# Chapter 6
# Examining the Senior Secondary School Chemistry Curriculum in China in View of Scientific Literacy

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## 6.1 Introduction

The latest round of curriculum reform in China was initiated in 1999 after a long period of ferment (Huang 2004). The ambition of this reform was to raise the quality of education in order for students to meet the challenges of new times. Specially, cultivating students' creativity and practical abilities has been a major concern in this round of curriculum reform (CCCPC and SC 1999). As part of the national curriculum, the Senior Secondary School Chemistry Curriculum (SSSCC, for Grades 10–12) came into a new era when its national standards were released by the Ministry of Education (MoE) in 2003. The official document argues that the SSSCC is an indispensable component of school science education and plays an important role in further raising the level of scientific literacy of senior secondary school students (MoE 2003a). Furthermore, it asserts that the "SSSCC is linked up with the chemistry or integrated science curricula at the compulsory education stage and therefore it is, in essence, a type of general education-oriented curriculum"[1] (MoE 2003b, p. 1). More importantly, according to the curriculum designers (Wang and Wang 2004), the curriculum goals are defined by the three dimensions in view of scientific literacy: (1) knowledge and skills, (2) processes and methods, and

[1] According to the Outline of Curriculum Reform of Basic Education (MoE 2001), at the junior secondary school level (Grades 7–9), the science curriculum can take either of two forms: separate curriculum (biology, chemistry, or physics) or integrated science curriculum.

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(3) emotions, attitudes, and values. In addition, according to the national standards, the SSSCC is made up of required and selective course modules. The required course modules are *Chemistry 1* and *Chemistry 2*, which are required for all senior secondary school students, and the six selective course modules are *Chemistry and Daily Lives*, *Chemistry and Technology*, *Particulate Structure and Properties of Substance*, *Chemical Reaction Mechanism*, *Basic Organic Chemistry*, and *Experimental Chemistry*, which are provided for students based on their needs and interests (MoE 2003a).

In China, textbooks are usually thought of as a constituent element of the national curriculum development (Wu et al. 1992). It is especially recognized in the circle of chemistry education in China that textbooks can be seen as the substantiation of the curriculum, and the ideas of new curriculum should be delivered to practicing teachers through textbooks (Wang 2010). Therefore, in the whole process of curriculum reform, no effort has been spared to compile and publish new textbooks (Wei 2012). Up to now, there have been three series of senior secondary school chemistry textbooks that were written according to the national standards of the SSSCC, have passed the official review, and are currently used in schools (Wang 2010). These three series of chemistry textbooks were edited by Song (2006) and Wang (2006, 2007), respectively. There are eight books for each series with two books for the required modules (*Chemistry 1* and *Chemistry 2*) and six books for the selective modules. As mentioned above, the notion of scientific literacy is the core theme in the new SSSCC. In this chapter, we are interested in examining to what extent the themes of scientific literacy have been reflected in both the national standards of the SSSCC and the three series of senior high school chemistry textbooks. Specifically, the research questions were posed as follows: (1) To what extent are the themes of scientific literacy distributed in the national standards of the SSSCC? (2) To what extent are the themes of scientific literacy distributed in the three series of senior secondary school chemistry textbooks? (3) What are the differences in the distributions of the themes of scientific literacy among the three series of senior secondary school chemistry textbooks? (4) What are the differences in the distributions of the themes of scientific literacy between the national standards and the textbooks of the SSSCC? (5) What are the differences in the distributions of the themes of scientific literacy between the current and traditional senior secondary school textbooks? and (6) What are the differences in the distributions of the themes of scientific literacy between theoretical and descriptive contents in the senior secondary school textbooks?

