JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

EXAMINING THE FACTORS THAT INFLUENCE HIGH SCHOOL CHEMISTRY TEACHERS' USE OF CURRICULUM MATERIALS: FROM THE TEACHERS' PERSPECTIVE

Bo Chen,
Bing Wei,
Xiaoling Wang

Abstract. *This research aimed to examine the impact of different factors on high school chemistry teachers' use of curriculum materials in China. The examination was conducted on a theoretical framework in which three aspects of curriculum materials and three ways of curriculum use are involved and nine factors are suggested. Through a questionnaire survey of 212 chemistry teachers, the findings included the following aspects. Firstly, the nine factors more induced teachers to supplement the teaching elements, but less affected teachers to delete the original contents in the curriculum materials. Secondly, among the nine factors, 'knowledge about students' was recognized as the core factor in the three dimensions of teaching objectives, teaching strategies, and teaching activities, whereas 'class size' was regarded as the peripheral factor in all three dimensions. 'Teaching resources' was another peripheral factor for the dimensions of teaching strategies and teaching activities. Thirdly, two factors were found to be significantly different among teachers who are in different areas of economic development: 'knowledge about students' and 'class size'. Fourthly, 'knowledge about curriculum' and 'knowledge about instructional strategies' were two factors that made significant differences in the comparison among teachers who have different years of teaching experience.*

Keywords: *curriculum materials, curriculum use, chemistry teachers, influencing factors*

Bo Chen
Nantong University, P. R. China
Bing Wei
University of Macau, Macau, P. R. China
Xiaoling Wang
Jiedong No.2 Middle School, P. R. China

Introduction

Curriculum materials are important resources for teachers to design and conduct teaching activities, which usually include textbooks, teacher's guides, teaching videos, exercise books, and other auxiliary materials. They provide teachers with a guide to think about what to teach, to whom, and how (Stein et al., 2007). It is commonly recognized that the use of curriculum materials is the core component of teachers' work (Lloyd et al., 2009). Educational scholars have been exploring the use of curriculum materials since the 1980s, and gradually developed an independent research field after the mid-1990s, called 'curriculum use' (Lloyd et al., 2009; Remillard, 2005). Most would agree that teachers' understanding and use of curriculum materials is complex and is usually affected by multiple factors (Brown, 2009; Powell & Anderson, 2002). Hence, the influencing factors of teachers' use of curriculum materials have been concerned by the field of 'curriculum use'.

Over the past two decades, varieties of approaches have been adopted to the exploration of the factors that influence the use of curriculum materials by science teachers, including questionnaires, interviews, classroom observation (e.g., Forbes, 2013; Roblin et al., 2018; Roehrig et al., 2007). Regardless of research paradigm adopted, either qualitative or quantitative, most of them focused on the influences exerted by some discrete factors (e.g., teachers' knowledge, teachers' beliefs, quality of curriculum materials) on teachers' curriculum use. However, they did not comprehensively and systematically investigate the impact of various factors on the way teachers use curriculum materials (i.e., supplement, adaptation, deletion) from teachers' perspective. This research attempted to bridge this research gap.

As argued above, teachers' use of curriculum materials is a complex process and involves a variety of factors. Hence, it is convinced that those various factors should be considered simultaneously so as to reveal which factors are more important and have more impact. For instance, teachers' knowledge is most closely related to teaching practice (Van Driel et al., 2014). According to Shulman (1987), teachers' knowledge can be divided into different categories, including content knowledge, curriculum knowledge, knowledge

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

of learners. Then, which category of teachers' knowledge has a greater impact on the use of curriculum materials is worth exploring. Furthermore, teachers are the person who use curriculum materials. We contended that their own voices on what factors affect their use of curriculum materials is an irreplaceable indicator that needs to be concerned with. Therefore, it is necessary to examine the factors that influence curriculum use from the teacher's perspective. While focusing on teachers' perspective and especially on their various 'levels of thinking and acting' (Vos et al., 2010, p.197), such an in-depth investigation of this study will be not only helpful to examine the use of curriculum materials in detail, but also to provide valuable suggestions for teacher professional development and the management of curriculum implementation.

Theoretical Framework

The Factors that Influence Curriculum Use

When recognizing that multiple factors might affect teachers' use of curriculum materials, many researchers have worked on some specific factors that have an actual impact. The influence of teachers' knowledge has been confirmed in the literature. For example, when investigating six high school chemistry teachers' interactions with the standards-based curriculum materials, Chen and Wei (2015a) found that these teachers' knowledge about students, knowledge about curriculum, and knowledge about instructional strategies influenced their adaptations of the curriculum materials. Brown (2002) also found that these types of knowledge affect the degree that science teachers implement inquiry-oriented curriculum materials. Teachers' beliefs have been proved to be an important influencing factor. In an empirical study, Roehrig et al. (2007) selected 27 high school chemistry teachers in the United States as participants to examine their teaching beliefs and their implementation of an inquiry-based curriculum, and found that the extents of inquiry in their teaching were significantly related to their teaching beliefs. In other words, teachers' beliefs about teaching strongly influenced their use of inquiry-based curriculum materials.

Besides teachers' knowledge and beliefs, the quality of curriculum materials also affected the use of curriculum materials. Hemmi et al. (2019) found that when Swedish mathematics teachers used translated Finnish curriculum materials, the lack of a clear rationale behind the organization of materials made a problem of interaction between teachers and curriculum materials. In another empirical study, Roblin et al. (2018) found that as the critical feature of science curriculum materials, providing adequate guidance and support to teachers had a positive impact on both student and teachers' outcomes. In addition, researchers have found that some context-specific factors affect the use of curriculum materials. These factors include teaching resources (Janssen et al., 2013; Nargund-Joshi et al., 2011), time constraint (Bodzin et al., 2003; Forbes, 2013), external examination (Chen & Wei, 2015a; Roehrig et al., 2007), and class size (Eisenmann, 2011; Zhang et al., 2003).

