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EXAMINING CHEMISTRY TEACHERS' PERCEPTIONS OF THEIR INTERACTION WITH CURRICULUM MATERIALS: A QUANTITATIVE APPROACH

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Abstract. *On the basis of the model of the interactive relationship between teachers and curriculum materials, this research proposed the four dimensions of the interaction of chemistry teachers with curriculum materials: 'routine use', 'scientific inquiry', 'STSE' and 'teacher learning'. An instrument with good validity and reliability was developed. Through a questionnaire survey of 208 junior high school chemistry teachers in three areas in Guangzhou, China, it was found that teachers thought they had a good interaction with curriculum materials, but the level of interaction is not very high. Teachers from different administrative areas were significantly different in the dimensions of 'STSE' and 'teacher learning'; teachers with different years of teaching experience showed significant differences in the dimensions of 'routine use', 'scientific inquiry' and 'STSE'. There was no interaction effect between the two variables of the areas and years of teaching. Designing educative curriculum materials and developing teacher training activities in terms of curriculum use are recommended to further improve teachers' ability to use curriculum materials.*

Keywords: *curriculum materials, curriculum use, chemistry teaching, survey research.*

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Introduction

Curriculum materials play a fundamental role in shaping classroom practice, helping teachers make thoughtful decisions about instruction. First of all, they often determine the taught curriculum for many teachers. Without the guidance of curriculum materials, teachers, especially novice teachers who are more dependent on curriculum materials because of a lack of teaching experience, often feel helpless (Bartholomew, Osborne, & Ratcliffe, 2004; Ball & Feiman-Nemser, 1988; Kauffman, Johnson, Kardos, Liu, & Peske, 2002). Secondly, curriculum materials can not only be used as teachers' learning resources, but also directly affect the teachers' choice of teaching methods, the design of teaching procedures, the assessment of students, etc., thus have an important influence on the curriculum implementation (Ball & Cohen, 1996; Davis & Krajcik, 2005). More importantly, curriculum materials are often seen as concrete vehicles for embodying the essential ideas of curriculum reform, playing a role in helping to initiate and sustain reform as well as guiding teachers to transform their knowledge and beliefs (Powell & Anderson, 2002). However, curriculum materials themselves cannot generate changes in the classroom. It is dependent on teachers who can use them to enact changes in practice (Fullan, 2001). Therefore, studying teachers' use of curriculum materials is an effective way in examining the effectiveness of curriculum reform and will have a positive significance for advancing and improving the curriculum reform.

Based on the above assumption, educational scholars have begun to pay attention to teachers' use of curriculum materials, and gradually developed an independent research field after the mid-1990s, called 'curriculum use' (Lloyd, Remillard, & Herbel-Eisenmann, 2009; Remillard, 2005). At present, in the field of 'curriculum use', research studies conducted in the international science education community mainly fall into these categories: (1) the comparison of teachers' classroom enactment with the intent of science curriculum materials

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(Schneider, Krajcik, & Blumenfeld, 2005; Vos, Taconis, Jochems, & Pilot, 2011); (2) the factors that influence teachers' use of curriculum materials (Brown, 2002; Roehrig, Kruse, & Kern, 2007), (3) preservice teachers' mobilization, critique and adaptation of existing curriculum materials (Beyer & Davis, 2012; Forbes, 2011); (4) the influence of pedagogical content knowledge (PCK) of teachers on curriculum materials use (Chen & Wei, 2015a); and (5) the effect of teachers' adaptations of the curriculum materials on student learning (Fogleman, Mcneill, & Krajcik, 2011). In the existing literature, as we have reviewed, most scholars only focus on how teachers interpret and make use of the curriculum materials but the issue of the interaction between teachers and curriculum materials has not been highlighted. In order to make up for the deficiency of the existing literature, this paper has developed an instrument to examine chemistry teachers' perceptions of their interaction with curriculum materials. With the purpose of addressing the issue of the interaction between teachers and curriculum materials by providing empirical data, we believe that this research would be helpful to enhance teacher professional development and implement the reform-oriented chemistry curriculum in practice.