## 6.2 Scientific Literacy and Curriculum Balance

The term scientific literacy was coined in the 1950s, and from its very beginning, it was rooted in the view of general education rather than specialized education (Bybee 1997a). That is to say, scientific literacy is oriented to "all" students or the future citizens in the society. As such, it has been used as a slogan to provide a symbol for contemporary reform and serves to unify people interested in science education reforms (Bybee 1997b). Since there is no correct interpretation of a slogan, it is little wonder that different individuals interpret scientific literacy in different ways (Laugksch 2000). As for school science curriculum in particular, scientific literacy is often defined in relation with varied curricular issues, such as purposes, content, and outcomes of science education. Champagne and Lovitts (1989), for example, observed that responses to the question "What does it mean to be scientifically literate?" usually include three kinds of descriptions: the behaviors of a scientifically literate person in a variety of contexts; the mental state of a scientifically literate person in terms of knowledge, skills, and disposition; and references to educational experiences that are assumed to produce a scientifically literate person. When examining the various interpretations of scientific literacy in the 1970s, Bybee (1997a) identified four perspectives of scientific literacy: "content" (Agin 1974), "context" (Shen 1975), "experiences" (NSTA 1971), and "outcomes" (Showalter 1974). Except for "context," the other three perspectives, "outcomes," "content," and "experiences," correspond to the three descriptions of Champagne and Lovitts (1989), respectively. It seems that the "content" perspective permeates the other three ones, as it aims to provide answers to the key question of "what constitutes science curriculum" in terms of scientific literacy. A typical example of the definition of scientific literacy in this perspective is the science content suggested by National Research Council (NRC 1996): (1) unifying concepts and processes, (2) science as inquiry, (3) physical science, (4) life science, (5) earth and space science, (6) science and technology, (7) science in personal and social perspectives, and (8) history and nature of science.

Obviously, the notion of scientific literacy expresses a set of themes that include traditional subjects and also the content cutting across these subjects, such as the nature and history of science, the relation between science and technology, and science-related social issues. According to Roberts (2007), these varied themes can be grouped into two types: science subject matter and situations in which science can play a role in other human affairs. In order to develop a science curriculum, various parts of science should come together to form some sort of a coherent whole so as to achieve scientific literacy. Specifically, for instance, Wellington (2000) suggests that a balanced curriculum in science should contain these elements: (1) a study of the content and concepts of the sciences; (2) consideration of the practices and processes of science; (3) study of the links between science, technology and society; and (4) consideration of the history and nature of science. Chiappetta et al. (1991a) argue that science textbooks should assist in the development of a scientifically literate society. They assert that in order to accomplish this task, the content of textbooks should provide a curriculum balance which stresses fairly equal proportions of knowledge, investigation, thinking, and the interaction between science, technology, and society. Furthermore, they developed a quantitative method to examine the content of different types of science textbooks for their relative emphases on four themes of scientific literacy: (1) science as a body of knowledge, (2) science as a way of investigating, (3) science as a way of thinking, and (4) the interaction among science, technology, and society. Applying this method to analyze chemistry textbooks commonly used in the United States, Chiappetta et al. (1991b) found that the majority of texts analyzed placed most emphases on "science as a body of knowledge," followed by "science as a way of investigating," while very little text was devoted to "the interaction among science, technology, and society" and even less to "science as a way of thinking."

By using the same method in analyzing physics textbooks in Australia, Wilkinson (1999) has found that the majority of the textbooks stress "science as a body of knowledge," place some emphases on "science as a way of investigating," and have little emphasis on "science as a way of thinking." Texts produced for a new physics course after 1990 are found to place more emphasis on the theme of "the interaction between science, technology, and society" than texts produced prior to 1990. The possible influence of science, technology, and society (STS) movement on this change was noted by Wilkinson, but no further analysis was made. Based on more recent conceptions of scientific literacy and the philosophy of science, BouJaoude (2002) modified the analytical framework proposed by Chiappetta et al. (1991a, b) in two ways: including the personal use of science in the theme of "interaction of science, technology, and society" and replacing the theme of "science as a way of thinking" with "science as a way of knowing." More significantly, BouJaoude (2002) extended his research to curriculum documents and distinguished them at different levels: general objectives (goals), introductions, objectives, instructional objectives, and learning activities. He found that the Lebanese curriculum emphasizes "the knowledge of science," "the investigative nature of science," and "interaction of science, technology, and society" but neglects "science as a way of knowing." BouJaoude's research demonstrated that the analytical framework can be used to analyze not only science textbooks but science curriculum documents also.