In sum, there are nine factors that have been widely reported, they are: teaching beliefs, knowledge about curriculum, knowledge about instructional strategies, knowledge about students, quality of curriculum materials, external examination, teaching time, teaching resources, and class size. Referring to Remillard (2005), who argued that the teacher, curriculum materials, and contexts were three main aspects that influenced teachers' curriculum material use, these nine factors can be divided into three categories: the first four factors fall into the category of teachers, quality of curriculum materials belongs to the category of curriculum materials, and the last four factors come together under the category of context. Hence, we took these factors as the observation points of this research and tried to reveal their influence on teachers' use of curriculum materials. The illustration of these nine factors is presented in Table 1.

Table 1
The Illustration of Nine Factors

Categories	Factors	Illustration
Teachers	Teaching beliefs	Beliefs about the purposes and orientations for teaching chemistry
	Knowledge about curriculum	Knowledge about curriculum standards and teaching materials
	Knowledge about instructional strategies	Knowledge about what kind of teaching strategy is applicable to a certain teaching content

https://doi.org/10.33225/jbse/20.19.893

Categories	Factors	Illustration
	Knowledge about students	Knowledge about students' characteristics, learning needs, and learning difficulty
Curriculum materials	Quality of curriculum materials	The rationality and guidance of the content in the curriculum materials
Context	External examination	The evaluation of students' academic performance
	Teaching time	The number of teaching hours arranged by the school
	Teaching resources	The basic teaching facilities provided by the school, such as teaching buildings, laboratories, teaching equipment, etc.
	Class size	The number of students in the class

Dimensions of Use and Ways of Use

According to Remillard (2005), curriculum use involved a participatory relationship between teachers and curriculum, and its nature was the interaction between teachers and curriculum materials. Regarding the level of interaction, Van Hiele (1986) distinguished three levels of abstraction (i.e., Gestalt level, schema level, theory level). These levels reflected both the types of communication on the innovative materials and teachers' learning in mastering the innovation. Based on Van Hiele's level theory, Vos et al. (2010) constructed the concept of 'three levels of thinking and acting', which contained specific teaching activities on the ground level, teaching-learning strategy on the descriptive level, and aims and objectives on the theoretical level. This concept has been successfully employed to identify characteristics of the interaction between teachers and innovative context-based teaching materials (Vos, et al., 2011). Referring to this concept, we took the 'three levels of thinking and acting', which were 'teaching objectives', 'teaching strategies', and 'teaching activities' as the dimensions of use in this research.

With regard to the ways of use, inspired by Brown (2009)'s classification of types of curriculum use, this research condensed the ways that factors affect the use of curriculum materials into three: supplement, adaptation, and deletion. Specifically, 'supplement' refers to the addition of teaching elements that are not included in the curriculum materials, 'adaptation' means that teachers adjust and modify the original content of the curriculum materials to a certain extent, and 'deletion' refers to the fact that teachers do not adopt some contents of curriculum materials according to their own teaching understanding.

Grounded on the above argumentation, the theoretical framework of this research was established (Figure 1). This framework would reflect the basic process of teachers' use of curriculum materials. As shown in Figure 1, the teaching objectives, teaching strategies, and teaching activities written in the curriculum materials are enacted in the classroom through teachers' perception and use. However, teachers' perception and use are usually affected by various factors, which make teachers supplement, adapt, or delete the elements of curriculum materials to a certain extent.

Research Focus

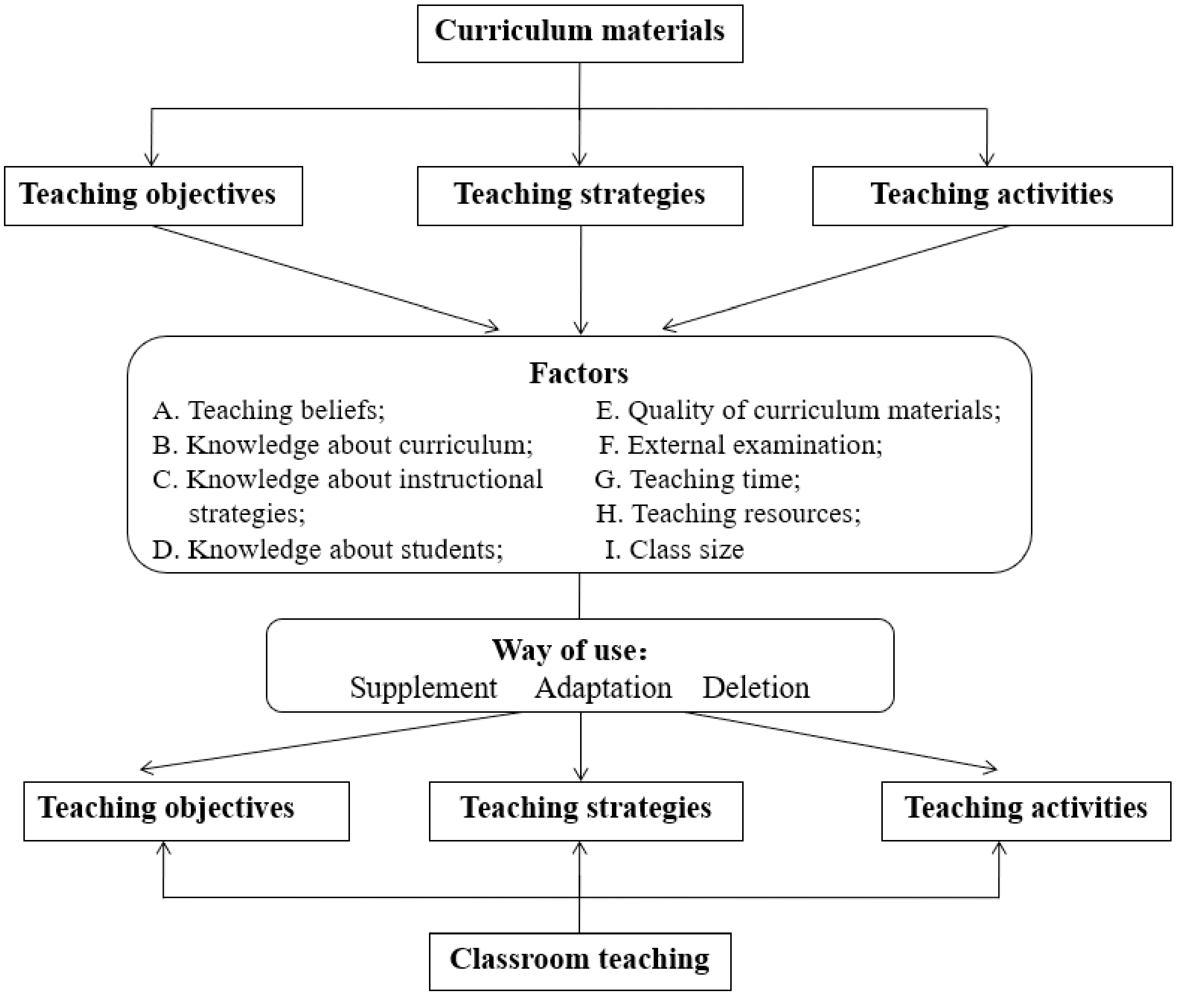
This research aimed to determine the extent to which the nine factors exerted impact on chemistry teachers' use of curriculum materials. According to Remillard (2005), social context and teachers' characteristics play important roles in the use of curriculum materials. Thus, it is reasonable to infer that the impact of these factors may be different in different social context and different groups of teachers. Hence, the present research was designed to select areas and years of teaching as variables, investigating the differences in the impact of factors on curriculum materials use for teachers from different areas of economic development and with different teaching experience. This research was intended to answer the following questions:

