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A study on textbook use and its effects on students' academic performance

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Abstract

Curriculum education reforms are being carried out in various countries, in which great research interest has been generated in the use of textbooks and the effectiveness of their use. In this study, the focus is on the actual use of textbooks by the first students to use the 2019 edition of general high school chemistry textbooks (students graduating in summer 2022 and summer 2023) and its relationship with students' interest and attitudes, and their academic achievements in chemistry. In this study, two questionnaires and one test with a standardized reliability and validity were developed. A quantitative analysis method was used to determine how the students ($N = 2874$) used the new textbooks. Correlation analysis was used to explore the correlation between the use of new textbooks and students' interest, attitudes, and academic achievements among students ($N = 250$).

The results show that students rate the new textbooks highly, but there is still much room for improvement in the functional value of the new textbooks. Correlation analysis and regression analyse showed that there was a significant correlation between students' use of chemistry textbooks and their interest and attitudes, but the correlation between them and their academic achievements in chemistry was not directly significant. At the same time, the use of the new textbooks revealed a different dynamic and atmosphere in the chemistry classroom, with more classroom student activities taking place and students being able to participate more deeply and actively in them. This contributed more to students' interest and attitudes, and improved their performance in chemistry. In this study, we strongly argue for the importance and value of textbook use for student learning on the one hand and for the enrichment of student-centred textbook use research on the other.

Keywords New curriculum reform, Use of new textbooks, Students

Introduction

Since the beginning of the 21st century, the rapid development of global technology and economy has posed new challenges to the competencies needed to train human workers. To better prepare students for the future, countries worldwide are carrying out curriculum and education reforms and have introduced new curriculum standards one after another. In 2013, for example, the National Academy of Sciences of the United States published the Next Generation Science Standards (NGSS Lead States, 2013). In 2015, the Finnish National Board of Education issued new national core curriculum standards for general high schools (The 2015 National Core Curriculum Standards for Senior High Schools) (Finnish National Agency for Education, 2017), and the OECD launched "OECD Future of Education and Skills 2030" to map out the future of education. In 2018, the OECD released the first outcome of the program, i.e., the "OECD Learning Framework 2030", which is one of the trends of curriculum reform in countries worldwide (Organization for Economic Cooperation and Development (OECD), 2018). However, these standards present criteria or goals for what students should know and be able to do, rather

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than curriculum and instruction. Therefore, countries also need to develop high-quality instructional materials or textbooks that are aligned with curriculum standards to help teachers implement instruction and help students learn. Therefore, the development of new instructional materials or textbooks and assessment materials for the relevant curriculum standards has become a new hot topic in international educational research. As individual curriculum standards, instructional materials, and assessment materials have moved into actual use, a very interesting research topic has followed: How do students use these new textbooks developed based on the new curriculum standards, and how do students' academic performance relate to the use of the new textbooks? Because the use of high-quality teaching materials can improve student performance in science (Harris et al., 2014), researchers have developed an interest in how teaching materials are used and the associated effectiveness (Harris et al., 2015).

Since the promulgation and implementation of the new curriculum standards in January 2018, (Ministry of Education of the People's Republic of China, 2018) a new round of curriculum reform is in full swing, aimed at "fulfilling the fundamental task of building moral character and cultivating students' core competence". Textbooks are the agents of curriculums, the implementation of many curriculum reform ideas is realized through textbooks, and the implementation of each curriculum reform is accompanied by the preparation and publication of new textbooks. Based on the new curriculum standards, the Ministry of Education prepared or revised textbooks for all subjects taught in general high schools and started implementing them in the fall semester of 2019.

The revised textbooks adhere to the fundamental task of "building moral character and cultivating students' core competence" to develop disciplinary core competence, with a view to becoming a "useful scaffold and conveyor belt" that can change students' learning methods, can cultivate their core competence in chemistry, and can improve their interest, attitudes, and achievements in chemistry (Wang & Chen, 2019a).

Currently, most research has focused on the interpretation of textbooks and strategies for their use, but little attention has been given to the actual use of textbooks and their impact (Wang & Chen, 2019a; Hu & Wang, 2021; Wan et al., 2022; Liu & Jiang, 2021). However, textbooks themselves cannot improve teachers' teaching abilities or students' learning capabilities; they can only exert an influence when fully utilized by teachers and students (Li, 2023). Therefore, it is crucial to investigate the use of textbooks and their relationship with student learning in order to determine whether the "reality" matches the "expectations."

What is the status of the use of the new textbook? What is the relationship between students' interest in learning chemistry, their attitudes, achievements in chemistry and the use of the new textbooks? We conduct a corresponding empirical study to comprehend the use and efficiency of the new textbooks and to demonstrate the connection between the two. This research also elucidates studies that examine whether using curricular materials based on standards can improve students' learning interests and attitudes as well as their achievements of the requirements of the curriculum standards.

Literature review

Students' use of textbooks

On the one hand, textbooks are generally seen as tools that embody the basic ideas of curriculum reform and play a role in helping to initiate and to sustain the reform; on the other hand, they are the primary teaching materials in schooling, the content carriers that enable students to meet the objectives set out in the curriculum standard; they are important resources and tools for teachers' teaching and students' learning. However, textbooks by themselves do not have an impact in the classroom; they can play a role only when being fully used by teachers and students (Fullan, 2000). Cronbach began calling for research on the use of textbooks as early as 1955 (Cronbach et al., 1955), and Rezat (2009) pointed out that the use of textbooks was always an important topic in educational research.

