - \bar{l}_y\right)^2}} \tag{1}$$

Similarly, the center's fuzzy coefficient can be calculated by using the center related fuzzy data. We considered the δ as a filter to adjust the length of correlation coefficient. Formula

(2) for δ transformation is:

$$\delta = 1 - \frac{\ln(1 + |r_l|)}{|r_l|} \tag{2}$$

Since $0 < r_l < 1$, the range of δ is $0 < \delta < 0.3069$.

3.3. **Redefining the fuzzy relevant interval.** In the final stage, this study defined the rules for taking the center and the length of fuzzy correlation coefficients. Let C_{x_i}, C_{y_i} be samples from the interval fuzzy matrix central point, l_{x_i}, l_{y_i} for the interval length. The r is the center of the correlation coefficient, δ is the fitter which can be used to correct the length of the correlation coefficient. The relevant interval with lower and upper bounds has been defined as follows [12,14]:

(i) $r \geq 0$, $r_l \geq 0$, $(r, \min(1, r + \delta))$
(ii) $r \geq 0$, $r_l < 0$, $(r - \delta, r)$
(iii) $r < 0$, $r_l \geq 0$, $(r, r + \delta)$
(iv) $r < 0$, $r_l < 0$, $(\max(-1, r - \delta), r)$

Finally, the meanings of correlation coefficients can be justified following the rules: $r > .65$ belongs to the high correlation, $.35 < r < .65$ is the moderate correlation, and $r < .35$ means the low correlation. Similarly, $r > -.35$ is low degree of negative correlation, $-.65 < r < -.35$ can be classified in moderate negative correlation, and $r < -.65$ can be classified into high negative correlation.

4. Results.

4.1. **Fuzzy means, centers and fuzzy variances for related indicators.** Table 1 shows the results of fuzzy transformation for student engagement (SE) and interpersonal interactions. In regard to student engagement, the fuzzy center of cognitive engagement domain ($C_o = 2.71$) has shown higher than others. Referred to relationships, the fuzzy center of relationship with family ($C_o = 3.09$) is higher than others. The results of fuzzy variances reveal the interpersonal interactions with higher S_o than that of engagement indicators. It implies the interpersonal interactions demonstrated wider differences among these samples.

TABLE 1. Fuzzy means, fuzzy centers and variances for selected indicators

Indicators	**Fuzzy means**	C_o	S_o
Student Engagement (SE)	$[1.50, 3.38]$	2.44	0.94
Emotion engagement (EE)	$[1.42, 3.58]$	2.50	1.08
Cognitive engagement (CE)	$[1.69, 3.73]$	2.71	1.02
Behavior engagement (BE)	$[1.32, 3.02]$	2.17	0.85
Relationship with teachers	$[1.59, 3.89]$	2.74	1.15
Relationship with classmates	$[1.26, 4.70]$	3.01	1.73
Relationship with family	$[1.53, 4.57]$	3.09	1.52

4.2. **The result of fuzzy correlation coefficient transformation.** Table 2 demonstrates the results of fuzzy r, r_l and δ between student engagement and interpersonal interactions. The fuzzy transformation has followed the definition in Formulas (1) and (2). The r and r_l are original fuzzy correlation coefficients. Both r and r_l will be justified by their attribution of correlation in terms of negative or positive. The δ is the fitter for correcting the length of the correlation coefficient for more reasonable fuzzy correlation format. The range of fitter (δ) for relationship with teachers is from .001 to .041. The range of fitter (δ) for relationship with classmates is from .003 to .048. The range of fitter (δ) for relationship with family is from .019 to .138. Negative correlation coefficients imply the r or r_l needed to be adjusted to fit the fuzzy correlation coefficient format.

TABLE 2. Fuzzy correlation transformation with r, r_l and δ

Fuzzy R	Relationship with teachers			Relationship with classmates			Relationship with family		
	r	r_l	δ	r	r_l	δ	r	r_l	δ
SE	−0.040	−0.070	**0.033**	−0.013	−0.044	**0.021**	0.066	−0.076	**0.036**
EE	−0.269	−0.087	**0.041**	0.169	−0.007	**0.003**	−0.016	−0.039	**0.019**
CE	0.041	0.003	**0.001**	0.116	0.022	**0.021**	0.049	0.100	**0.047**
BE	0.268	0.061	**0.029**	−0.120	−0.079	**0.048**	0.134	0.307	**0.138**

4.3. **Determining the fuzzy correlation.** Table 3 displays the fuzzy correlation coefficients between engagement and personal interaction. Based on the rule of judgment for the correlation coefficients, $r > .65$ belongs to the high correlation, $.35 < r < .65$ is the moderate correlation, and $r < .35$ means the low correlation. Similarly, $r > -.35$ is low degree of negative correlation, $-.65 < r < -.35$ has been classified in moderate negative correlation, and $r < -.65$ is specified to high negative correlation. This study found the fuzzy correlation coefficients did not fit these scopes, because the result reveals that transformed fuzzy correlation coefficients located in the range from $-.035$ to $.035$. However, the results reveal student engagement has negative tendency in interaction with teachers and classmates. Emotional engagement indicators also show negative tendency with teachers and family. While behavior engagement has shown negative correlation with classmates. The relationship between student engagement and its sub-domain indicators is relative low. The findings may provide school teachers meaningful messages for their students' learning conditions.

