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Evaluation of teaching quality in mathematical courses using relative important index: A case study in Neijiang Normal University

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ABSTRACT

Evaluation of teaching quality is an essential part of classroom teaching. The key to evaluation is to choose an appropriate evaluation tool and assign reasonable weights to its evaluation indexes. This study chooses reformed teaching observation protocol (RTOP) as an evaluation instrument to measure the relative importance of RTOP factors in mathematical courses. To achieve this goal, the relative importance index method was adopted to determine the values of relative importance among items. The indexes were ranked according to values. The sample of this study consisted of 30 mathematics teachers and students. All relative importance values were greater than 0.5, which indicates that items are medium to high level in importance. Furthermore, the ranking results showed that the factor lesson design and implementation ranked first, followed by propositional knowledge and procedural knowledge, while factor communicative interactions ranked last. The findings also show that lesson design and implementation are the most important factors in ensuring the teaching quality of mathematical courses among the respondents.

Keywords: classroom teaching evaluation; RTOP; mathematical courses; relative importance index; teaching quality

1. INTRODUCTION

A series of theoretical and practical research studies (Cerbin, 1994; Bernstein, 2008; Tong et al., 2020) have shown that scientific methods occupy an essential position in evaluating and enhancing the quality of classroom teaching. A key step of evaluation is choosing a reasonable, operable and practical evaluating system (Qiu et al., 2016; Li and Fu, 2018), and then promoting the improvement of the whole classroom teaching effect based on the system. Wu (2011) introduced a classroom observation instrument called "reformed teaching observation protocol" (RTOP) in China. The RTOP was designed to capture the current teaching reform movement, and improve the ability of science and mathematics teachers by an evaluation team at Arizona State University in 1995 (Piburn and Sawada, 2000; Lawson, 2003). RTOP consists of five factors which are lesson design and implementation, propositional knowledge, procedural knowledge, classroom culture-communicative interactions, and classroom culture-student/teacher relationships (short for B_1–B_5). Each factor comprises five observable classroom behaviors or items.

After a long-term development process and analysis of experimental data, psychometric properties including reliability, R-squared, correlation coefficient, face validity and construct validity, are all analyzed. From the content structure and statistical results, RTOP is considered a scientific and professional classroom teaching evaluation tool that is consistent with modern educational concepts and has strong feasibility and authority, with quantifiable

items, high levels of reliability (Adamson et al., 2003) and prediction validity (Sawada et al., 2010). In addition, Wu (2011) pointed out that RTOP could adapt to the current teaching evaluation environment by carrying out a physics classroom teaching evaluation, and its core evaluation concept was consistent with the reform concept of basic curriculum education in China. After that, Tong et al. (2020) made use of RTOP to evaluate physics classroom teaching and proved that RTOP is suitable for the context of classroom-teaching evaluation in China. Amrein-Beardsley and Popp (2012), Budd et al., (2013) and other authors have given detailed descriptions of the applications of RTOP, such as encouraging self-reflection. Teachers can also find the advantages or disadvantages of their teaching behaviors according to the standards of RTOP; therefore, it can guide teachers to reflect on and improve their teaching quality.

However, two main problems have been highlighted from previous studies (Wu, 2011; Tong et al., 2020). The first problem is regarding the localization of RTOP, and the second problem is related to the RTOP scoring rules needing further refinement. Hence, the focus of this study is to approach the first problem by measuring the relative importance index in RTOP.

2. MATERIALS AND METHODS

2.1 Instrument-RTOP

The structure of RTOP is listed in Figure 1, where C_i (i=1, 2, …,25) are the items further explained in the appendix.

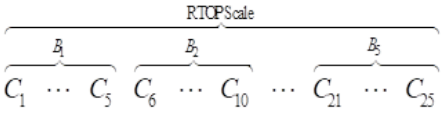

Figure 1. The structure of RTOP

2.2 Sampling and data collection

In order to collect data, a five-point Likert scale was used in a questionnaire based on the RTOP scale to rank the indexes' importance. For each index, the Likert scale was described from "very unimportant" to "very important". Meanwhile, this study intended to evaluate mathematical courses such as advanced algebra at Neijiang Normal University. The respondents here comprised 5 teachers and 25 senior students with mathematics backgrounds who were invited to complete the questionnaire and take part in an interview. The students had enrolled in the courses of advanced mathematics, advanced algebra, pedagogic principles and had other professional knowledge of mathematics education. Moreover, they had received at least a two-week internship in primary or secondary schools. Hence, they had some professional mathematics classroom teaching evaluation ability.