A review of recent research on textbook use covers teachers' use of textbooks and students' use of textbooks. The recent research on teachers' use of textbooks is more than plentiful (Remillard & Bryans, 2004; Nicol & Crespo, 2006; Lepik et al., 2015; Donald et al., 2016; McDonald, 2016); therefore, this study is not conducted for further research on teachers' use of textbooks and instead is focused primarily on students' use of textbooks.

We argue that students are the most important participants in using textbooks, and the ultimate purpose of teachers' use of textbooks is for students' development, so ignoring students' use of textbooks may hinder the realization of the original purpose of textbook design. For this reason, some researchers have studied students' use of textbooks. Rezat (2009) found that German secondary school students used textbooks mainly for (i) finding support for solving tasks and problems; (ii) consolidation; (iii) acquiring mathematical knowledge; and (iv) activities related to mathematical interests. In their study of the textbook use of 206 Chinese and 161 British secondary school students in Shanghai, Wang & Fan (2021) discovered that the majority of British and Shanghai secondary school students used their textbooks for prereading, reviewing, in-class learning, and information gathering. According to Weinberg et al. (2012), students used textbooks mostly for homework and test preparation. The amount of time students spent reading textbooks was significantly less than that of the number of hours necessary for the course, according to Sikorski et al. (2002). For instance, students spent only 2.6 h per week studying and reading instructional materials such as chemistry textbooks and student instructional manuals, even though the chemistry curriculum states that students should spend 4.1 h per week reading textbooks. Phillips and Phillips (2007) found that only 17% of students read textbook-related material before class discussions and 55% read textbooks after class. Clump et al. (2004) found that 70% of students chose to read the textbook content before the test, while only 27% of students read the assigned textbook content before the class. Sinapuelas (2011) proposed a division of students' levels of textbook use and a description of each level into four levels: memorizer, programmer, critical thinker, and researcher. The researcher found that level 1 (memorizer) and level 2 (proceduralist) are the levels at which most students use textbooks, i.e., remembering relatively independent fragmented knowledge and drawing information, making connections between information, being unable to evaluate or interpret information, and being unable to apply knowledge to solve problems. In his doctoral dissertation, Zeng (2016) proposed a theoretical framework for students' use of textbooks from an activity theory perspective and then used a case study approach to analyse and to compare the use of textbooks by four students. The findings revealed that (1) students lacked in-depth textbook reading behaviours and their textbook use behaviours were similar; (2) students instrumentalized textbooks in the process of using textbooks, but the level of instrumentalization was not high, so they were not able to give full play to the functions of textbooks; and (3) students used textbooks at different levels, but the levels were all low, playing the role of "memorizers" and focusing on problems. It is clear from the existing studies that although students' use of textbooks has been characterized in various models of curriculum implementation, the number of studies on students' use of textbooks is very small compared to that of the studies on teachers' use of textbooks. Both research theories and research paradigms are still in the exploratory stage and have not yet formed a consensus. However, students should be the most important subject in using textbooks, the ultimate purpose of teachers' use is still for students' development, and ignoring students' use of textbooks may hinder the realization of the original purpose of textbook design (Zeng & Cui, 2019). Therefore, the study of students' use of textbooks should not be ignored or marginalized but should be given more attention and research.

The influence of students' use of textbooks

To comprehensively study students' use of textbooks, first, it is necessary to clarify what impact the use of textbooks can have on students to promote the use of textbooks among students. Son & Diletti (2017) stated that textbooks are one of the factors that influence students' learning. Wakefield's (2007) research found that students' use of textbooks seems to help students learn and consolidate their knowledge and skills. Students' use of textbooks was also shown in the theoretical framework of research on students' use of textbooks constructed by Zeng (2016) to have an impact on students' interest, attitudes and achievements.

In summary, researchers have concluded that students' use of textbooks can have an impact on students' interest, attitudes and their academic achievements in chemistry. However, research in this area is still relatively scarce; there is a lack of empirical studies, and the applicability and generalizability of the findings need to be further verified.

In this study, we focus on students' activities of using textbooks independently, and the research framework of this study is modified based on Zeng's model (as shown in Fig. 1), in which students are the main subjects, the contents in textbooks are the objects of activities, and the outcomes are the goals they want to achieve by using textbooks. The student factors include the purpose of use, beliefs about use, and willingness to use, etc., the behaviours, the level of use of tools, and the use of illustrations

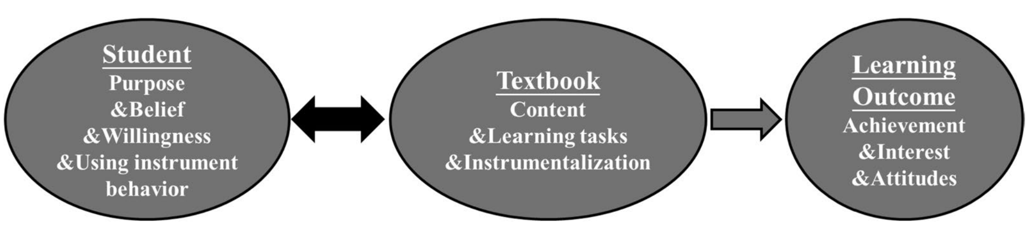

Fig. 1 A framework model for student use of textbook research (modified from Zeng, 2016)

shown by the actual use of textbooks by students. The outcomes refer to the learning goals of students, such as interest, attitudes and achievements.

This framework provides a basis for investigating the framework structure of students' textbook use on the one hand and provides theoretical support for the impact of textbook use on students on the other hand.