Even though these aforementioned studies were based on the concept of curriculum balance, neither of them, however, gave an exact definition of the desired state of curriculum balance. In order to effectively evaluate the extents of the SSSCC and the three series of senior secondary school chemistry textbooks in terms of curriculum balance, we argue that the themes of scientific literacy should be weighed equally at varied levels of this curriculum. The basis of this argument is that there should not be a difference among the values of varied curriculum emphases, and every curriculum emphasis is equally important in terms of scientific literacy (Roberts 1988, 2007). This ideal state will be used as a criterion to analyze the real state of curriculum balance in this chapter. In the following section, we will describe three issues involved in the methodology of this chapter.

## 6.3 Method

### *6.3.1 Analysis Targets*

As mentioned earlier, this chapter aims to examine the distribution of the themes of scientific literacy in the senior secondary school chemistry curriculum, which includes the official curriculum document released by the MoE (2003a), that is, the *Senior Secondary School Chemistry Curriculum Standards* (SSSCCS), and the accompanying chemistry textbooks. Therefore, the SSSCCS, and the three series of the new chemistry textbooks compiled under the guide of the SSSCCS, constitute the main analysis targets in this chapter. In the SSSCCS, curriculum objectives are presented in three dimensions: they are “knowledge and skills,” “processes and methods,” and “emotions, attitudes, and values,” with each one containing several items. Content standards comprise two parts: “teaching objectives” and “recommended activities and investigation” (for short “activities”). The contents of these two parts are presented item by item under secondary themes. In brief, the SSSCCS were analyzed at three levels: “curriculum objectives,” “teaching objectives,” and “activities.” For textbooks, it should be noted that only those for the two required course modules (i.e., *Chemistry 1* and *Chemistry 2*) in the SSSCC were analyzed in this chapter. This was based on the consideration that required course modules are taken by all senior secondary school students, which fits correctly with the meanings of scientific literacy. Furthermore, in order to explore the changing tendency of the embedding of the idea of scientific literacy in textbooks, Volume 1 in the series of Wu and Hu (2003) was also included in the analysis targets. This textbook volume was compiled by the People Education Press (PEP)[2] under the guide of the teaching syllabus of senior secondary school chemistry (State Education Commission 1996) rather than the SSSCCS (MoE 2003a) and thus was taken as a representative of traditional chemistry curriculum in this chapter. It should be noted that as the content distributions and layouts in traditional chemistry textbooks were very different from those in the new chemistry books, we only selected the representative topics to make comparisons between the current chemistry textbooks and traditional ones. Textbooks analyzed in this study are listed in Table 6.1.

In addition, as we know, chemistry subject matter can be generally categorized into theoretical and descriptive parts. In order to examine the differencesof the distributions of the themes of scientific literacy between these two types of subject knowledge, we took the topics of “atomic structure” and “sulfur and its compounds” as typical examples of theoretical and descriptive chemistry, respectively, and made comparisons between them. The selection of these two topics was based

[2] Since the 1950s, the PEP has been the designated national education press that produces the national unified syllabi and textbooks directly under the leadership of the Ministry of Education (Wu et al. 1992). Although its status as a monopoly has decreased in recent years, textbooks produced by the PEP are still popular in primary and secondary schools in China.

**Table 6.1** The textbooks of the senior secondary school chemistry analyzed in this study

| Chief editor | Title | Publisher | Publication date | Edition |
|---|---|---|---|---|
| Wu and Hu | Chemistry volume 1 | PEP | June 2003 | 1st |
| Song | Chemistry 1 | PEP | June 2006 | 2nd |
| | Chemistry 2 | PEP | May 2006 | 2nd |
| Wang | Chemistry 1 | JEP | June 2006 | 3rd |
| | Chemistry 2 | JEP | June 2006 | 3rd |
| Wang | Chemistry 1 | SSTP | July 2007 | 3rd |
| | Chemistry 2 | SSTP | July 2007 | 3rd |

*PEP* People's Education Press, *JEP* Jiangsu Education Press, *SSTP* Shandong Science and Technology Press

on the consideration that they are important elements both in traditional and current curricula.