1) In chemistry teachers' view, to what extent do various factors exert impact on their use of curriculum materials?
2) Is there any significant difference in the degree of impact of various factors on their use of curriculum materials among teachers from different areas of economic development based on chemistry teachers' reports?
3) Is there any significant difference in the degree of impact of various factors on their use of curriculum materials among teachers with different years of teaching experience based on chemistry teachers' reports?

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 1
Theoretical Framework of this Research



Research Methodology

General Background

This research was a quantitative survey. For the purpose of the research, high school chemistry teachers' evaluations of the factors affecting their use of curriculum materials were examined by 'Questionnaire on Factors that Influence Chemistry Teachers' Use of Curriculum Materials'(QFICTUCM). Data were collected in June and July 2018 from the high school chemistry teachers in three areas of Guangzhou, China.

Context

In this research, the term 'curriculum materials' refers to chemistry textbooks and accompanying teacher's guides. In the chemistry education circle in China, textbooks and teachers' guides are regarded as entities of the curriculum (Wang, 2010a). Teachers rely on them to determine the content and sequence of teaching.

This research was conducted in Guangzhou, a metropolis in southern China. In Guangzhou, the high school

https://doi.org/10.33225/jbse/20.19.893

chemistry teachers use the series of chemistry textbooks and teacher's guides published by People's Education Press (PEP). Units and sections constitute the main body of textbooks. Each unit has three to six sections, which are the basic teaching units. Some special activities, such as 'experiments', 'thinking and communication', and 'practical activities', are inserted in the texts. Teacher's guides are matched with textbooks. For each unit, the status and function of this unit, teaching objectives, and teaching hours are given. For each section, the analysis of the teaching content, and teaching strategies are provided. In the present study, the teaching objectives and teaching strategies in the curriculum materials are written in the teacher's guides, and the teaching activities in the curriculum materials are presented in the textbooks.

Instrument

According to the theoretical framework above, we developed QFICTUCM as the instrument of this research. The questionnaire was based on the three dimensions of use, three ways of use, and nine factors. To ensure the content validity, in the process of developing the questionnaire, five experts on chemistry education had been consulted for their comments on the design of questions and some high school chemistry teachers in Guangzhou had been invited to participate in the pilot study. The experts and teachers were asked to provide feedback on the initial questionnaire, focusing on whether they understood the questions in the questionnaire and which statements in the questionnaire were not clear enough to cause ambiguity. This work was helpful in revising the questionnaire. For instance, in the initial questionnaire, the illustration of nine factors was not presented. Both the experts and teachers suggested that the illustration should be presented in the questionnaire so that teachers could better understand the factors. Therefore, following the advice of the experts and teachers, the illustration of the factors was added in the final version.

The questionnaire includes two parts: personal background information and main questions. Personal background information involves the district where the teacher lives and years of teaching experience. The main questions (questions 1-9) focus on the way teachers use curriculum materials and influencing factors in different dimensions. The detailed distribution of questions was shown in Table 2. Each question is divided into part A and part B. Part A inquires teachers about how they supplement, adapt, or delete the contents of curriculum materials in a particular dimension. The purpose of setting part A is to stimulate teachers' evaluations about the degree of influence of the factors in part B. For instance, before asking teachers to evaluate the degree to which nine factors affect them to add teaching objectives that are not included in the curriculum materials (Question 1B), an open-ended question is set to probe what kind of teaching objectives do they usually supplement (Question 1A). The details of Questions 1A and 1B are presented in the appendix. Part B includes the nine factors as the items and four responses as the options (4 = very much, 3 = somewhat, 2 = little, 1 = never). The higher the score selected by the teacher, the greater the degree of influence that the teacher thinks the factor has. This research focused on the data collected from part B questions.