Research questions

In this study, we analyse the actual use of the new textbooks by high school students graduating in the summers of 2022 and 2023, their effects on students' interest and attitudes, and the associated student achievements in chemistry by answering the following three research questions. On the one hand, we summarize the characteristics of and experiences of students who used the new textbooks and provide useful suggestions for students who are about to start using them to maximize their functional value. On the other hand, we confirm the beneficial effects of students' use through empirical data to raise the importance of textbook use by educators and learners; in addition, this research also contributed to the development and enrichment of the field of textbook use research.

This study is dominated by the following research questions.

> RQ1: How are high school students graduating in the summers of 2022 and 2023 using the new textbooks in their chemistry studies? (e.g., students' overall awareness of new textbooks, the time, the frequency, and the behaviours of students who use the textbooks and specific columns, etc.)
> RQ2: Does the use of new textbooks by students have an impact on students' interest in and attitudes towards chemistry learning?
> RQ3: Does the use of new textbooks by students have an impact on students' achievements in chemistry?

As the RQ 2 & 3 involve correlations, in order to better develop the research, At the same time, based on the framework model for students' use of textbook research, two research hypotheses of this paper are proposed:

> Hypothesis 1: Students' use of textbooks can have a direct positive effect on students' interest and attitudes. That is, the better the students' performance in using textbooks, the better the performance of students' interests and attitudes in learning chemistry.
> Hypothesis 2: Students' use of textbooks can have a direct positive effect on students' achievements in chemistry. That is, the better the students' performance in using textbooks, the better the students' achievements in chemistry.

Method

A quantitative research method was used in this study. The researcher-developed "Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks" was used to examine the students' use of the new textbooks in their studies. The researcher developed "Questionnaire on General High School Students' Interest and Attitudes in the Context of the New Curriculum" was used to examine students' interest and attitudes. In particular, students' attitudes were measured in terms of both attitudes towards learning chemistry and attitudes towards chemical science. In addition, a large chemistry achievements test developed by the researcher's team was also used to obtain the students' academic achievements in chemistry. A descriptive statistical analysis of the quantitative data collected was performed when describing students' use of the new textbooks, their interest and attitude, and their academic achievements in chemistry. Correlation analysis and regression analysis were conducted to determine whether there was a correlation between students' use of the new textbooks, interest in and attitudes towards chemistry learning, and academic achievements.

New textbook materials

In 2019, the Expert Committee of China National Textbook Committee reviewed and approved three versions of general high school chemistry textbooks, which were published by the People's Education Press (hereinafter referred to as the "PEP version"), Shandong Science and Technology Press (hereinafter referred to as the "SSTP version"), and Jiangsu Phoenix Education Press (hereinafter referred to as the "JPEP version"). Each version of the textbook consists of five volumes, including two required volumes and three optionally required volumes. The three optionally required volumes are titled "Optionally Required Book 1: Principles of Chemical Reactions", "Optionally Required Book 2: Structure and Properties of Substances", and "Optionally Required Book 3: Fundamentals of Organic Chemistry". The two required textbooks are used in the senior year and the three optional required textbooks are used in the sophomore year.

With the General High School Chemistry Textbook (2019 Edition) published by Shandong Science and Technology Press (hereinafter referred to as "SSTP version") as an example (Wang & Chen, 2019b), we introduce the features and structure of the new textbook as follows.

The SSTP version, based on inheriting and carrying forward the characteristics of the old textbook, highlights the new orientation of building moral character and cultivating students' core competence, strives to interpret the connotation of core competence from a high viewpoint, broad vision, and multiple perspectives, and scientifically constructs the developmental progression of core competence, presenting the following features, as shown in Table 1.

Taking the SSTP version (Wang & Chen, 2019b) as an example, we selected one of the chapters in one textbook to roughly introduce its content structure, as shown in Table 2. The chapter includes three parts, one microproject, Self-evaluation Form, and Post-Chapter Exercises. Each part begins with the "Think & Question" column, followed by the main text, diagrams, the "Activities & Inquiry" column, the "Methodology Guide" column, the "Communication & Discussion" column, and informative columns providing relevant materials and information, and ends with the "Overview & Integration" column and the "Exercises & Activities". This is the basic structure of each part. After the microproject, there is a "Self-evaluation Form for This Chapter", which encourages students to be more conscious and active in self-evaluation and reflection against the curriculum standard and requirements. The chapter ends with post chapter exercises.

Sampling

Among the abovementioned three versions of general high school chemistry textbooks, the most widely used ones are the PEP and SSTP versions, so we focus on students who use these two versions of textbooks. The student data were obtained from high school students graduating in Beijing and Shandong in the summers of 2022 and 2023. These two locations were focused on because, on the one hand, they both have schools that use the PEP and SSTP versions; on the other hand, the schools in these two locations work closely with the researcher's team, so it was easier for them to obtain complete data in a standardized manner.

Among them, 2,874 high school students graduating in the summer of 2022 and 2023 in two Chinese provinces (Beijing and Shandong) were taken as the study samples

Table 1 The features of the SSTP version

Purposes	Features
Externalize the thinking process and methods and promote the transformation of core knowledge into competence and competence	• Set up columns such as the "Methodology Guide"
Real problems and situations are created to improve students' interest and attitudes	• Select a variety of real situation materials in the main body of the textbook and informative columns • Set up a "microproject" specifically at the end of each chapter
Refine the experience of core activities, to integrate the practice of scientific inquiry with the construction of core chemical concepts	• Stipulate the student's needed experiments
To enhance students' interest in learning chemistry and their learning attitudes in the chemistry classroom	• Select situational materials that not only highlight contemporaneity but also have Chinese characteristics, paying attention to reflecting traditional culture and the contributions of Chinese chemists to the development of modern science and technology