2.3 Relative important index method

For all Likert-type items, the relative important index (*RII*) method was used (Tam et al., 2007; Waris et al., 2014) to discuss the relative importance of the items. The formula of *RII* is given in Equation 1:

$$RII_i = \frac{\sum w_{ij}}{w_h * m} (0 \le RII_i \le 1) \quad (1)$$

where w_{ij} represents the weighting given to index-i by respondent-j within the range {0,1,2,3,4}, and the specific symbolic representation of 0: very unimportant ($\overline{\text{VUI}}$), 1: unimportant ($\overline{\text{UI}}$), 2: medium ($\overline{\text{M}}$), 3: important ($\overline{\text{I}}$), and 4: very important ($\overline{\text{VI}}$), w_h is the maximum weighting and in this article w_h =4, m is the number of respondents (in this article, m = 30).

Three important levels (IL) in teaching quality evaluation indexes, i.e. low level (L) ($0 \le RII_i < 0.5$), medium level (M) ($0.5 \le RII_i < 0.8$) and high level (H) ($0.8 \le RII_i \le 1$), were further converted from the values of RII.

3. RESULTS AND DISCUSSION

The respondents scoring results are listed in Table 1. By collecting and analyzing the data, values of *RII* and the importance levels for all items were obtained using Equation 1.

3.1 Reliability analysis

The Cronbach's α of the whole RTOP scale and sub-scale were analyzed with SPSS 22. The result are listed as in Table 2. The whole Cronbach's α coefficient of this questionnaire in RTOP was 0.967, and the Cronbach's α coefficient of five factors ranged from 0.820 to 0.942, which are all greater than 0.8 which highlights good reliability. Judging from the criteria of reliability coefficient (Tong et al., 2020), the evaluation data have consistency, stability and reliability in this survey.

3.2 Discussion of the results

Firstly, all values of *RII* ranged from 0.53 to 0.85. Hence, all items were at medium to high levels of importance in the evaluation of teaching quality. It shows that RTOP structure and item design are reasonable and acceptable in mathematical courses, which could be used to evaluate mathematical teaching classrooms in the following study.

Secondly, all items were ranked by descending values of *RII*. Through the ranking, C_8, the teacher had a solid grasp of the subject matter content inherent in this lesson, ordered as the first priority with a value of 0.85, and the other top five items were all greater than 0.8. The values of the lowest five items were all below 0.61. The items' ranking results are consistent with the views of the interviewees and teaching requirements. For example, they explained that teachers' professional knowledge directly affects the quality and process of student training. Besides, for a teacher, the success or failure of teaching quality often depends on the level of teachers' knowledge and teaching skills, therefore, they gave a high score for item C_8. Four of the respondents marked item C_{19} as "very unimportant", and six of the respondents scored item C_{19} as "unimportant". For these reasons, some teachers said in classroom teaching, they must complete teaching content according to the syllabus and teaching plan. Therefore, the item C_{19} ranked 25th with the lowest relative importance value of 0.53. Some respondents further explained that if a teacher shifts the focus of the classroom teaching because of students' questions, the teaching content cannot be completed in a given period of time.

Thirdly, the sum of *RII* values for factors B_1–B_5 were calculated as 3.65, 3.61, 3.59, 3.20 and 3.58, respectively. Factor B_1, lesson design and implementation, took the

most important position in the RTOP scale. According to the ranking values in Table 1, it is stated that two of the top five items belong to factor B_1, i.e. C_3 and C_4 ranked third and fifth, respectively. On the contrary, for factors B_2, B_3, B_5, only one item ranked in the top five items. Besides, all values of *RII* in B_4 are less than 0.8. Actually, this conclusion is also consistent with both theoretical conclusions and practical views. Without good instructional design, teachers' teaching effect will be greatly reduced and the quality of school education will be restricted. Furthermore, the majority of the interviewees said that "Lesson design and implementation" can be described as the guiding work for teachers to give good lessons and carry out teaching practices. Besides, lesson design reflects the teachers' working attitude.

Table 1. Respondents' scoring results

Scale	Items	The number of respondents scoring					*RII*	IL
		$\overline{\text{VUI}}$	$\overline{\text{UI}}$	$\overline{\text{M}}$	$\overline{\text{I}}$	$\overline{\text{VI}}$		
B_1	C_1	1	2	4	16	7	0.7167	*M*
	C_2	1	1	5	13	10	0.7500	*M*
	C_3	1	0	1	16	12	0.8167	*H*
	C_4	1	0	2	16	11	0.8000	*H*
	C_5	5	4	4	12	5	0.5667	*M*
B_2	C_6	2	2	3	14	9	0.7167	*M*
	C_7	2	3	2	15	8	0.7000	*M*
	C_8	0	0	2	14	14	0.8500	*H*
	C_9	2	3	4	14	7	0.6750	*M*
	C_{10}	1	4	5	14	6	0.6667	*M*
B_3	C_{11}	4	3	4	14	5	0.6083	*M*
	C_{12}	0	4	8	11	7	0.6750	*M*
	C_{13}	1	3	6	11	9	0.7000	*M*
	C_{14}	0	0	4	12	14	0.8333	*H*
	C_{15}	0	1	5	14	10	0.7750	*M*
B_4	C_{16}	1	4	6	13	6	0.6583	*M*
	C_{17}	3	4	2	12	9	0.6667	*M*
	C_{18}	3	5	4	12	6	0.6083	*M*
	C_{19}	4	6	6	10	4	0.5333	*M*
	C_{20}	0	3	5	13	9	0.7333	*M*
B_5	C_{21}	0	0	5	13	12	0.8083	*H*
	C_{22}	0	1	7	11	11	0.7667	*M*
	C_{23}	0	4	6	12	8	0.7000	*M*
	C_{24}	4	4	6	8	8	0.6000	*M*
	C_{25}	0	4	6	11	9	0.7083	*M*