It is well known that social context and teachers' characteristics have been assumed to play important roles in curriculum materials use (Remillard, 2005). In order to deeply explore the issue of the interaction between chemistry teachers and curriculum materials in a given social context with teachers' characteristics underscored, the present research was designed to select areas and years of teaching as variables, investigating the influence of the level of regional economic development and teaching experience on the interaction of teachers with curriculum materials. Specifically, this research was intended to answer the following three questions: (1) How do chemistry teachers perceive their interaction with curriculum materials? (2) What are the differences in the way they perceive their interaction with curriculum materials for chemistry teachers from different administrative areas in terms of their economic development? (3) What are the differences in the way they perceive their interaction with curriculum materials for chemistry teachers with different years of teaching experience?

Literature Review

Theoretical Perspectives on the Teacher-Curriculum Relationship

There is a basic assumption in the field of 'curriculum use' that teachers are central players in the process of transforming curriculum ideas into reality (Lloyd, Remillard, & Herbel-Eisenmann, 2009). It is the teachers who make textual teaching activities and plans become real classroom activities (Davis, Janssen, & Van Driel, 2016). The term 'use' is a broader word, including the analysis, modification and enactment of curriculum materials (Schwarz, et al., 2008). It should be noted that curriculum materials use is different from curriculum materials implementation with the former emphasizing the two aspects: a teacher would not enact the curriculum precisely as envisioned by the designers and the process is not a straightforward but involves substantial engagement, interpretation, and decision-making on the part of the teacher (Lloyd, Remillard, & Herbel-Eisenmann, 2009). That is to say, when employing the term of 'curriculum materials use', the subjectivity of teachers in the process of the enactment of curriculum materials is highlighted in a more intense way than using the term of 'curriculum material implementation'.

According to Brown (2009), there should be an interactive relationship between teachers and curriculum materials. On the one hand, curriculum materials affect teachers through their affordances and constraints; on the other hand, teachers make use of the curriculum materials through personal perceptions and decisions. Remillard (2005) has provided a more detailed interpretation of the relationship between teachers and curriculum materials in an interactive framework, in which she argued that teachers have an active interpretation and participatory roles in the use of curriculum materials. According to Remillard (2005), teachers should interpret, evaluate, adapt and enact curriculum materials according to their own knowledge and beliefs as well as students' needs and the teaching context they are in, and actively put the ideas and goals advocated by the curriculum and the specific curriculum content into the classroom. At the same time, continued by Remillard (2005), curriculum materials should also promote the professional development of teachers: they would learn new subject matter knowledge and pedagogical content knowledge from curriculum materials, and constantly improve the quality of teaching through the reflection on the use of curriculum materials. This framework echoes Powell and Anderson's (2002) view that 'the interaction of the teacher with the materials determines what happens in the classroom' (p. 112). Obviously, the interaction between teachers and curriculum materials is the core issue of the research field of 'curriculum use' and deserves in-depth examination. This paper is based on the interactive framework proposed by Remillard (2005) to examine chemistry teachers' perceptions of their interaction with curriculum materials.

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Theoretical Framework

To explore the issue of the interaction between teachers and curriculum materials, it is needed to explain the notion of 'interaction' and provide evidence for particular constituent dimensions of the interaction. As suggested by Remillard's (2005) framework of the teacher-curriculum relationship, 'interaction' can be explained in different ways. The first, teachers possess orientations toward the active, participatory use of curriculum materials in which they interpret, evaluate, and adapt curriculum materials. The second, teachers engage in these curriculum design activities specifically to promote reform-oriented practices in the classroom. The third, teachers possess orientations toward their own capacity to learn directly from, and from the use of, curriculum materials, including pedagogical content knowledge and subject matter knowledge. Based on the above argumentation, we defined the interaction of chemistry teachers with curriculum materials from four dimensions (Figure 1).