Table 2 The structure of one of the chapters in one textbook (the SSTP version)

	Content
Part 1	• The "Think & Question" column • Main text, diagrams, "Activities & Inquiry" column, "Methodology Guide" column, "Communication & Discussion" column, and information columns providing relevant materials and information • "Overview & Integration" column • "Exercises & Activities" column
Part 2	Same as Part 1
Part 3	Same as Part 1
Micro-projects	• Project Learning Objectives • Project Activity 1 • Project Activity 2 • Project Activity 3 • Project results showcase
Self-evaluation Form for This Chapter	• Core competencies development focus • Academic Requirements
Post-Chapter Exercises	• Understanding • Applying • Innovating

to learn the use of the new textbooks. Since the test on students' interest, attitudes and achievements in chemistry was not the same test as the test on the use of the new textbook, some participants did not correspond between the two tests, so the number of participants in the study was reduced from the previous test, with a total of 250 high school students. The specifics of the two research samples are shown in Table 3.

Instruments

To answer the research questions, this study needs three instruments: the Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks, the Questionnaire on General High School Students' Interest and Attitudes, and the Chemistry Achievements Test for General High School Students.

For the instruments needed in this study, it is necessary to take the new curriculum standards and new textbooks as the background. There are no mature instruments that can be used directly, so instruments need to be developed by the researcher based on relevant standards, literature, realistic needs, and research purposes. The instruments in this study are very important, and the value and reliability of the findings are directly determined by their quality.

On the one hand, our team went through many discussions, modifications, and quality test. Reliability was reflected by the Cronbach coefficients, and validity was based on the validation factor analysis using AMOS 26.0. At the same time, two experts in the field of chemistry education, who are also experts in developing the new curriculum standard and the new textbooks, and a graduate student of chemistry education were invited to guide and to validate these instruments development phase. Research instruments development and revision process is shown in Fig. 2.

The third instrument was described in detail later due to its specificity.

Questionnaire on the use of the 2019 edition of general high school chemistry textbooks

Researchers developed a "Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks" based on the "Chemistry Curriculum Standard for General High Schools (2017 Edition)" and related literature. The framework of the questionnaire is shown in Table 4. The questionnaire consists

Table 3 Overview of basic information of samples

		Samples for RQ 1		Samples for RQ 2 & 3	
		Number	**Percent (%)**	**Number**	**Percent (%)**
Gender	Boys	1401	48.75	106	42.40
	Girls	1473	51.25	144	57.60
Grade	Graduated in the summer of 2022	755	26.27	39	15.60
	Graduated in the summer of 2023	2119	73.73	211	84.40
Province	Beijing	1543	53.69	176	70.40
	Shandong	1331	46.31	74	29.60
Class	Ordinary classes	2156	75.02	188	75.20
	Better classes	718	24.98	62	24.80
Textbook version	PEP	881	30.65	222	88.80
	SSTP	1993	69.35	28	11.20
	Total	2874	100.00	250	100.00

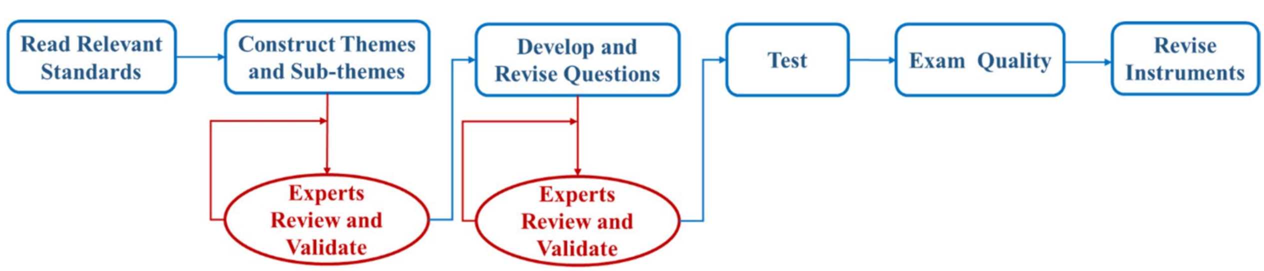

Fig. 2 Research instruments development and revise process

Table 4 The framework of "Questionnaire on the use of the 2019 edition of general high school chemistry textbooks "

Themes	Sub-themes	
Overall awareness of textbooks	Awareness of using textbooks	
	Motivations of using textbooks	
	Purposes of using textbooks	
	Evaluation of textbooks used	
Actual use of textbooks	Time of use	
	Frequency of use	
	Specific use behaviors	
	The actual use of specific contents in the textbook	The relevant column system
		Students' compulsory experiments
		Overview & Integration column
		Exercises & Activities
		Micro-projects
		Self-evaluation form

of three parts. The first is basic information, such as school, gender, and textbook version used; the second is students' overall awareness of new textbooks; and the third is the actual use of textbooks. There are 33 five-point Likert questions designed for the evaluation of textbooks, the choices were assigned with values of "1 = strongly disagree", "2 = disagree", "3 = not sure", "4 = agree" and "5 = strongly agree". The other contents were investigated in the form of single-choice or multiple-choice questions, with a total of 54 questions.