### 6.3.2 *Instrument*

In order to answer the research questions, a framework of scientific literacy adapted from Chiappetta et al. (1991a) and BouJaoude (2002) was employed to analyze the SSSCCS and the senior secondary school chemistry textbooks. The validity of the framework has been ensured through its conceptual and empirical bases. The framework of scientific literacy is shown in Table 6.2.

### 6.3.3 *Data Analysis*

The unit of analysis of the SSSCCS was the items presented in "curriculum objectives," "teaching objectives," and "activities." Each item was analyzed and categorized using the framework described above. When an item contained more than one theme of scientific literacy, each theme involved was counted once. The item was not categorized if it was not involved in any of the four themes of scientific literacy.

The elements of a textbook (units of analysis) that were used in the analysis included complete paragraphs, figures, tables, marginal comments, complete steps in laboratory or hands-on activity, and specific sections. Prefaces, tables of contents, appendixes, and exercises in a textbook, however, were not analyzed in this chapter. Each unit of analysis was analyzed and categorized using the framework described above. When a unit of analysis contained more than one theme of scientific literacy, each theme involved was counted once. The unit of analysis was not categorized if it was not involved in any of the four themes of scientific

**Table 6.2** The framework of scientific literacy

| Category | Subcategory | Illustration |
|---|---|---|
| I. The knowledge of science | Facts, concepts, principles, and laws | Check this category if the intent of the text is to present, discuss, or ask the student to recall information, facts, concepts, principles, laws, theories, etc. It reflects the transmission of scientific knowledge where the student receives information |
| | Hypotheses, theories, and models of science | |
| II. The investigative nature of science | Requires students to answer a question through the use of materials | Check this category if the intent of the text is to stimulate thinking and doing by asking the student to "find out." It reflects the active aspect of inquiry and learning, which involves the student in the methods and processes of science such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting, etc. |
| | Requires students to answer a question through the use of charts, tables, etc. | |
| | Requires students to reason out an answer | |
| | Requires students to make a calculation | |
| | Engages students in a thought experiment or activity | |
| | Requires students to communicate through the use of a variety of means, such as writing, speaking, and using graphs, tables, and charts | |
| III. Science as a way of knowing | Describes how scientists experiment | Check this category if the intent of the text is to illustrate how science in general or a certain scientist in particular went about "finding out." This aspect of the nature of science represents thinking, reasoning, and reflection, where the student is told about how the scientific enterprise operates |
| | Shows the historical development of an idea | |
| | Emphasizes the empirical nature and objectivity of science | |
| | Illustrates the use of assumptions | |
| | Shows how science proceeds by inductive and deductive reasoning | |
| | Gives cause and effect relationships | |
| | Discusses evidence and proof | |
| | Presents the scientific methods and problem-solving steps | |
| | Role of self-examination in science | |
| IV. Interaction of science, technology, and society | The usefulness of science and technology to society | Check this category if the intent of the text is to illustrate the effects or impacts of science on society. This theme of scientific literacy pertains to the application of science and how technology helps or hinders humankind. In addition, it involves social issues and careers |
| | The negative effects of science and technology on society | |
| | Social issues related to science or technology | |
| | Careers and jobs in scientific and technological fields | |
| | Personal use of science to make everyday decisions, solve everyday problems, and improve one's life | |
| | Science-related moral and ethical issues | |

Adapted from Chiappetta et al. (1991a) and BouJaoude (2002) literacy or it was only involved in review questions, vocabulary words, or goal and objective statements.

After the categorization of units of analysis was completed, then the descriptive statistics were adopted, that is, the frequency and the percentage of occurrence of each theme were calculated. As argued above, the ideal state of curriculum balance is that the themes of scientific literacy should be weighed equally. Therefore, the less the difference among the percentages of the four themes of scientific literacy is, the better the issue of curriculum balance is treated; the greater the difference among the percentages of the four themes is, the worse the issue of curriculum balance is treated.

To ensure the reliability of the results, the two researchers met several times to discuss the framework in order to reach a common understanding of its components and subcomponents. Following these meetings, they conducted the analysis and categorization independently with the result of an inter-rater agreement of 90 %, then discussed the discrepancies, and reached consensus on categorization. It is worth noting that due to the analysis method in this study, the sums of frequencies are not always equal to the number of units of analysis, and the total percentage is not always equal to 100 %.