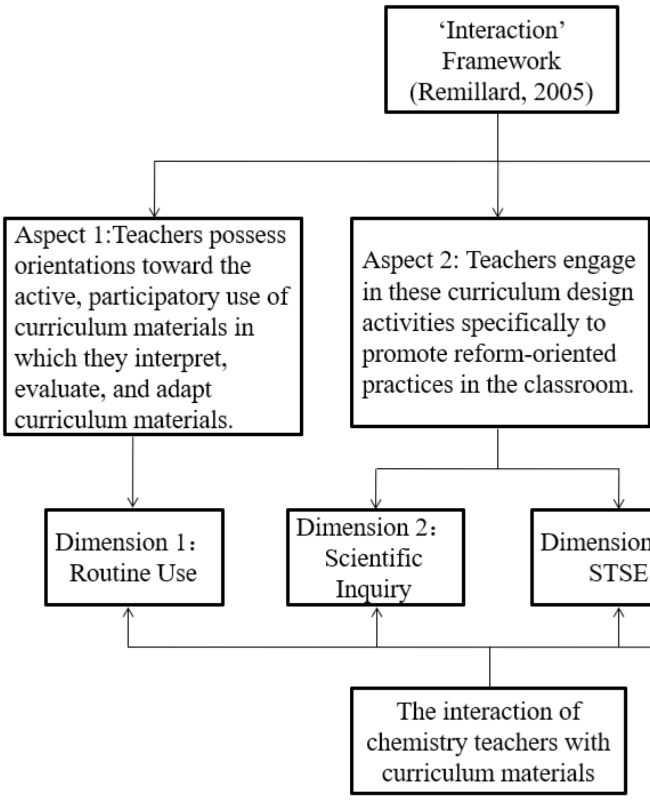

Figure 1. The framework of the interaction of chemistry teachers with curriculum materials.

The first dimension refers to the ways and habits of teachers in the use of curriculum materials in daily teaching, including teachers' evaluation of teaching objectives, teaching guidance, and student activities in curriculum materials, as well as the selection and adaptation of curriculum materials based on students' needs and available teaching resources. It is called 'routine use'.

The next two dimensions refer to teachers' enactment of curriculum ideas and curriculum content in classroom. Improving students' scientific literacy is regarded as a central goal in the current Chinese chemistry curriculum (MoE, 2011). Compared with the traditional curriculum, the most significant change is the inclusion of two themes of scientific literacy, 'scientific inquiry' and 'interaction between science, technology, society, and environment (STSE)', into the curriculum (Wei, 2012). 'Science inquiry' mainly refers to the ability to discover scientific problems in the real world, and the abilities to observe, question, design and carry out experiments, analyze and interpret data according to specific chemical phenomena (DeBoer, 2004). 'STSE' mainly aims to promote students to understand the positive effects of chemistry and technology on improving human life and promoting social development,

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pay attention to social or environmental issues related to chemistry and technology, and develop a sense of active participation in social decision-making (Pedretti & Nazir, 2011). Hence, the second and third dimensions focus on the enactment of the above two themes by teachers in the use of curriculum materials. These two dimensions are called 'scientific inquiry' and 'STSE' respectively.

The fourth dimension refers to how teachers use curriculum materials to promote their own professional development. It includes teachers' learning of new subject matter knowledge, teaching strategies, assessment methods from curriculum materials as well as reflections on the use of curriculum materials in teaching. It is called 'teacher learning'.

Research Methodology

General Background

This research in a quantitative survey. For the purpose of the research, the cluster sampling method was applied. In this research, chemistry teachers' perceptions of their interaction with curriculum materials were examined by 'Questionnaire on the Use of Curriculum Materials by Chemistry Teachers'(QUCMCT) developed by the researchers. Data were collected from junior high school chemistry teachers in three areas of Guangzhou, China during 2017-2018 academic year.

Participants

This research was conducted in Guangzhou, the capital of Guangdong province in southern China. Guangzhou is a metropolis with a high level of economic development, with a total area of 7434 square kilometers and a population over 20 million. There are 11 administrative districts in Guangzhou, which can be classified as three types: the urban area, the newly expanded urban area, and the suburban area. The urban area has a decent economic development with a concentration of high-quality educational resources mainly reflected in the large number of famous schools and teachers, and the overall high-quality education; while the suburban area has a relatively weak economic development with inadequate educational resources mainly reflected by the large number of relatively underequipped schools, a lack of famous teachers, and the overall average-quality education. The conditions of the newly expanded urban area are in the middle. In this research, we selected junior high school chemistry teachers from an urban area (X area), a newly expanded urban area (Y area) and a suburban area (Z area) of Guangzhou as the participants by cluster sampling. First, we contacted chemistry teaching supervisors[1] in these three areas, and distributed paper questionnaires when junior high school chemistry teaching and research activities were carried out in each area. The first author and the chemistry teaching supervisors of each area served as the examiners, and the time for the teacher to fill in the questionnaire was about 15 minutes. It should be noted that the questionnaire was filled out anonymously, which could avoid the social desirability bias and guarantee the authenticity of the teachers' reports. From the 216 questionnaires distributed to the teachers in the three areas, 208 valid questionnaires have been collected with the valid questionnaire recovery rate reaching 96.3%. Among them, there are 59 valid questionnaires in X area (recovery rate is 96.7%), 64 valid questionnaires in Y area (recovery rate is 98.5%), and 85 valid questionnaires in Z area (recovery rate is 94.4%). The demographic information of the participants is presented in Table 1.