The Cronbach's coefficient (α) test was executed on the data of this questionnaire and the resulting α was 0.952. The same test was executed on the questions of each dimension and the resulting α for students' overall awareness of new textbooks was 0.853; that for the actual use of chemistry textbooks was 0.950. With both being greater than 0.8, we know that this questionnaire had a very good reliability coefficient. Confirmatory factor analysis of the structural validity of the questionnaire was conducted by using AMOS 26.0, and the results showed that RMSEA was 0.066, less than 0.08, indicating that the fitness was quite good; CFI was 0.861, greater than 0.85, indicating that the result fitness was acceptable; NFI was 0.850, indicating that the result fitness was acceptable; IFI was 0.861, greater than 0.85, indicating that the result fitness was acceptable; and TLI was 0.853, greater than 0.85, indicating that the result fitness was also acceptable. Due to many samples and potential variables, the overall structural model fitness of the "Questionnaire on Students' Use of Chemistry Textbooks in General High Schools 2019" was acceptable based on the above indicator values.

Questionnaire on general high school students' interest and attitudes in the context of the new curriculum

Researchers developed a "Questionnaire on General High School Students' Interest and Attitudes in the Context of the New Curriculum". The questionnaire consisted of 3 items: interest in learning chemistry; attitude towards chemistry learning; and attitude towards chemical science. Each item consisted of 6, 3, and 8 questions, respectively, totaling 17 questions, presented in the form of a three-point Likert scale, the choices were assigned with values of "1 = disagree", "2 = not sure", "3 = agree".

The Cronbach's coefficient (α) test was executed on the data of this questionnaire, and the resulting α was 0.937. The same test was executed on the questions of each item, and the resulting α for interest in learning chemistry was 0.898, that for attitude towards chemistry learning was 0.868, and that for attitude toward chemical science was 0.964, where all scores were greater than 0.8, indicating that the questionnaire had a very good reliability coefficient. Confirmatory factor analysis of the structural validity of the questionnaire was conducted by using AMOS 26.0, and the results showed that RMSEA was 0.073, less than 0.08, indicating that the fitness was quite good; CFI was 0.966, greater than 0.9, indicating that the result fitness was acceptable; NFI was 0.963, greater than 0.9, indicating that the result fitness was acceptable; IFI was 0.966, greater than 0.9, indicating the result fitness was acceptable; and TLI was 0.957, greater than 0.9, indicating that the result fitness was also acceptable. Overall, the fitness of the overall structural model of the "Questionnaire on General High School Students' Interest and Attitudes in the Context of the New Curriculum" is acceptable.

Chemistry achievements test for general high school students

The chemistry education research team of Beijing Normal University developed The Chemistry Achievements Test to assess the development of students' core literacy in chemistry, based on the General High School Chemistry Curriculum Standards (2017 Edition), new textbooks and studies related to chemistry subject competencies, for the 5 compulsory topics and 3 optional compulsory topics that candidates who chose chemistry to take the Academic Level Examination need to study, which has 296 test points. The test includes a variety of questions, including multiple-choice, fill-in-the-blank, and short answer. The test questions were developed by senior chemistry education experts, teaching researchers with rich experience in proposing questions, and excellent front-line teachers. The results of several sets of tests are relatively stable, so they are considered to have high reliability and expert validity. The chemistry ability values calculated by Rasch was used to characterize the students' achievements in chemistry.

The quality of the test instrument was examined by using the Rasch model. Rasch model estimates both item and person reliability on a scale of 0 to 1. Generally, reliabilities of 0.70 or above are considered acceptable for low stake assessment (Nunnally et al., 1967). The separation index is the ratio of the true standard deviation of a person (or item) to the error standard deviation. The separation index is used to reflect the discrimination of the different ability levels of the subjects by assessment tools. The larger the separation index, the better the discrimination effect. A separation index higher than 1.5 is acceptable, and a separation index greater than 2 is considered good (Duncan et al., 2003). The person reliability was 0.90 (> 0.70) and person separation was 3.01 (> 2.00), indicating that the sample was appropriately selected, the students responded carefully, and the reliability was good. The test item reliability was 0.89 (> 0.70) and separation was 2.82 (> 2.00), indicating that the test instrument was able to distinguish between different student levels, while the repeatability of the test items was strong. Second, the mean difficulty of the test items was 0.00, and the mean ability value of the student sample was -0.47, reflecting that the test instrument was slightly difficult for the participating students but within an acceptable range. A variance greater than or equal to 50% explained by the Rasch dimension can be regarded as evidence that the scale is unidimensional (Linacre, 2013) and the unexplained variance by the first contrast is less than 5% (Oon & Subramaniam, 2011). The Rasch model explained 40.2% (equal to 50%) of the total variance and the maximum unexplained rate was 2.5% (< 5%), consistent with the assumption of one-dimensionality. The mean square residual (MNSQ) is typically used as the fit indices to examine how well each item is coherent with the Rasch modeling. In general, items have acceptable fit if their MNSQs fall into the range from 0.6 to 1.4 for rating scale (Linacre, 2013). The MNSQ values of INFIT were between 0.7 and 1.3 for 95% of the 296 test items, and the data fit was good. The wright map shows that the 296 test items have a wide distribution of difficulty levels, and all the ability value levels of the participating samples have specific levels of test items corresponding to them, indicating that the test instrument is a more comprehensive test of students' chemistry performance.

Data collection and analysis

The questionnaires were uploaded by the researchers to the "Questionnaire Star" (Wenjuanxin in Chinese), a questionnaire collection platform, and the response links were provided to chemistry teachers in Beijing and Shandong, who then sent the links to their students. The whole process strictly followed China's data protection laws and regulations.