Table 2
The Distribution of Questions in the Questionnaire

Dimensions of Use	Ways of Use	Questions
Teaching objectives	Supplement	1A; 1B
	Adaptation	2A; 2B
	Deletion	3A; 3B
Teaching strategies	Supplement	4A; 4B
	Adaptation	5A; 5B
	Deletion	6A; 6B
Teaching activities	Supplement	7A; 7B
	Adaptation	8A; 8B
	Deletion	9A; 9B

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Participants

Guangzhou is a metropolis with a high level of economic development. 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 study, we selected 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. To achieve this goal, the chemistry teaching supervisors[1] in these three areas were commissioned to distribute and collect questionnaires in their own area. From the 226 questionnaires distributed to the teachers in the three areas, 14 questionnaires were not completely filled in, and were therefore considered invalid. 212 valid questionnaires were collected with the valid questionnaire recovery rate reaching 93.8%. Among them, there were 62 valid questionnaires in X area (recovery rate is 95.4%), 67 valid questionnaires in Y area (recovery rate is 94.4%), and 83 valid questionnaires in Z area (recovery rate is 92.2%). The background information for the participants is shown in Table 3.

Table 3
Background Information for Participants

		X Area	Y Area	Z Area
Valid Questionnaires		62	67	83
Teaching Experience	1-3 Years	13 (21.0)	15 (22.4)	14 (16.9)
	4-9 Years	14 (22.6)	18 (26.9)	16 (19.3)
	10-Plus Years	35 (56.4)	34 (50.7)	53 (63.8)

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.

Data Analysis

Before the data analysis, the reliability of the questionnaire was examined. As this research focused on the impact of factors on teachers' use of curriculum materials, only the data collected from part B questions (1B-9B) were used. The Cronbach α coefficient of the nine questions is .923, indicating that this questionnaire had strong reliability and stability (Nunnally, 1978).

The data analysis of this research mainly contained two aspects. The first was to use repeated measures to reveal the relative degree of influence of nine different factors in the different dimensions. During the analysis, given that Bonferroni test could control the Type I error rate very well (Field, 2009), this test was used for pairwise comparisons. In order to classify the degree of influence of the nine factors into different classes, we chose the factor that the average score was in the middle (the fifth one) as the reference. If the score of some factor was significantly higher than the reference, then it belonged to the core factor. If the score of some factor was significantly lower than the reference, then it belonged to the peripheral factor. The rest of factors and the reference belonged to the secondary factor together. The second was to select the areas and years of teaching as variables respectively by taking into account the answers about background information of the questionnaire, and then carried out one-way ANOVA to test whether there was a significant difference of the degree of impact of each factor among these groups.

https://doi.org/10.33225/jbse/20.19.893

Research Results

Chemistry Teachers' Evaluations of the Extent to which Nine Factors Influenced Their Use of Curriculum Materials

Teaching objectives

In the dimension of teaching objectives, the scores of the nine factors were shown in Table 4. For the way of supplement, there existed a significant difference between the nine factors (F=23.984, p< .001, η^2= .102). The factor that the mean score was in the middle was Factor C. By pairwise comparisons, the score of Factor D was significantly higher than that of Factor C (p< .05), so Factor D belonged to the core factor. The score of Factor I was significantly lower than that of Factor C (p< .05), so Factor I belonged to the peripheral factor. There was no significant difference between the score of the rest of factors and the score of factor C (p> .05), so they belonged to the secondary factors together. For the way of adaptation, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors. For the way of deletion, the factor that the mean score was in the middle was Factor A. By repeated measures and pairwise comparisons, Factor D, F, and G belonged to the core factors; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors.

Table 4
The Classification of Influencing Factors in the Dimension of Teaching Objectives

Factors	Way of use		
	Supplement	Adaptation	Deletion
Core factors	D (3.46)	D (3.31)	D (2.69) F (2.58) G (2.56)
Secondary factors	F (3.28) B (3.26) A (3.19) C (3.17) G (3.15) E (3.09) H (2.99)	F (3.08) B (2.98) G (2.97) C (2.96) A (2.94) E (2.90) H (2.89)	C (2.43) A (2.41) E (2.40) B (2.37) H (2.35)
Peripheral factors	I (2.72)	I (2.68)	I (2.24)
Repeated measures	F=23.984, p< .001, η^2= .102 D>C; I<C	F=16.846, p< .001, η^2= .074 D>C; I<C	F=14.478, p< .001, η^2= .064 D>A; F>A; G>A; I<A

Note: A= Teaching beliefs, B= Knowledge about curriculum, C= Knowledge about instructional strategies, D= Knowledge about students, E= Quality of curriculum materials, F= External examination, G= Teaching time, H= Teaching resources, I= Class size.

Overall, for all the three ways of use, 'knowledge about students' (Factor D) was recognized as the core factor. Besides, 'external examination' (Factor F) and 'teaching time' (Factor G) were the other two core factors for the way of deletion. In contrast, 'class size' (Factor I) was recognized as the peripheral factor for all the three ways of use. Through the comparison of the scores of each factor in three ways of use, it was interesting to find that the influences of each factor on the three ways of use were ranked in a descending order as follows: supplement > adaptation > deletion. It showed that these factors more induced teachers to supplement the teaching objectives, but less affected teachers to delete the original teaching objectives in the curriculum materials.

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Teaching strategies

In the dimension of teaching strategies, the scores of nine factors were shown in Table 5. For the way of supplement, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors. For the way of adaptation, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor H and I belonged to the peripheral factors; the rest of factors belonged to the secondary factors. For the way of deletion, the factor that the mean score was in the middle was Factor G. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors.

Table 5
The Classification of Influencing Factors in the Dimension of Teaching Strategies

Factors	Way of use		
	Supplement	Adaptation	Deletion
Core factors	D (3.19)	D (3.06)	D (2.72)
Secondary factors	A (3.02) F (3.01) B (2.98) C (2.93) G (2.91) E (2.85) H (2.78)	F (2.92) A (2.89) B (2.89) C (2.85) G (2.84) E (2.73)	F (2.60) A (2.59) C (2.58) G (2.57) B (2.55) E (2.49) H (2.45)
Peripheral factors	I (2.58)	H (2.66) I (2.51)	I (2.28)
Repeated measures	F=21.882, p< .001, η^2= .094 D>C; I<C	F=19.862, p< .001, η^2= .086 D>C; H<C; I<C	F=13.698, p< .001, η^2= .061 D>G; I<G

Note: A= Teaching beliefs, B= Knowledge about curriculum, C= Knowledge about instructional strategies, D= Knowledge about students, E= Quality of curriculum materials, F= External examination, G= Teaching time, H= Teaching resources, I= Class size.