Table 1. Demographic information of participants.

		X Area	Y Area	Z Area
Valid Questionnaires		59	64	85
Teaching Experience	1-3 Years	9 (15.3)	16 (25.0)	8 (9.4)
	4-9 Years	6 (10.2)	19 (29.7)	13 (15.3)
	10-Plus Years	44 (74.6)	29 (45.3)	64 (75.3)

Note: As for data about years of teaching experience, those outside the parenthesis are the total number of items, while those inside the parenthesis are percentages. Each percentage is calculated based on the total number of items and the corresponding number of valid questionnaires in its area.

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Curriculum Materials

In this research, the term 'curriculum materials' refers to chemistry textbooks and the accompanying teacher's guides. It is commonly recognized that the national curriculum system is centralized in China. Prior to the science education reform starting in 2001, there was a one-standard and one-textbook system in which all teachers in the country were expected to follow the same student textbook and teacher's guide in their teaching. Although the current science education reform intends to change this system by making available multiple textbooks and teacher's guides based on the same curriculum standards (e.g., junior high school chemistry), each province (e.g., Guangdong) still adopts one textbook and its accompanying teacher's guides. Hence, the participants in this research use the same curriculum materials.

In Guangzhou, the series of chemistry textbooks published by the People's Education Press (PEP), which has been designated as the national education press to produce the syllabi and textbooks directly under the leadership of the Ministry of Education (MoE) since the 1950s, is mandated in all junior high schools. This series comprises two textbooks (Volume A and Volume B). Units and sections constitute the main body of the textbooks. Each unit has two to four sections, which are the basic teaching units in class. In most cases, some special columns, such as 'experiments', 'inquiry activities', 'scientific perspectives', and 'history of chemistry', are inserted in the texts. Main knowledge points are summed in the 'summary of this unit'. The units end with student exercises. Each textbook is accompanied by one teacher's guide, which is organized in the same sequence as the textbooks. For each unit, the general status and function of this unit, the teaching objectives of this unit, and the time allocation for each section of this unit are provided. For each section, the specific status and the function of the section, and pedagogical suggestions are given.

Instrument

According to the four dimensions defined in the theoretical framework, we developed QUCMCT as the instrument of this research. The items of each dimension are compiled based on the specific meaning of each dimension, that is, the items are closely related to their relevant dimensions. Taking the 'teacher learning' dimension as an example, as argued in the section of 'Theoretical Framework', this dimension refers to how teachers use curriculum materials to promote their own professional development, including teachers' learning of new subject matter knowledge, teaching strategies, assessment methods from curriculum materials as well as reflections on the use of curriculum materials in teaching. According to this definition, four items which refer to 'learning of subject matter knowledge' (item 10), 'learning of teaching strategies' (item 7), 'learning of assessment methods' (item 16) and 'teachers' self-reflection' (item 4) respectively have been designed. To ensure the content validity, in the process of developing the questionnaire, we had consulted five experts on chemistry education for their comments on the four dimensions and had asked a dozen of school chemistry teachers in Guangzhou to participate in a pilot study. This work helped us strengthen the match between the items and their relevant dimensions and modify the wordings and the expressions of the questionnaire. For example, in the initial questionnaire, some items were described as 'I am able to draw on curriculum materials …' The experts and teachers both suggested that replace "draw on" with "mobilize" more appropriate. Therefore, in the final version, these items were changed to 'I am able to mobilize curriculum materials …' The questionnaire is presented in the Likert 5-point scale, which is composed of 17 items belonging to the 'routine use', 'scientific inquiry', 'STSE' and 'teacher learning' dimensions respectively. The contents of these items are all positive expressions, and each item has five options: fully disagree, disagree, not sure, agree, and fully agree, which are assigned 1 to 5 scores respectively. In Table 2, four items (one item for each dimension) are presented as examples of the questionnaire.