The data of each questionnaire respondent were collected. Before analysis, the data were checked for duplicate submissions, missing data, or blank records. Data from all respondents were then categorized and these records were analysed. Descriptive statistics of quantitative data on students' use of textbooks are shown by tables or graphs to achieve an overall description of students' use of new textbooks to answer RQ1. Correlation analysis is conducted to examine the effects of new textbooks on students' interest and attitudes, as well as their academic achievements in chemistry. The statistical significance value(sig.) is used to determine whether there is an influence relationship between them, and the correlation coefficient value is used to judge the strength of the influence relationship. Thus, RQ2 and RQ3 are answered. The tools used in data analysis were Microsoft Office Excel 2019, SPSS 25.0 for Windows, and AMOS 26.0. The samples, research instruments, and data analysis methods for each research question are shown in Table 5.

Results

In this section, we summarize the results of the data analysis, and it is divided into three subsections. The subsections provide evidence to address the research questions of this study.

Students' use of the new textbooks

Students' overall knowledge of the new textbooks

The researchers believe that students should treat textbooks dialectically. On the one hand, textbooks should have great authority in students' minds and be the most important learning resource; on the other hand, they should realize that textbooks are not perfect, and they

Table 5 Overview of samples, instruments and analysis methods for each research question

Questions	Samples	Instruments	Methods
RQ1	2874	Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks	Descriptive statistics、Variance tests
RQ2	250	Questionnaire on General High School Students' Interest and Attitudes in the Context of the New Curriculum	Descriptive statistics、Correlation analysis、Regression analysis
RQ3		Chemistry Achievements Test for General High School Students	

can of course question the textbooks when finding any errors or mistakes in them. Therefore, the first step of the study was to understand the students' attitudes towards or perceptions of textbooks. It was found that although only 62.67% of the students regarded textbooks as the most important learning material, this does not mean that other students do not value textbooks. Ninety-two percent of the students thought that textbooks cannot be replaced by teachers' courseware, study plans issued, and extracurricular tutorials. This shows that textbooks are irreplaceable in the minds of students. However, they were also rational and objective and did not blindly worship textbooks. Ninety-six percent of the students believed that textbooks may still contain errors or be incomplete, which spurs the textbook writing team to make continuous progress.

Evaluation of the new textbooks

The questions asked in the questionnaire are designed to assess students' satisfaction with the new textbooks. Respondents were asked to rate their satisfaction (the total score is 10 points). The results showed that the respondents' average satisfaction with the textbooks was 8.5, with a standard deviation of 1.73. The data analysis showed that the average value of students' evaluation of new textbooks was 4.22, and the average values of the abovementioned five dimensions were 4.42, 4.32, 4.36, 3.50, and 4.52 respectively (see Table 6).

Regarding whether the new textbooks could meet the students' learning needs, the survey results showed that most of the respondents (72.75%) replied that the new textbooks fully or almost fully met their learning needs, 21.50% said their needs were met, while only a few (5.74%) students said that their needs were not met by the new textbooks. See Fig. 3.

Actual use of the new textbooks

Firstly, when and how often respondents used the new textbooks was investigated. It was found that 85.00% of them used the new textbooks in class, 74.30% in after-class review, and 71.20% in preclass preview (see Fig. 4). Based on the Kendall W algorithm, the nonparametric test of multiple association samples showed that there was a significant difference between the three ($p=0.000, <0.05$). The frequency of using the new textbooks at different times was also calculated (see Fig. 5). More than 40% of the respondents indicated that they used their textbooks frequently before, during, and after class. Specifically, 30.47% of the respondents indicated that they used the textbooks in every class, with 21.49% and 16.55% of the respondents indicating that they used their textbooks every time they previewed and reviewed the lesson.

Respondents who chose not to use textbooks were also asked what learning materials they use. It was found that for preview, 78.99% of the respondents use teacher-distributed preview materials, 44.53% use extracurricular supplementary books and 33.29% use online learning resources; for review, 78.43% of the respondents refer to their notes taken in class, 62.68% use teacher-distributed in-class learning materials, 52.19% use extracurricular supplementary books, and 33.38% use teachers' PPT presentation texts; for in-class study, 72.73% of the respondents use teacher-distributed in-class learning materials, 72.26% use teachers' PPT presentation texts, and 36.83% use extracurricular supplementary books.

We were interested in not only the time and frequency of students' use of new textbooks but also in their specific use behaviour (see Table 7). For the before class preview, more than half of the respondents (54.40%) said that they carefully read what they were about to learn in

Table 6 Results of descriptive statistics of the new textbook evaluations

Compliance with curriculum standard		Content organization		Column system		Evaluation design		Safety design		Evaluation	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4.42	0.70	4.32	0.81	4.36	0.64	3.50	0.58	4.52	0.68	4.22	0.55