## 6.4 Results

### *6.4.1 The Distribution of the Themes of Scientific Literacy in the SSSCCS*

The distribution of the themes of scientific literacy in the SSSCCS at different levels is presented in Table 6.3.

As seen in Table 6.3, the emphasis in curriculum objectives is the theme of “the investigative nature of science.” The percentage of this theme reaches as high as 41.67 %, while the percentages of the other three ones are all only 16.67 %. In teaching objectives, “the knowledge of science” is treated with the highest weight

**Table 6.3** The distribution of the themes of scientific literacy in the SSSCCS

| Level | | Themes of scientific literacy | | | | Total items |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | |
| Curriculum objectives | Frequency | 2 | 5 | 2 | 2 | 12 |
| | Percentage (%) | 16.67 | 41.67 | 16.67 | 16.67 | |
| Teaching objectives | Frequency | 20 | 8 | 6 | 14 | 34 |
| | Percentage (%) | 58.82 | 23.53 | 17.65 | 41.18 | |
| Activities | Frequency | 7 | 20 | 2 | 12 | 40 |
| | Percentage (%) | 17.50 | 50.00 | 5.00 | 30.00 | |

Themes of scientific literacy: I = the knowledge of science; II = the investigative nature of science; III = science as a way of knowing; IV = interaction of science, technology, and society

(58.82 %), followed by "interaction of science, technology, and society" (41.18 %) and "the investigative nature of science" (23.53 %). "Science as a way of knowing" is given the lowest weight (17.65 %). For activities, "the investigative nature of science" has the highest proportion (50.00 %). The frequency of "interaction of science, technology, and society" (30.00 %) is slightly higher than that of "the knowledge of science" (17.50 %). "Science as a way of knowing" is still in the lowest proportion (5.00 %).

From the results above, it can be concluded that the percentage distributions of the themes of scientific literacy are different among curriculum objectives, teaching objectives, and activities in the SSSCCS. The issue of curriculum balance is treated best in "teaching objectives" (58.82 %, 23.53 %, 17.65 %, and 41.18 %, respectively, to each theme) and worst in "activities," with "curriculum objectives" being between the two. Overall, of the four themes of scientific literacy, "the knowledge of science," "the investigative nature of science," and "interaction of science, technology, and society" are emphasized in the SSSCCS, while "science as a way of knowing" is neglected.

### *6.4.2 The Distributions of the Themes of Scientific Literacy in New Senior Secondary School Chemistry Textbooks*

The distributions of the themes of scientific literacy in the three series of new senior secondary school chemistry textbooks are presented in Table 6.4.

**Table 6.4** The distributions of the themes of scientific literacy in the three series of new senior secondary school chemistry textbooks

| Textbooks | | Themes of scientific literacy I | II | III | IV | Total units of analysis |
|---|---|---|---|---|---|---|
| Chemistry 1 (Song 2006) | Frequency | 233 | 117 | 7 | 50 | 435 |
| | Percentage (%) | 53.56 | 26.90 | 1.61 | 11.49 | |
| Chemistry 2 (Song 2006) | Frequency | 212 | 94 | 8 | 70 | 416 |
| | Percentage (%) | 50.96 | 22.60 | 1.92 | 16.83 | |
| Chemistry 1 (Wang 2006) | Frequency | 198 | 116 | 15 | 58 | 408 |
| | Percentage (%) | 48.53 | 28.43 | 3.68 | 14.22 | |
| Chemistry 2 (Wang 2006) | Frequency | 225 | 107 | 7 | 55 | 426 |
| | Percentage (%) | 52.82 | 25.12 | 1.64 | 12.91 | |
| Chemistry 1 (Wang 2007) | Frequency | 279 | 139 | 15 | 132 | 604 |
| | Percentage (%) | 46.19 | 23.01 | 2.48 | 21.85 | |
| Chemistry 2 (Wang 2007) | Frequency | 217 | 117 | 17 | 87 | 452 |
| | Percentage (%) | 48.01 | 25.88 | 3.76 | 19.25 | |

Themes of scientific literacy: I = the knowledge of science; II = the investigative nature of science; III = science as a way of knowing; IV = interaction of science, technology, and society