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Table 2. Four items in the questionnaire.

Dimension	Item
Routine Use	I am able to evaluate the student activities arranged in the curriculum materials (item 1)
Scientific Inquiry	I am able to mobilize curriculum materials to engage students in collecting and analyzing the experimental data (item 5)
STSE	I am able to mobilize curriculum materials to make students be aware of the social or environmental issues related to chemistry and technology (item 9)
Teacher Learning	I have learned new assessment methods from curriculum materials (item16)

In the guidance of the questionnaire, we explicitly require teachers to make the choice according to their actual perceptions of their daily use of curriculum materials. Therefore, the higher the teachers' score on an item or dimension, the better their ability or performance on that item or dimension they think they have. For instance, in the 'routine use' dimension, if teachers have higher scores, that means teachers think they can be more active in evaluating the objectives and activities of curriculum materials and are more adept at mobilizing curriculum materials according to students' needs and available resources. At the outset of the questionnaire, participants need to answer two personal background questions on the district where he/she lives and years of teaching experience.

The validity of the scale was examined from three aspects: the degree of differentiation, the internal structure, and the goodness-of-fit of the model, and the reliability of the scale from the internal consistency reliability. First, the highest 26% and the lowest 26% of the teacher data in terms of the total score in the scale were categorized as high-score and low-score groups. The independent sample *t*-test showed that there was a significant difference between the two groups of data in all items ($p < .001$), indicating a decent degree of differentiation. Secondly, the Pearson correlation showed that there was a significant positive correlation between the scores of each item and of the dimension to which it belongs. ($r = .630\text{-}.837$, $p < .01$), and a significant positive correlation between the scores of each dimension and of the scale ($r = .860\text{-}.942$, $p < .01$), indicating that the scale had a good internal structure. Next, Confirmatory factor analysis (CFA) was run by Amos 21.0. All goodness-of-fit indices ($\chi^2/df = 1.184$, $GFI = .943$, $AGFI = .903$, $TLI = .986$, and $RSMEA = .030$) indicated good model fit. Therefore, we accepted the four-factor model and divided the scale into four dimensions. Finally, Cronbach's alpha value for each dimension was shown in Table 3, ranging from .739 to .931, indicating that the scale had strong internal consistency reliability (Nunnally, 1978). Based on the good validity and reliability of the questionnaire, teachers' response to the questionnaire could be regarded as reliable, reflecting the actual perceptions of their use of curriculum materials.

Table 3. The Cronbach's alpha value for each dimension and the scale.

Dimension	Sum of Item	Item Number	Cronbach's alpha
Routine Use	5	1, 6, 8, 11, 14	.791
Scientific Inquiry	4	3, 5, 12, 15	.785
STSE	4	2, 9, 13, 17	.813
Teacher Learning	4	4, 7, 10, 16	.739
Scale	17	1-17	.931

Data Analysis

Based on the data collected from the valid questionnaires, analysis results about the chemistry teachers' perceptions of their interaction with curriculum materials were obtained through Excel and SPSS. Different responses from different teachers were firstly inputted in the Excel, and then transcribed into the data document that was applicable to SPSS for further analysis.

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With the help of SPSS 22.0, the data analysis of this research mainly contained two aspects. The first was to make an overall analysis of the scores of all samples, and detect if there was a statistically significant difference between the mean scores of the four dimensions; the second was to select the areas (X area, Y area, Z area) and years of teaching experience (1-3 years, 4-9 years, 10-plus years) as variables by taking into account the answers about background information of the questionnaire, and then carried out two-way ANOVA and one-way ANOVA.

Research Results

Overall Results of All Samples

In general, if the mean score in a certain dimension is more than 3.5, it means that teachers have positive perception on that dimension. In Table 4, the mean scores of all dimensions and of the scale are more than 3.5, but none exceed 4. It indicated that teachers thought they had a good interaction with the curriculum materials, but the level of interaction is not very high.