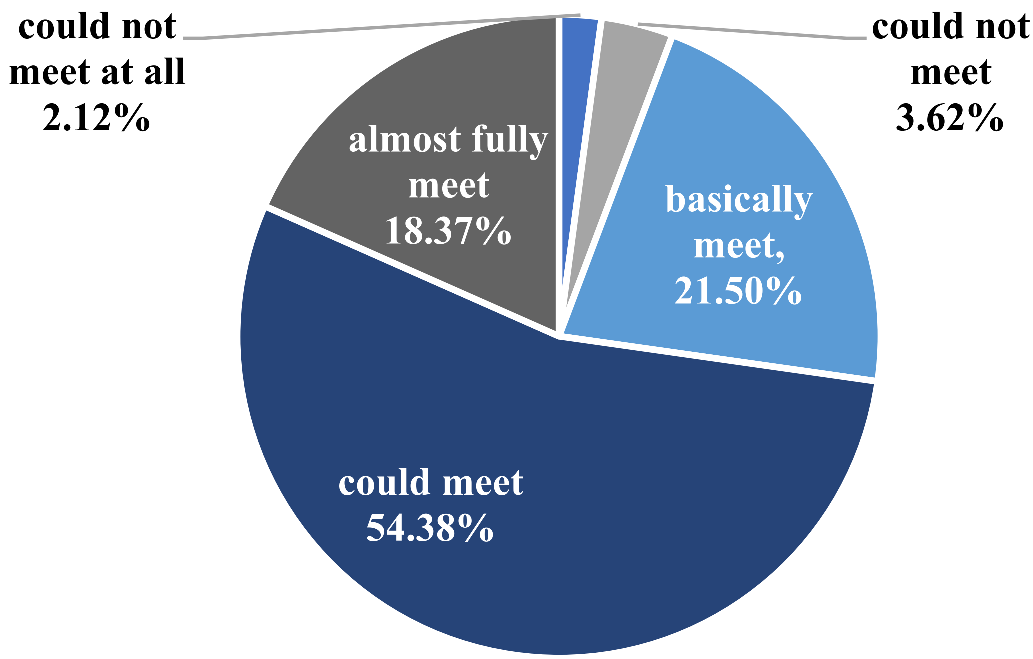

Fig. 3 Whether the new textbooks could meet the students' learning needs?

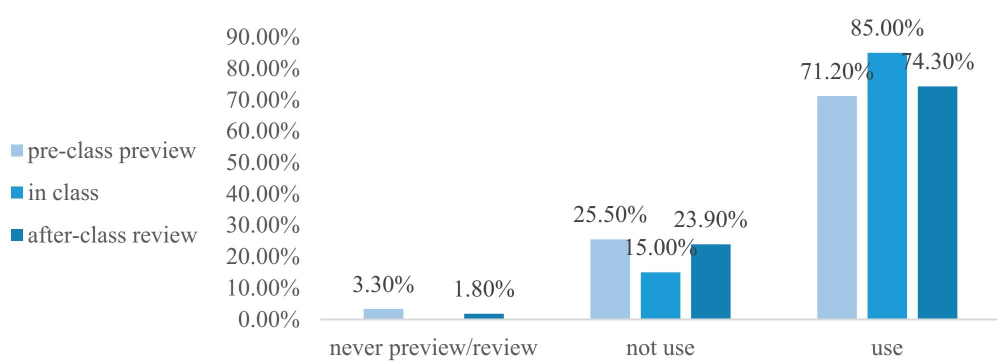

Fig. 4 Time of use the new textbook

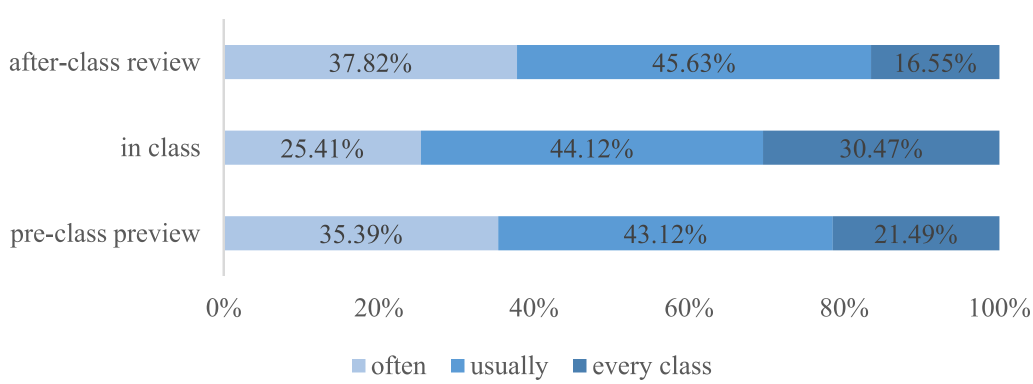

Fig. 5 Frequency of use the new textbook

Table 7 The behavior of use the new textbook

Time of use	Use behavior	Percent
Preview	Read textbooks passively instead of actively, just to complete the preview tasks assigned by teachers.	15.70%
	Only pay attention to the parts they were interested in.	7.30%
	Roughly browse the relevant content in the textbook to get a preliminary understanding of what they were about to learn.	22.60%
	Carefully read what they were about to learn in the textbook and mark out the parts they did not understand.	54.40%
	Total	100%
In-Class	Use textbooks only when the teacher explicitly required them to do so.	8.50%
	Take the initiative to consult textbooks when they had questions in class or when the teacher asked them to answer questions.	36.90%
	Use textbooks to follow the teacher's ideas.	36.50%
	The respondents would use textbooks actively.	18.00%
	Total	100%
Review	Read textbooks only when they had difficulty doing after-class exercises	16.70%
	Only browsed the notes recorded in the textbook.	6.00%
	Only browse the relevant content and corresponding notes in the textbook.	35.60%
	Read the relevant content and the notes they wrote in the textbook, thinking about and consolidating what they had learnt.	41.70%
	Total	100%

the textbook and indicated the parts they did not understand; 22.60% said that they roughly browsed the relevant content in the textbook to obtain a preliminary understanding of what they were about to learn; 7.30% said that they only paid attention to the parts they were interested in; and 15.50% said that they read textbooks passively instead of actively, just to complete the preview tasks assigned by teachers.

Concerning in-class learning, more respondents used textbooks under the teacher's prompt or instruction. Specifically, 36.90% of the respondents took the initiative to consult textbooks when they had questions in class or when the teacher asked them to answer questions; 36.50% used textbooks to follow the teacher's ideas; 8.50% used textbooks only when the teacher explicitly needed them to do so; and only 18.00% of the respondents used textbooks actively.