TABLE 3. Fuzzy correlation between student engagement and interpersonal interactions

Fuzzy correlation	With teachers	With classmates	With family
SE	**(−0.074, −0.040)**	**(−0.034, −0.013)**	(0.030, 0.066)
EE	**(−0.300, −0.269)**	(0.166, 0.169)	**(−0.035, −0.016)**
CE	(0.041, 0.042)	(0.116, 0.132)	(0.049, 0.096)
BE	(0.268, 0.297)	**(−0.168, −0.120)**	(0.134, 0.272)

5. **Conclusions.** This study proposes a fuzzy format survey to explore the engagement and interpersonal interaction issue in schools. Even the result did not demonstrate the significant fuzzy correlations among these selected variables, this study provides a practical example for high school teachers to realize their students' problem and prompt to select better strategies for improvement. The self-designed fuzzy questionnaire with conceptual indicators can provide a strong theoretical support for the target issues. Fuzzy statistics has demonstrated which can be used to transform the interval data with reasonable formats in this study. The relationships among variables can be determined by fuzzy data transformation with means, centers, and variances. The study provides an example to transform fuzzy correlation coefficients and interpret their meanings in practices. For further studies, the fuzzy survey and data transformation can be used to tackle similar issues in the other settings.

REFERENCES

[1] J. A. Fredericks, P. C. Blumenfeld and A. H. Paris, School engagement: Potential of the concept, state of the evidence, *Review of Educational Research*, vol.74, pp.59-109, 2004.

[2] M. J. Furlong and S. L. Christenson, Engaging students at school and with learning: A relevant construct for all students, *Psychology in the Schools*, vol.45, no.5, pp.365-368, 2008.

[3] M. J. Furlong, A. D. Whipple, G. St. Jean, J. Simental, A. Soliz and S. Punthuna, Multiple contexts of school engagement: Moving toward a unifying framework for educational research and practice, *California School Psychologist*, vol.8, pp.99-114, 2003.
[4] G. D. Kuh, Assessing what really matters to student learning: Inside the national survey of student engagement, *Change*, vol.33, no.3, pp.10-17, 2001.
[5] J. Brophy, *Motivating Students to Learn*, 2nd Edition, Mahwah, New Jersey, Lawrence Erlbaum, 2004.
[6] K. R. Wentzel, Social relationships and motivation in middle school: The role of parents, teachers, and peers, *Journal of Educational Psychology*, vol.90, pp.202-209, 2009.
[7] E. A. Skinner, J. R. Pitzer and J. S. Steele, Can student engagement serve as a motivational resource for academic coping, persistence, and learning during late elementary and early middle school?, *Developmental Psychology*, vol.52, no.12, pp.2099-2117, 2016.
[8] E. Chapman, Alternative approaches to assessing student engagement rates, *Practical Assessment, Research and Evaluation*, vol.13, no.8, pp.1-7, 2003.
[9] S. R. Jimerson, E. Campos and J. L. Greif, Toward an understanding of definitions and measures of school engagement and related terms, *California School Psychologist*, vol.8, pp.7-27, 2003.
[10] G. R. Pike, NSSE benchmarks and institutional outcomes: A note on the importance of considering the intended uses of a measure in validity studies, *Research in Higher Education*, vol.54, no.2, pp.149-170, 2013.
[11] D.-F. Chang and H.-M. Wang, Colleagues' perception on servant leadership explained by fuzzy measurement, *ICIC Express Letters*, vol.8, no.1, pp.165-171, 2014.
[12] D.-F. Chang and W.-C. Chou, Detecting the linkage of time management and performance explained by soft computing, *ICIC Express Letters*, vol.9, no.3, pp.721-727, 2015.
[13] D.-F. Chang and W.-C. Chou, Fuzzy correlation with the issues of study in domestic campus or intent to study abroad, *Lecture Notes in Information Technology*, vol.10, pp.123-128, 2012.
[14] D.-F. Chang, W.-C. Chou and C.-W. Yu, Fuzzy relationship between *Facebook* using and security awareness, *ICIC Express Letters*, vol.8, no.1, pp.31-36, 2014.