Table 4. An overall analysis of all samples (*N* = 208)

Dimension	*M*	*SD*
Routine Use	3.97	.51
Scientific Inquiry	3.85	.59
STSE	3.98	.55
Teacher Learning	3.93	.56
Scale	3.93	.48

The mean scores of the four dimensions were ranked in a descending order as follows: STSE> routine use> teacher learning> scientific inquiry. The mean score of 'STSE' was relatively high, while the mean score of 'scientific inquiry' was relatively low. By comparing the mean scores of the four dimensions, it was found that there existed a significant difference between the mean scores of the four dimensions ($F = 16.696$, $p < .001$, $\eta^2 = .075$). Then Bonferroni method was adopted to run the pairwise comparisons (Holm, 1979). We found that the mean score of 'scientific inquiry' dimension was statistically significantly lower than that of the other three dimensions ($p < .05$), while there was no significant difference between the other three dimensions ($p > .05$). The results showed that in terms of the four dimensions, teachers had a lower self-evaluation in 'scientific inquiry' dimension.

Interaction Effect between Two Variables

Two-way ANOVA was used to test whether there existed interaction effect between the two variables of the area and years of teaching experience. As indicated in Table 5, there was no interaction effect between the two variables in the average scores of each dimension and of the scale ($p > .05$). Therefore, we run one-way ANOVA for each of the two variables in the next step.

Table 5. Interaction effect between two variables

Variables	Dimension	*F*	*p*
Area × Years of Teaching	Routine Use	.736	.569
	Scientific Inquiry	.332	.856
	STSE	.337	.853
	Teacher Learning	1.133	.342
	Scale	.466	.761

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A Comparison of Teachers in Different Areas

The mean scores of the teachers in the three areas in each dimension and the scale were shown in Table 6. From Table 6, we can see that teachers in the three areas had a mean score of 3.5 or more in each dimension and the scale. In a further comparison, teachers in Y area had the highest mean scores in the dimensions of 'routine use' and 'STSE'. Teachers in Z area had the highest mean scores in the dimensions of 'scientific inquiry' and 'teacher learning' and the scale, while teachers in X area had the lowest mean scores in all dimensions and the scale.

Through one-way ANOVA, it was found that the teachers in the three areas were significantly different in the mean scores of the dimensions of 'STSE' and 'teacher learning', and of the scale ($p < .05$). Bonferroni method was adopted to run the pairwise comparisons. The results showed that in the dimension of 'STSE', the mean score of teachers in Y area was significantly higher than those of teachers in X area; in the 'teacher learning' dimension and the scale, the mean score of teachers in Z area was significantly higher than those of teachers in X area.

Table 6. A comparison of teachers in different areas

Dimension	X Area (*N* =59)		Y Area (*N* =64)		Z Area (*N* =85)		*F*	Effect Size (η2)	Pairwise Comparisons
	M	*SD*	*M*	*SD*	*M*	*SD*			
Routine Use	3.88	.48	4.02	.53	4.00	.52	2.427	.023	
Scientific Inquiry	3.72	.55	3.86	.67	3.93	.54	2.872	.027	
STSE	3.82	.51	4.05	.55	4.02	.56	7.338*	.067	Y >X
Teacher Learning	3.75	.54	3.95	.60	4.05	.52	9.292*	.083	Z >X
Scale	3.80	.44	3.97	.54	4.00	.49	7.271*	.066	Z >X

*Note: ① X area is an urban area; Y area is a newly expanded urban area, Z area is a suburban area; ② *p < .05*

A Comparison of Teachers with Different Years of Teaching Experience

The mean scores of teachers with different years of teaching experience in all dimensions and the scale were shown in Table 7. As indicated in Table 7, the mean scores of the three groups of teachers in all dimensions and the scale were all above 3.5. In a further comparison, we found that, with the exception of the dimension of 'teacher learning', the rankings of teachers with different teaching experience in the other three dimensions were as follows (in the descending order): more than 10 years > 4-9 years > 1-3 years.