In sum, for all the three ways of use, 'knowledge about students' (Factor D) was recognized as the core factor, whereas 'class size' (Factor I) were regarded as the peripheral factor. Furthermore, 'teaching resources' (Factor H) was another peripheral factor for the way of adaptation. Similar to the dimension of teaching objectives, the influences of each factor on the three ways of use were ranked in a descending order, that is, supplement > adaptation > deletion. It embodied that these factors more induced teachers to supplement the teaching strategies, but less affected teachers to delete the teaching strategies presented in the curriculum materials.

Teaching activities

In the dimension of teaching activities, the scores of nine factors were shown in Table 6. For the way of supplement, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor H and I belonged to the peripheral factors; the rest of factors belonged to the secondary factors. For the way of adaptation, the factor that the mean score was in the middle was Factor B. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor E, H, and I belonged to the peripheral factors; the rest of factors belonged to the secondary factors. For the way of deletion, the factor that the mean score was in the middle was Factor E. By repeated measures and pairwise comparisons, Factor D and G belonged to the core factors; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors.

https://doi.org/10.33225/jbse/20.19.893

Table 6
The Classification of Influencing Factors in the Dimension of Teaching Activities

Factors	Way of use		
	Supplement	Adaptation	Deletion
Core factors	D (3.14)	D (3.01)	D (2.61) G (2.52)
Secondary factors	A (2.95) B (2.93) F (2.92) C (2.91) G (2.82) E (2.75)	C (2.87) A (2.85) F (2.85) B (2.84) G (2.75)	F (2.47) A (2.44) E (2.41) B (2.39) C (2.39) H (2.36)
Peripheral factors	H (2.66) I (2.49)	E (2.67) H (2.64) I (2.46)	I (2.23)
Repeated measures	F=29.545, p< .001, η^2= .122 D>C; H<C; I<C	F=21.121, p< .001, η^2= .091 D>B; E<B; H<B; I<B	F=15.094, p< .001, η^2= .067 D>E; G>E; I<E

Note: A= Teaching beliefs, B= Knowledge about curriculum, C= Knowledge about instructional strategies, D= Knowledge about students, E= Quality of curriculum materials, F= External examination, G= Teaching time, H= Teaching resources, I= Class size.

Overall, for all the three ways of use, 'knowledge about students' (Factor D) was recognized as the core factor. Moreover, 'teaching time' (Factor G) was another core factor for the way of deletion. In contrast, 'class size' (Factor I) was regarded as the peripheral factor for all the three ways of use. Besides, 'teaching resources' (Factor H) was another peripheral factor for the ways of supplement and adaptation. In addition, teachers also evaluated 'quality of curriculum materials' (Factor E) as the peripheral factor for them to adapt teaching activities. Consistent with the first two dimensions, the influences of each factor on the three ways of use were ranked in a descending order as follows: supplement > adaptation > deletion. It reflected that these factors more induced teachers to add the teaching activities, but less affected teachers to delete the teaching activities arranged in the curriculum materials.

Integrated analysis of three dimensions

To examine the overall impact of nine factors in a certain dimension, we integrated supplement, adaptation, and deletion into 'use' by calculating the mean score. The scores of nine factors in three dimensions were shown in Table 7. For the dimension of teaching objectives, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor I belonged to the peripheral factor; the rest of factors belonged to the secondary factors. For the dimension of teaching strategies, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor H and I belonged to the peripheral factors; the rest of factors belonged to the secondary factors. For the dimension of teaching activities, the factor that the mean score was in the middle was Factor C. By repeated measures and pairwise comparisons, Factor D belonged to the core factor; Factor H and I belonged to the peripheral factors; the rest of factors belonged to the secondary factors.

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 7
The Classification of Influencing Factors in Three Dimensions

Factors	Dimension of Use		
	Teaching objectives	Teaching strategies	Teaching activities
Core factors	D (3.15)	D (2.99)	D (2.92)
Secondary factors	F (2.98) G (2.89) B (2.87) C (2.85) A (2.85) E (2.80) H (2.74)	F (2.84) A (2.83) B (2.81) C (2.79) G (2.77) E (2.69)	A (2.75) F (2.75) B (2.72) C (2.72) G (2.70) E (2.61)
Peripheral factors	I (2.55)	H (2.63) I (2.46)	H (2.55) I (2.39)
Repeated measures	F=28.818, p< .001, η^2= .120 D>C; I<C	F=25.259, p< .001, η^2= .107 D>C; H<C; I<C	F=29.918, p< .001, η^2= .124 D>C; H<C; I<C

Note: A= Teaching beliefs, B= Knowledge about curriculum, C= Knowledge about instructional strategies, D= Knowledge about students, E= Quality of curriculum materials, F= External examination, G= Teaching time, H= Teaching resources, I= Class size.

In sum, for all the three dimensions, 'knowledge about students' (Factor D) was recognized as the core factor, whereas 'class size' (Factor I) was regarded as the peripheral factor. Besides, 'teaching resources' (Factor H) was another peripheral factor for the dimensions of teaching strategies and teaching activities.

The Comparison of Chemistry Teachers in Different Areas with Their Evaluations of the Degree of Influence of Nine Factors

The evaluation of chemistry teachers in three areas on the degree of various factors affecting their use of curriculum materials in different dimensions were counted respectively. Through one-way ANOVA and subsequent pairwise comparisons (Bonferroni test), the significant differences (p< .05) for each dimension among three groups were identified and presented in Table 8.