Note: when the values of *RII* are the same, the items are ranked according to the number of respondents scoring very important

Table 2. Reliability of the RTOP scale

Category	Number of items	Cronbach's α
The whole questionnaire of the RTOP	25	0.967
B_1: lesson design and implementation	5	0.820
B_2: propositional knowledge	5	0.927
B_3: procedural knowledge	5	0.894
B_4: communicative interactions	5	0.942
B_5: student/ teacher relationships	5	0.909

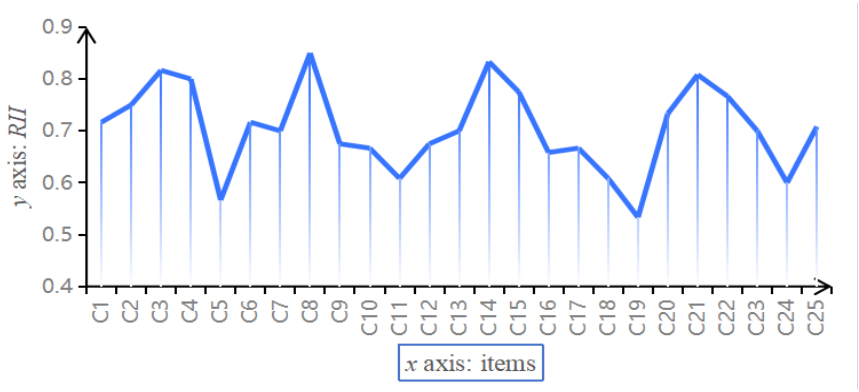

Figure 2. The ranking of items

4. CONCLUSION

This study aimed to evaluate teaching quality with the RTOP scale in mathematical courses. As to the relative important indexes, all values were greater than 0.5, and items were at medium to high levels of importance. Furthermore, the ranking results showed the factor "lesson design and implementation" ranked first, followed by "propositional knowledge" and "procedural knowledge", while the factor "communicative interactions" ranked last. The ranking trends of *RII* are in line with the Chinese classroom teaching requirements and environment, so the RTOP scale could be adopted to evaluate mathematical classroom teaching quality.

Although this is the first contact with the RTOP tools for some of the respondents, they have an all-round professional direction guide, which could help them to reflect on teaching, optimize the teaching process and then improve the quality of classroom teaching. Therefore, RTOP has a strong guiding significance for the evaluation of mathematical classroom teaching and teaching reform.

In our planned further study, the evaluation instrument- RTOP scale will be employed to evaluate classroom teaching quality in mathematical courses, combing with multi-attribute decision making methods and fuzzy evaluation linguistic terms.

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APPENDIX. RTOP SCALE

Factor	Item
B_1: lesson design and implementation	C_1: the instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein
	C_2: the lesson was designed to engage students as members of a learning community
	C_3: in this lesson, student exploration preceded the formal presentation
	C_4: this lesson encouraged students to seek and value alternative modes of investigation or problem-solving
	C_5: the focus and direction of the lesson were often determined by ideas originating from students
B_2: propositional knowledge	C_6: the lesson involved fundamental concepts of the subject
	C_7: the lesson promoted strongly coherent conceptual understanding
	C_8: the teacher had a solid grasp of the subject matter content inherent in the lesson
	C_9: elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so
	C_{10}: connections with other content disciplines and/or real-world phenomena were explored and valued
B_3: procedural knowledge	C_{11}: students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena
	C_{12}: students made predictions, estimations and/or hypotheses and devised means for testing them
	C_{13}: students were actively engaged in thought-provoking activities that often involved the critical assessment of procedures
	C_{14}: students were reflective about their learning
	C_{15}: intellectual rigor, constructive criticism, and the challenging of ideas were valued
B_4: communicative interactions	C_{16}: students were involved in the communication of their ideas to others using a variety of means and media
	C_{17}: the teacher's questions triggered divergent modes of thinking
	C_{18}: there was a high proportion of student talk and a significant amount of it occurred between and among students
	C_{19}: students' questions and comments often determined the focus and direction of classroom discourse
	C_{20}: there was a climate of respect for what others had to say
B_5: student–teacher relationships	C_{21}: active participation of students was encouraged and valued
	C_{22}: students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence
	C_{23}: in general the teacher was patient with students
	C_{24}: the teacher acted as a resource person, working to support and enhance student investigations
	C_{25}: the metaphor "teacher as listener" was very characteristic of this classroom.