Through one-way ANOVA, it was found that except for the 'teacher learning' dimension, teachers with different years of teaching experience demonstrated significant differences in the mean scores of all dimensions and of the scale ($p < .05$). Bonferroni method was used to run the pairwise comparisons. The results showed that the mean scores of teachers with 4-9 and more than 10 years of teaching experience were significantly higher than those of teachers with 1-3 years in the dimension of 'routine use'; in the 'scientific inquiry' and 'STSE' dimensions and the scale, the mean scores of teachers with more than 10 years of teaching experience were significantly higher than those of teachers with 1-3 years. Therefore, it can be seen that compared with experienced teachers, beginning teachers have a lower self-evaluation of the level of their interaction with curriculum materials. It implies that chemistry educators need to focus on improving the level of teachers with 1-3 years of teaching experience in using curriculum materials through adequate teacher training.

Table 7. A comparison of teachers with different years of teaching experience

Dimension	A (*N* =33)		B (*N* =38)		C (*N* =137)		*F*	Effect Size (η2)	Pairwise Comparisons
	M	*SD*	*M*	*SD*	*M*	*SD*			
Routine Use	3.66	.56	4.00	.37	4.03	.51	10.461*	.093	B>A C>A
Scientific Inquiry	3.57	.63	3.73	.59	3.95	.56	9.256*	.083	C>A
STSE	3.73	.59	3.94	.42	4.05	.56	7.617*	.069	C>A

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Dimension	A (*N* =33)		B (*N* =38)		C (*N* =137)		*F*	Effect Size (η2)	Pairwise Comparisons
	M	*SD*	*M*	*SD*	*M*	*SD*			
Teacher Learning	3.71	.53	4.01	.51	3.96	.57	2.898	.027	
Scale	3.67	.52	3.92	.42	4.00	.50	9.032*	.081	C>A

*Note: ① A=1-3 years, B=4-9 years, C=More than 10 years; ② *p < .05*

Discussion

In this research, a quantitative approach was adopted to examine chemistry teachers' perceptions of their interaction with curriculum materials in China. As the findings revealed, participant teachers thought they had a good interaction with curriculum materials, but the level of interaction is not very high. Among the four dimensions, the mean score of 'scientific inquiry' dimension was statistically significantly lower than that of the other three dimensions, while there was no significant difference between the other three dimensions. Teachers from different administrative areas were significantly different in the dimensions of 'STSE' and 'teacher learning'; teachers with different years of teaching experience showed significant differences in the dimensions of 'routine use', 'scientific inquiry' and 'STSE'.

As shown in the results, the score in the dimension of 'scientific inquiry' was relatively low, implying that chemistry teachers' enactment of the theme of 'scientific inquiry' in the process of using curriculum materials need to be improved. The similar findings came from the research of Zhang et al. (2003) and Chen and Wei (2015b). These two studies both demonstrated Chinese science teachers faced several challenges and dilemmas when enacting the idea of scientific inquiry in actual practice, such as external examinations, class size and teaching resources. The finding of this research is also consistent with the current situation of international science education, that is, although inquiry-oriented science curriculum materials are available, the implementation of these materials may not be adequate (e.g., Schneider, Krajcik, & Blumenfeld, 2005; Roehrig, Kruse, & Kern, 2007).

Some studies have shown that external environment is an important factor affecting the use of curriculum materials by teachers. In economically underdeveloped areas, teachers often fail to implement goals and activities in curriculum materials due to lack of adequate teaching resources (Lantz & Kass, 1987; Haney, Czerniak, & Lumpe, 1996; Nargund-Joshi, Rogers, & Akerson, 2011). In this research, the urban area has higher level of economic and educational development than the newly expanded urban and suburban areas and endorsed more education resources. However, teachers in the urban area did not show more positive perception than those in the newly expanded urban and suburban areas in terms of the use of curriculum materials. Instead, compared with the responses of teachers in the urban area, the newly expanded urban teachers had a higher self-evaluation in 'STSE' dimension; the suburban teachers had a higher self-evaluation in 'teacher learning' dimension. These findings went against the original research expectations to some extent, demonstrating that there may be no inevitable relation between the external environment in which teachers are located and their use of curriculum materials. The findings of this research could be interpreted in this way: in China's economically developed metropolis, for example Guangzhou, although the suburban areas belong to administrative districts with relatively low level of economic development, the education resources are sufficient to support the use of curriculum materials by teachers, indicating the development and progress of economy and education in China.