Table 8
Significant Differences for Each Dimension among Teachers in the Three Areas

Dimension	Way of use		
	Supplement	Adaptation	Deletion
Teaching objectives	Class size (F=8.352; η^2= .074; Z>X)	___	Knowledge about students (F=8.221; η^2= .073; X>Z) Class size (F=7.143; η^2= .064; Y>X)
Teaching strategies	Knowledge about students (F=9.205; η^2= .081; X>Z) Class size (F=6.904; η^2= .062; Y>X)	Knowledge about students (F=10.855; η^2= .094; X>Y, X>Z) Class size (F=7.271; η^2= .065; Z>X)	Knowledge about students (F=7.995; η^2= .071; X>Z)
Teaching activities	Knowledge about students (F=12.266; η^2= .105; X>Y, X>Z)	Knowledge about students (F=11.227; η^2= .097; X>Y, X>Z)	Knowledge about students (F=8.957; η^2= .079; X>Z) Class size (F=8.465; η^2= .075; Z>X)

Note: X= An urban area, Y= A newly expanded urban area, Z= A suburban area

https://doi.org/10.33225/jbse/20.19.893

As shown in Table 8, the factors that had made significant differences among teachers in different areas were concentrated in the two factors: 'knowledge about students' and 'class size'. The evaluation scores of 'knowledge about students' of teachers in the urban area were usually significantly higher than those in the newly expanded urban area and the suburban area, while the evaluation scores of the 'class size' of teachers in the newly expanded urban area or the suburban area were significantly higher than those in the urban area. That is to say, teachers in the urban areas dealt with the curriculum materials more based on students' existing knowledge and learning difficulties, while teachers in the newly expanded urban areas and the suburban area were more affected by the class size when using the curriculum materials.

The Comparison of Chemistry Teachers' Teaching Experience with Their Evaluations of the Degree of Influence of Nine Factors

The average evaluation of chemistry teachers with different teaching experience on the degree of various factors affecting their use of curriculum materials in different dimensions were counted respectively. Through one-way ANOVA and subsequent pairwise comparisons (Bonferroni test), the significant differences ($p< .05$) for each dimension among three groups were identified and presented in Table 9.

Table 9

Significant Differences for Each Dimension among Teachers with Different Teaching Experience

Dimension	Way of use		
	Supplement	Adaptation	Deletion
Teaching objectives	Knowledge about instructional strategies (F=10.599; η^2= .092; T>R, T>S)	—	—
Teaching strategies	—	Knowledge about instructional strategies (F=12.005; η^2= .103; T>R, T>S) Knowledge about curriculum (F=9.339; η^2= .082; T>R)	—
Teaching activities	Knowledge about instructional strategies (F=8.844; η^2= .078; T>R) Knowledge about curriculum (F=8.108; η^2= .072; T>R)	Knowledge about instructional strategies (F=7.511; η^2= .067; T>R)	—

Note: R=1-3 years, S=4-9 years, T=More than 10 years

As indicated in Table 9, the factors that had made significant differences among teachers with different teaching experience were 'knowledge about instructional strategies' and 'knowledge about curriculum'. In particular, the factor of 'knowledge about instructional strategies' appeared in all three dimensions. The results showed that compared with the teachers with less teaching experience, the teachers with rich teaching experience thought that they were better at supplementing and adapting the curriculum materials based on their own 'knowledge about instructional strategies' and 'knowledge about curriculum'.

Discussion

In this research, a quantitative approach was adopted to examine high school chemistry teachers' evaluations of the factors affecting their use of curriculum materials in China. It can be seen from this study that the various factors more induced teachers to supplement the teaching elements, but less affected teachers to delete the original teaching elements in the curriculum materials (see Table 4, 5, and 6). There may be two reasons for this conclusion. First, under the influence of advanced teaching ideas, teachers are no longer confined to textbooks and teacher's guides; instead, they tend to use a diversity of resources and materials to enrich their own classroom teaching. Second, the presentation of textbooks and teacher's guides in China tends to be simplified (Wang, 2010b), which provides teachers with more space to supplement these curriculum materials. Indeed, it is a good idea to encourage teachers to supplement the teaching elements and enrich the classroom teaching based on the diversified

https://doi.org/10.33225/jbse/20.19.893

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

curriculum resources. However, according to Chen and Wei (2015b), in China, high school chemistry teachers often add subject matter and the 'exercise' teaching strategy. Hence, the rationality of supplementary teaching elements needs to be highlighted. Teachers should not blindly supplement the advanced subject matter and increase the academic burden of students without following the requirements of curriculum standards or considering the actual intellectual level of students, which may have a negative impact on the development of students' scientific literacy.

As shown in the results, the core factor that affected teachers' use of curriculum materials was 'knowledge about students' (see Table 7), indicating that high school chemistry teachers paid great attention to the characteristics and needs of students when using curriculum materials in China. This finding echoed the fact that teachers' teaching modes have changed from teacher-centered to student-centered with the influence of the ideas embedded in the reform-based curriculum (Wei, 2012). In contrast, 'class size' and 'teaching resources' have been found to be the peripheral factor (see Table 7). As we see, they are associated with the teaching context. One possible explanation is that in China's economically developed metropolis, such as Guangzhou, the educational resources are relatively sufficient, and the class size of the school is relatively reasonable. The conducive educational environment provides the basic guarantee for the enactment of the new curriculum and thus reduces the possibility of the influence of context factors.

In this research, two factors that make significant differences in the comparison among chemistry teachers who are in different areas of economic development in terms of the degree of factors affecting their use of curriculum materials have been identified. They were 'knowledge about students' and 'class size'. Specifically, teachers in the urban area were more affected by 'knowledge about students', while teachers in the newly expanded urban area and the suburban area were more affected by 'class size'. This result was understandable. Due to the differences in the level of educational and economic development, the class size of newly expanded urban and suburban schools is usually larger than that of urban schools. In some newly expanded urban and suburban schools, the class size even exceeds 50 students. When the class size is large, it not only exerts more restriction on classroom teaching, but also restricts teachers to make teaching decisions based on the characteristics and needs of students (Eisenmann, 2011; Zhang et al., 2003). Hence, these two factors, 'knowledge about students' and 'class size', showed the opposite situation when they affect the use of curriculum materials by teachers in different areas. In order to better implement the idea of 'student-oriented' advocated by the current science curriculum (Wei, 2020), it is suggested that educational administrative institutions and schools, especially in the newly expanded urban and suburban areas, should make joint efforts to formulate appropriate class size and create a good class environment for teachers and students.