Table 6.4 shows that the percentage distributions of the four themes of scientific literacy in the six textbooks have similar trends, which place most emphases on "the knowledge of science," followed by "the investigative nature of science," while very little is devoted to "interaction of science, technology, and society" and even less to "science as a way of knowing." The percentages of "the knowledge of science" for the analyzed textbooks range from 46.19 % (Chemistry 1, Wang 2007) to 53.56 % (Chemistry 1, Song 2006). This implies that the contents of new senior secondary school chemistry textbooks are more concerned about scientific facts, concepts, principles, theories, laws, etc. Conversely, the proportions of "science as a way of knowing" in the three series are very low, ranging from 1.61 % (Chemistry 1, Song 2006) to 3.76 % (Chemistry 2, Wang 2007). It suggests from these results that none of the three series deals well with the issue of curriculum balance. By comparison, however, the issue of curriculum balance is treated best in Wang's (2007) and worst in Song's (2006), with Wang's (2006) being between the two. On the whole, the new textbooks are worse than the SSSCCS in dealing with the issue of curriculum balance.

### *6.4.3 The Distributions of the Themes of Scientific Literacy on the Topic of "atomic structure" in the Different Series of Chemistry Textbooks*

The distributions of the themes of scientific literacy on the topic of "atomic structure" in the different series of chemistry textbooks are presented in Table 6.5.

As shown in Table 6.5, the traditional series (Wu and Hu 2003) stresses the first theme, "the knowledge of science." The percentage of this theme reaches as high as 78.13 %, while the percentages of the second through fourth themes are only

**Table 6.5** The distributions of the themes of scientific literacy on the topic of "atomic structure" in the different series of chemistry textbooks

| Textbooks | | Themes of scientific literacy | | | | Total units of analysis |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | |
| Wu and Hu (2003) | Frequency | 25 | 2 | 3 | 1 | 32 |
| | Percentage (%) | 78.13 | 6.25 | 9.38 | 3.13 | |
| Song (2006) | Frequency | 16 | 3 | 0 | 2 | 25 |
| | Percentage (%) | 64.00 | 12.00 | 0 | 8.00 | |
| Wang (2006) | Frequency | 21 | 8 | 8 | 2 | 42 |
| | Percentage (%) | 50.00 | 19.05 | 19.05 | 4.76 | |
| Wang (2007) | Frequency | 15 | 12 | 5 | 6 | 39 |
| | Percentage (%) | 38.46 | 30.77 | 12.82 | 15.38 | |

Themes of scientific literacy: I = the knowledge of science; II = the investigative nature of science; III = science as a way of knowing; IV = interaction of science, technology, and society

6.25 %, 9.38 %, and 3.13 %. This obviously shows that the distribution of the four themes of scientific literacy is fairly unequal in this series. Compared with the traditional one, the proportions of "the investigative nature of science" and "interaction of science, technology, and society" have been added in the three new series. For "science as a way of knowing," although there was no content of this theme in Song's (2006), the proportions of this theme in Wang's (2006) (19.05 %) and Wang's (2007) (12.82 %) are considerable. Overall, the current series are better than the traditional one in dealing with the issue of curriculum balance. As far as three series of new textbooks are concerned, the issue of curriculum balance is treated best in Wang's (2007) (38.46 %, 30.77 %, 12.82 %, and 15.38 %, respectively) and worst in Song's (2006), with Wang's (2006) being between the two.

### *6.4.4 The Distributions of the Themes of Scientific Literacy on the Topic of "sulfur and its compounds" in the Different Series of Chemistry Textbooks*

The distributions of the themes of scientific literacy on the topic of "sulfur and its compounds" in the different series of chemistry textbooks are presented in Table 6.6.