Furthermore, it was found that teachers with longer years of teaching had a higher self-evaluation of the level of their interaction with curriculum materials. We think this finding is understandable. Many studies have shown that teachers' PCK exert an important influence on the use of curriculum materials (e.g., Chen & Wei, 2015a; Bismack, Arias, Davis, & Palincsar, 2014). In general, novice or beginning teachers are relatively lacking in PCK, while teachers with rich teaching experience usually have more PCK (Van Driel, Verloop, & De Vos, 1998). As teachers with longer years of teaching have higher degree of familiarity with curriculum materials and the use of curriculum materials, it is little wonder they had a higher self-evaluation of the level of their interaction with curriculum materials.

As mentioned earlier, although some research on science teachers' use of curriculum materials had been presented in the literature, we defined the notion of 'interaction' into four dimensions and developed an instrument to examine teachers' perception of their interaction with curriculum materials for the first time, especially paying attention to the influence of curriculum materials on the teacher professional development. Moreover, we

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have tried to reveal the influence of social context and teachers' characteristics on the interaction of teachers with curriculum materials by two variables. In this regard, we believe that this research has made a contribution to the international literature of curriculum use in the field of chemistry and science education. Furthermore, there have been many studies on science teachers' beliefs or perceptions, such as beliefs about science teaching (Buldur, 2017; Lumpe, Czerniak, Haney, & Beltyukova, 2012), beliefs about science (Kind, 2015; Tsai, 2002) and perceptions of school environments (Huang, 2006; Huang & Fraser, 2010). However, no research has been reported on teachers' perceptions of their interaction with curriculum materials. In this sense, the present research has filled in the gap.

Conclusions and Recommendations

This research contributed to existing theory and knowledge base of curriculum use by developing an instrument to examine chemistry teachers' perceptions of their interaction with curriculum materials. In what follows, the recommendations for teacher professional development and future research are provided.

The results of this research showed that teachers thought they had a good interaction with curriculum materials, but the level of interaction is not very high. Therefore, it is recommended that appropriate measures be taken to further improve teachers' ability to use curriculum materials. Specific recommendations are made in the following two aspects in the view of the interaction between chemistry teachers and curriculum materials.

Firstly, to better support beginning and experienced teachers' learning, it is crucial for curriculum developers to design educative curriculum materials that support their teaching practice by making them flexibly adaptive or conducive to local adaptation. Embedding features that are explicitly educative for teachers who use the curriculum materials will help these materials speak to teachers rather than through them, thus making the teacher-curriculum relationship more productive. For example, for the theme of 'scientific inquiry', the curriculum materials may elaborate on the 'learning cycle'-a mode of inquiry teaching-supplemented by specific teaching cases. These educative supports embedded within curriculum materials can help teachers learn to employ principles and methods of inquiry-oriented chemistry teaching over time and across settings.

The second is to develop teacher training activities in terms of curriculum use, including continuing education program, metropolis or district-level teaching and research activities, and school-based training activities. For example, when carrying out metropolis or district-level teaching and research activities, teaching supervisors can take several specific teaching cases as examples and discuss in depth with in-service teachers on how to use curriculum materials rationally and effectively while taking into account the meaning of scientific literacy education; schools may also invite expert teachers to share the use of curriculum materials before, during, and after class with their own teaching cases, which will set a good role model and be a reference for teachers, especially beginning teachers.

Finally, it is admitted that we only examined teachers' perceptions of their interaction with curriculum materials, rather than the specific behavior of interaction. This is the limitation in this research. In the future, qualitative research can be used to delineate how chemistry teachers interact with curriculum materials in depth, including how they evaluate and adapt curriculum materials, how they mobilize curriculum materials to enact reform-oriented practice, and how they learned from curriculum materials, which will help us better understand the nature of the interaction.

Notes

[1] In China, the education department of each administrative district set up a research department of teacher education, which will be equipped with 1-2 chemistry teaching supervisors whose regular work is to guide the teaching of teachers in the district, and regularly organize teaching and research activities to promote the professional development of teachers.

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