Furthermore, it was found that 'knowledge about curriculum' and 'knowledge about instructional strategies' were two factors that made significant differences in the comparison among chemistry teachers who have different years of teaching in terms of the degree of factors affecting their use of curriculum materials. This finding was not surprising. According to Magnusson et al. (1999), both knowledge about curriculum and knowledge about instructional strategies belong to the components of teachers' pedagogical content knowledge (PCK). As we know, PCK is a kind of practical knowledge, and its development is mainly based on classroom teaching practice (Van Driel et al., 2001). As teachers with rich teaching experience usually have a relatively developed PCK (Kind, 2009), it is little wonder that they use curriculum materials more based on their own knowledge about curriculum and knowledge about instructional strategies. According to this finding, we suggest that teacher educators, such as teaching supervisors, may organize teacher training activities to invite experienced expert teachers to share experience with novice teachers on how to use curriculum materials effectively based on knowledge about curriculum and knowledge about instructional strategies. In addition, to better support novice teachers' learning, it is necessary for curriculum designers to develop educative curriculum materials to support their teaching practice (Davis et al., 2017; Drake et al., 2014). More guidelines and effective instructional strategies should be included in the curriculum materials to promote the development of PCK for novice teachers.

Conclusions and Recommendations

This research comprehensively and simultaneously examined the impact of various factors on the way teachers use curriculum materials from teachers' perspective. In particular, the impact of various factors on 'three levels of thinking and acting', involving different levels of interaction between teachers and curriculum materials was revealed, which made the research more systematic and in-depth. Moreover, the research has disclosed the differences in the impact of factors on curriculum materials use for teachers from different areas of economic

https://doi.org/10.33225/jbse/20.19.893

development and with different teaching experience. In this regard, this research contributed to existing theory and knowledge base of curriculum use in the field of chemistry and science education.

All in all, this research was intended to address the issue of the impact of different factors on the way chemistry teachers use curriculum materials in different dimensions, and its main findings have illustrated that chemistry teachers' use of curriculum materials in different dimensions is affected by various factors and the degree of influence of these factors are different. However, as a quantitative study, it is difficult for this research to answer the detailed questions about the specific influence of various factors on curriculum materials use, such as 'how the factor of knowledge about students affects teachers to supplement teaching objectives' or 'how the factor of teaching time leads to teachers' deletions of teaching activities'. In the future, qualitative research can be carried out from the perspective of teacher-curriculum relationship by observing and interviewing to delineate how chemistry teachers interact with curriculum materials in depth.

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.

References

Behm, S. L., & Lloyd, G. M. (2009). Factors influencing student teachers' use of mathematics curriculum materials. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 205-222). Routledge. https://doi.org/10.4324/9780203884645

Bodzin, A. M., Cates, W. M., & Price, B. (2003). *Formative evaluation of the exploring life curriculum: Year two implementation fidelity findings*. Paper presented at the meeting of the National Association for Research in Science Teaching (NARST), Philadelphia, PA.

Brown, M. W. (2002). *Teaching by design: Understanding the interactions between teacher practice and the design of curricular innovation*. Unpublished doctoral dissertation, Northwestern University, Evanston, IL.

Brown, M. W. (2009). The teacher-tool relationship: Theorizing the design and use of curriculum materials. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp.17-36). Routledge.

Chen, B., & Wei, B. (2015a). Investigating the factors that influence chemistry teachers' use of curriculum materials: The case of China. *Science Education International, 26*(2), 195-216. https://files.eric.ed.gov/fulltext/EJ1064037.pdf

Chen, B., & Wei, B. (2015b). Implementation of standards-based curriculum by chemistry teachers: From curriculum materials to teaching practice. In M. S. Khine (Ed.), *Science education in East Asia: Pedagogical innovations and research-informed practices* (pp. 523-547). Springer. https://doi.org/10.1007/978-3-319-16390-1_21

Davis, E. A., Palincsar, A. S., Smith, P. S., Arias, A. M., & Kademian, S. M. (2017). Educative curriculum materials: Uptake, impact, and implications for research and design. *Educational Researcher, 46*(6), 293-304. https://doi.org/10.3102/0013189X17727502

Drake, C., Land, T. J., & Tyminski, A. M. (2014). Using educative curriculum materials to support the development of prospective teachers' knowledge. *Educational Researcher, 43*(3), 154-162. https://doi.org/10.3102/0013189X14528039

Eisenmann, T. (2011). Curriculum differential enactment: The interplay of teacher, class, and curriculum materials. *Curriculum and Teaching, 26*(2), 33-50. https://doi.org/10.7459/ct/26.2.04

Field, A. (2009). *Discovering statistics using SPSS* (3rd Ed.). SAGE Publications.

Forbes, C. T. (2013). Curriculum-dependent and curriculum-independent factors in preservice elementary teachers' adaptation of science curriculum materials for inquiry-based science. *Journal of Science Teacher Education, 24*(1), 179-197. https://doi.org/10.1007/s10972-011-9245-0

Hemmi, K., Krzywacki, H., & Liljekvist, Y. (2019). Challenging traditional classroom practices: Swedish teachers' interplay with Finnish curriculum materials. *Journal of Curriculum Studies, 51,* 342-361. https://doi.org/10.1080/00220272.2018.1479449

Janssen, F. J. J. M., Westbroek, H. B., Doyle, W., & Van Driel, J. H. (2013). How to make innovations practical. *Teachers College Record, 115*(7), 1–43. https://doi.org/10.1590/sajs.2013/20120069

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education, 45*(2), 169-204. https://doi.org/10.1080/03057260903142285

Lloyd, G. M., Remillard, J. T., & Herbel-Eisenmann, B. A. (2009). Teachers' use of curriculum materials: An emerging field. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics Teachers at work: Connecting curriculum materials and classroom instruction* (pp. 3-14). Routledge.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome, & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95–132). Kluwer. https://doi.org/10.1007/0-306-47217-1_4

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Nargund-Joshi, V., Rogers, M. A. P., & Akerson, V. L. (2011). Exploring Indian secondary teachers' orientations and practice for teaching science in an era of reform. *Journal of Research in Science Teaching, 48*(6), 624-647. https://doi.org/10.1002/tea.20429

Nunnally, J. (1978). *Psychometric methods*. McGraw.