Table 6.6 shows that no treatment is given to the theme of "science as a way of knowing" in any of the four series. This means that neither the traditional series nor the new ones deal with the issue of curriculum balance well. In other words, the problem of the imbalanced distribution of the themes of scientific literacy in the traditional series has not been solved in the new ones. Comparing the new series with the traditional one, "the investigative nature of science" seems to have

**Table 6.6** The distributions of the themes of scientific literacy on the topic of "sulfur and its compounds" in the different series of chemistry textbooks

| Textbooks | | Themes of scientific literacy | | | | Total units of analysis |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | |
| Wu and Hu (2003) | Frequency | 28 | 16 | 0 | 8 | 54 |
| | Percentage (%) | 51.85 | 29.63 | 0 | 14.81 | |
| Song (2006) | Frequency | 22 | 13 | 0 | 12 | 48 |
| | Percentage (%) | 45.83 | 27.08 | 0 | 25.00 | |
| Wang (2006) | Frequency | 16 | 14 | 0 | 8 | 40 |
| | Percentage (%) | 40.00 | 35.00 | 0 | 20.00 | |
| Wang (2007) | Frequency | 20 | 12 | 0 | 11 | 43 |
| | Percentage (%) | 46.51 | 27.91 | 0 | 25.58 | |

*Note*. Themes of scientific literacy: I = the knowledge of science; II = the investigative nature of science; III = science as a way of knowing; IV = interaction of science, technology, and society changed little, while "interaction of science, technology, and society" in the new series has gained at the expense of "the knowledge of science."

### 6.4.5 The Comparison of Theoretical Chemistry and Descriptive Chemistry With Respect To the Distribution of the Themes of Scientific Literacy

As mentioned earlier, we take the topics of "atomic structure" and "sulfur and its compounds" as examples of theoretical chemistry and descriptive chemistry, respectively, in this chapter. The comparison of these two topics with respect to the distribution of the themes of scientific literacy is presented in Table 6.7.

As seen in Table 6.7, for the theme of "the knowledge of science," the proportion in "atomic structure" is higher than that in "sulfur and its compounds" in all series except Wang's (2007). For "the investigative nature of science," the proportion in "sulfur and its compounds" is higher than that in "atomic structure" in all series except Wang's (2007). For "science as a way of knowing," there is no content of this theme in the topic of "sulfur and its compounds" in any of the four series. Conversely, there are some contents on this theme in the topic of "atomic structure" in all series except Song's (2006). Like the situation of "the investigative nature of science," the proportion in "sulfur and its compounds" is higher than that in "atomic structure" in all series in "interaction of science, technology, and society." It can be inferred from this result that theoretical chemistry is better than descriptive chemistry in dealing with the issue of curriculum balance in both the traditional and new series.

**Table 6.7** The comparison of the topics of "atomic structure" and "sulfur and its compounds" with respect to the percentage distribution of the themes of scientific literacy in different series of chemistry textbooks

| Textbooks | Topics | Themes of scientific literacy | | | |
|---|---|---|---|---|---|
| | | I (%) | II (%) | III (%) | IV (%) |
| Wu and Hu (2003) | Atomic structure | 78.13 | 6.25 | 9.38 | 3.13 |
| | Sulfur and its compounds | 51.85 | 29.63 | 0 | 14.81 |
| Song (2006) | Atomic structure | 64.00 | 12.00 | 0 | 8.00 |
| | Sulfur and its compounds | 45.83 | 27.08 | 0 | 25.00 |
| Wang (2006) | Atomic structure | 50.00 | 19.05 | 19.05 | 4.76 |
| | Sulfur and its compounds | 40.00 | 35.00 | 0 | 20.00 |
| Wang (2007) | Atomic structure | 38.46 | 30.77 | 12.82 | 15.38 |
| | Sulfur and its compounds | 46.51 | 27.91 | 0 | 25.58 |

Themes of scientific literacy: I = the knowledge of science; II = the investigative nature of science; III = science as a way of knowing; IV = interaction of science, technology, and society