Powell, J. C., & Anderson, R. D. (2002). Changing teachers' practice: Curriculum materials and science education reform in the USA. *Studies in Science Education, 37*, 107-136. https://doi.org/10.1080/03057260208560179

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*(2), 211-246. https://doi.org/10.3102%2F00346543075002211

Roblin, N. P., Schunn, C., & McKenney, S. (2018). What are critical features of science curriculum materials that impact student and teacher outcomes? *Science Education, 102*(2), 260-282. https://doi.org/10.1002/sce.21328

Roehrig, G. H., Kruse, R. A., & Kern, A. (2007). Teacher and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching, 44*(7), 883-907. https://doi.org/10.1002/tea.20180

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Stein, M. K., Remillard, J., & Smith, M. (2007). How curriculum influences student learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 319–369). Information Age.

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching, 38*(2), 137-158. https://doi.org/10.1002/1098-2736(200102)38:23.0.CO;2-U

Van Driel, J. H., Berry, A., & Meirink, J. (2014). Research on science teacher knowledge. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education, Volume II* (pp. 848-870). Routledge. https://doi.org/10.4324/9780203097267.ch42

Van Hiele, P. M. (1986). *Structure and insight: A theory of mathematics education*. Academic Press.

Vos, M. A. J., Taconis, R., Jochems, W. M. G., & Pilot, A. (2010). Teachers implementation context-based teaching materials: A framework for case-analysis in chemistry. *Chemistry Education Research and Practice, 11*(3), 193-206. https://doi.org/10.1039/C005468M

Vos, M. A. J., Taconis, R., Jochems, W. M. G., & Pilot, A. (2011). Classroom implementation of context-based chemistry education by teachers: The relation between experiences of teachers and the design of materials. *International Journal of Science Education, 33*(10), 1407-1432. https://doi.org/10.1080/09500693.2010.511659

Wang, L. (2010a). Ji chu hua xue jiao yu ke cheng gai ge shi nian jin zhan yu fan si (shang) [Progress and reflection of secondary chemical curriculum reform in the past ten years]. *Hua Xue Jiao Yu, 31*(4), 15-21. https://doi.org/10.3969/j.issn.1003-3807.2010.04.010

Wang, L. (2010b). Ji chu hua xue jiao yu ke cheng gai ge shi nian jin zhan yu fan si (xia). *Chinese Journal of Chemical Education*, *31*(5), 20-24. https://doi.org/10.3969/j.issn.1003-3807.2010.05.009

Wei, B. (2012). Chemistry curriculum reform in China: Policy and practice. In H. Yin & C. J. Lee (Eds.), *Curriculum reform in China: Changes and challenges* (pp. 95-109). Nova Science Publishers.

Wei, B. (2020). The change in the intended senior high school chemistry curriculum in China: Focus on intellectual demands. *Chemistry Education and Research Practice, 21*(1), 14-23. https://doi.org/10.1039/C9RP00115H

Zhang, B., Krajcik, J. S., Sutherland, L. M., Wang, L., Wu, J., & Qian, Y. (2005). Opportunities and challenges of China's inquiry-based education reform in middle and high schools: Perspectives of science teachers and teacher educators. *International Journal of Science and Mathematics Education, 1*(4), 477-503. https://doi.org/10.1007/s10763-005-1517-8

Appendix

Question 1A:

In addition to the teaching objectives listed in the teacher's guides, what kind of teaching objectives do you usually add to your teaching?

Question 1B:

To what extent do the following factors induce you to add the teaching objectives that are not included in the teacher's guides? Please select the number you approve of.

Factors	Very much	Somewhat	Little	Never
A. Teaching beliefs	4	3	2	1
B. Knowledge about curriculum	4	3	2	1
C. Knowledge about instructional strategies	4	3	2	1
D. Knowledge about students	4	3	2	1
E. Quality of curriculum materials	4	3	2	1
F. External examination	4	3	2	1
G. Teaching time	4	3	2	1
H. Teaching resources	4	3	2	1
I. Class size	4	3	2	1

Received: *June 04, 2020* Accepted: *November 17, 2020*

Cite as: Chen, B., Wei, B., & Wang, X. (2020). Examining the factors that influence high school chemistry teachers' use of curriculum materials: From the teachers' perspective. *Journal of Baltic Science Education*, *19*(6), 893-907. https://doi.org/10.33225/jbse/20.19.893

Bo Chen *(Corresponding author)*
PhD, Associate Professor, School of Chemistry and Chemical Engineering, Nantong University, No.9, Seyuan Road, Nantong, P. R. China.
E-mail: njcb0128@aliyun.com
ORCID: https://orcid.org/0000-0001-5671-9223

Bing Wei
PhD, Associate Professor, Faculty of Education, University of Macau, Room 3027, E33, Av. da Universidade, Taipa, Macau, P. R. China.
E-mail: bingwei@um.edu.mo
ORCID: https://orcid.org/0000-0002-5591-8025

Xiaoling Wang
Master, Jiedong No.2 Middle School, North Section of Jinfeng Road, Jieyang, P. R. China.
E-mail: 1787718476@qq.com
ORCID: https://orcid.org/0000-0003-3710-0729