## 6.5 Conclusion and Discussion

In this chapter, we have analyzed the distribution of the themes of scientific literacy in the new senior secondary school chemistry curriculum in China. A general conclusion drawn from the findings of this chapter is that the issue of curriculum balance has not been well treated in this curriculum. Specifically, five points should be noted. Firstly, the theme of "science as a way of knowing" is greatly lacking in the SSSCCS, and the percentage distributions of the themes of scientific literacy are different among "curriculum objectives," "teaching objectives," and "activities" in this official document. Secondly, the percentage distributions of the four themes of scientific literacy in the three series of the new senior secondary school chemistry textbooks have similar trends, but none of the three series deals well with the issue of curriculum balance. Thirdly, by comparison, the issue of curriculum balance is treated best in Wang's (2007) and worst in Song's (2006), with Wang's (2006) being between the two, and the new textbooks are worse than the SSSCCS in dealing with the issue of curriculum balance. Fourthly, compared with the traditional one, the themes of "the investigative nature of science" and "the interaction of science, technology, and society" have been increased in the three new series. Fifthly, when taking the topics of "atomic structure" and "sulfur and its compounds" as examples of theoretical chemistry and descriptive chemistry, respectively, we found that the former is better than the latter in dealing with the issues of curriculum balance in both traditional and new textbooks.

From the results of this study, we can infer that the issue of curriculum balance has associations with science curriculum policy, the authorship effect of curriculum documents and science textbooks, and the nature of subject content knowledge (such as theoretical or descriptive chemistry content in this study). It is beyond the scope of this chapter to discuss each of these factors. In short, similar to Chiappetta et al.'s (1991a, b) and Wilkinson's (1999) studies, this chapter has shown that the issue of curriculum balance has not been dealt with well in science textbooks. The most remarkable defect is that "science as a way of knowing" is greatly lacking. Although the themes of "the investigative nature of science" and "interaction of science, technology, and society" have gradually grown in new science textbooks under the influence of the movements of "Scientific Inquiry" (Abd-El-Khalick et al. 2004) and "STS" (Solomon and Aikenhead 1994), respectively, the theme of "science as a way of knowing" is still lacking in recent years. At this point, our research is consistent with those studies which focused on examining representations of the nature of science in science textbooks (e.g., Abd-El-Khalick et al. 2008; Wei et al. 2013). Furthermore, we found in this study that the theme of "science as a way of knowing" is lacking both in textbooks and in science curriculum documents. Linking with BouJaoude's (2002) study, which was conducted in Lebanon, a current situation in developing countries is revealed: this theme is heavily marginalized in science curriculum documents. The reasons for this situation need further exploration.

In China, as mentioned earlier, the goals of the senior secondary school chemistry curriculum are defined by three dimensions in view of scientific literacy: (1) knowledge and skills, (2) processes and methods, and (3) emotions, attitudes, and values. Comparing these three dimensions with the four themes of scientific literacy, it can be seen that "knowledge and skills" and "processes and methods" are roughly equal to the themes of "the knowledge of science" and "the investigative nature of science," respectively, and some viewpoints of "interaction of science, technology, and society" are encompassed in the dimension of "emotions, attitudes, and values." However, the theme of "science as a way of knowing" is missing. The reasons must be multiple. One definite reason is that scientific epistemology and the contemporary scholarship of the nature of science are neglected by chemistry curriculum designers. As Driver et al. (1996) argued, the nature of science has great potential contribution to one's scientific literacy. Thus, we cannot imagine what a scientifically literate person would be like if he or she is ignorant of the nature of science. This is the reason that the theme of "science as a way of knowing" is included in the framework when discussing the issue of curriculum balance in view of scientific literacy. In the future revision of senior secondary school chemistry curricula, curriculum designers and textbook writers should treat the issue of curriculum balance better so as to achieve the balanced development of scientific literacy of students. When dealing with the issue of curriculum balance, our suggestion is that, as a first step, chemistry curriculum designers should fully and comprehensively grasp the meanings of scientific literacy imported from the West, especially those informed by the contemporary development of the philosophy of science, and then transmit these meanings into chemistry curriculum documents and chemistry textbooks. More specifically, the theme of "science as a way of knowing" should be included as a dimension of the curriculum goals presented in national standards, and increased history of science and nature of science content should be included in textbooks. Finally, we must say that this chapter was based on frameworks in the Western literature, but we ignored the interpretations and perceptions of chemistry curriculum designers and textbook writers on the notions of "scientific literacy" and "science as a way of knowing." This is a limitation of this chapter. Furthermore, we must acknowledge that this study focused on only the national standard document and textbooks; further investigation of classroom instruction and assessments may reveal different pictures of curriculum balance.

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