For after-class review, 41.70% of the respondents carefully read the relevant content and the notes they wrote in the textbook, thinking about and consolidating what they had learned; 35.60% browse only the relevant content and corresponding notes in the textbook; 16.70% read textbooks only when they had difficulty doing after-class exercises. In addition, very few respondents did not pay attention to the content of the textbooks themselves but browsed only the notes recorded in the textbooks.

We were particularly interested in whether the contents of the new textbook served the fundamental task of building moral character and cultivating students' core competence in chemistry, so we investigated the use of specific content in the new textbook.

We expected students to pay attention to the relevant columns in the new textbook in class, so we managed to determine the students' attention through the questionnaire survey, as shown in Table 8.

We found that more than 60% of students autonomously and actively pay attention to most or all of the activity columns, methodology guide columns, and informative columns. In particular, informative columns attracted the attention of most students (66.3%). The data showed that students paid less attention to exercises and hands-on tasks, and the proportion of students who took the initiative to pay attention to most/all relevant columns was less than 50%.

Table 8 Students' attention to the relevant columns of the new textbooks

	Activity column	Methodology guide column	Informative columns	Summary column	Exercise	Hands-on tasks
Hardly ever	4.3%	11.3%	2.9%	3.1%	6.9%	9.2%
Few	12.9%	7.1%	8.0%	9.7%	13.9%	12.8%
half	21.7%	17.8%	22.9%	30.8%	33.2%	32.7%
Most	40.4%	39.5%	48.6%	40.7%	32.6%	30.2%
All	20.6%	24.3%	17.7%	15.6%	13.4%	15.1%
total	100%	100%	100%	100%	100%	100%

For the activity column, we were more concerned about whether experimental and related activities were carried out by students for these activity columns. Surprisingly, more than 70% of respondents replied that experimental and related activities were carried out for 2/3 or all of the activity columns.

With the summary column, students are expected to establish the connection between the old and new knowledge under the guidance of the column and summarize and integrate the knowledge, skills, processes, and methods they have learned. Similarly, teachers can also use the summary column to organize new lessons, to review each section, to obtain timely feedback from students, and to evaluate the students. Therefore, we want to know how students use this column.

Data analysis showed that most students made full use of this column. Specifically, 41.60% of respondents tried to sort out the relevant knowledge structure by themselves and then compared it with this column to improve their knowledge structure; 37.40% of respondents chose to read this column carefully when reviewing their lesson after class or preparing for the exam; the remaining 21.00% respondents read this column only roughly, without giving full play to its functional value.

Corresponding exercises are designed at the end of each section and chapter of the textbook. We found that only 42.70% of teachers always or often assign these exercises to students as homework; 16.10% of teachers assign more than 80% of the exercises to students as homework; 27.00% of teachers would assign 60% ~ 80% of the exercises to students as homework; and other teachers do so sometimes, occasionally, or rarely. This shows that the utilization rate of exercises in the textbook was rather low.

What do the teacher do after the exercises were assigned to the students? Our survey shows that 70.6% of teachers evaluated students' homework and chose difficult exercises to explain to students; only 28.20% of the teachers offered guidance on all the assigned exercises; and 1.20% of teachers did not offer guidance on the assigned exercises at all.

For the differences in the ways of dealing with exercises in the textbook, we want to know whether teachers' explanations of exercises could promote students' chemistry learning. Approximately 90% of the respondents said that the teacher's explanation did promote or greatly promote their chemistry study. Students are eager for teachers to offer guidance on the exercises in the textbooks because it is beneficial to their chemistry study.

The new curriculum standard specifies 18 student needed experiments. Are the student needed experiments done by students? How are the experiments done by them? These are issues of great concern to researchers.

Our study found that 58% of the respondents said that they had the opportunity to design experimental plans and to carry out related experimental activities when they had to do experiments in their studies. After the activities, they summarized the ideas and methods of solving experimental problems. Half of them said that they still had the opportunity to conduct several rounds of experimental activities to improve their experimental skills. However, approximately 41% of the respondents said that they just operated directly according to the existing experimental scheme (see Fig. 6).

The curriculum standard mentions that teachers should carefully organize students to complete the required experiments, and schools with the necessary conditions should provide as many opportunities as possible for students to perform hands-on experiments. According to our survey results, however, the implementation of the required experiments was not satisfactory. To investigate the causes of this phenomenon, we perhaps need to obtain a glimpse of what teachers focus on in the teaching of required experiments. Our data analysis showed that in their teaching, teachers paid the most attention to the knowledge and conclusions involved in the experiment (34.49%). This explains why there is still much room for improvement in the implementation of the student needed experiments.

Textbooks has set up special columns to promote the all-round development of students' core competence in chemistry, such as the "microproject" column after each chapter in the SSTP version and the "research & practice" column in the PEP version.

Of course, we were interested in students' evaluation of these special columns. Our questionnaire survey found that the "microproject"/ "research & practice" column was highly rated by students, with a mean score of above 4 out of 5, and the score for each functional value of the column was also above 4. Specifically, the part that improved students' ability to analyse and solve practical problems had the highest score, 4.33 for "microproject" and 4.47 for "research & practice" (see Table 9).

We investigated students' views on the necessity of "microproject"/ "research & practice" column. Surprisingly, more than 70% of them said it was necessary or very necessary. Next, we wanted to know their actual attention to towards and usage of the column.

First, we investigated whether students actively read the "microproject"/ "research & practice" column in the textbook. It was found through statistics that only a few students always read each of the columns. Specifically, 17.21% of users of the SSTP version always read each "microproject" column, 11.24% of users of the PEP version always read each "research & practice"

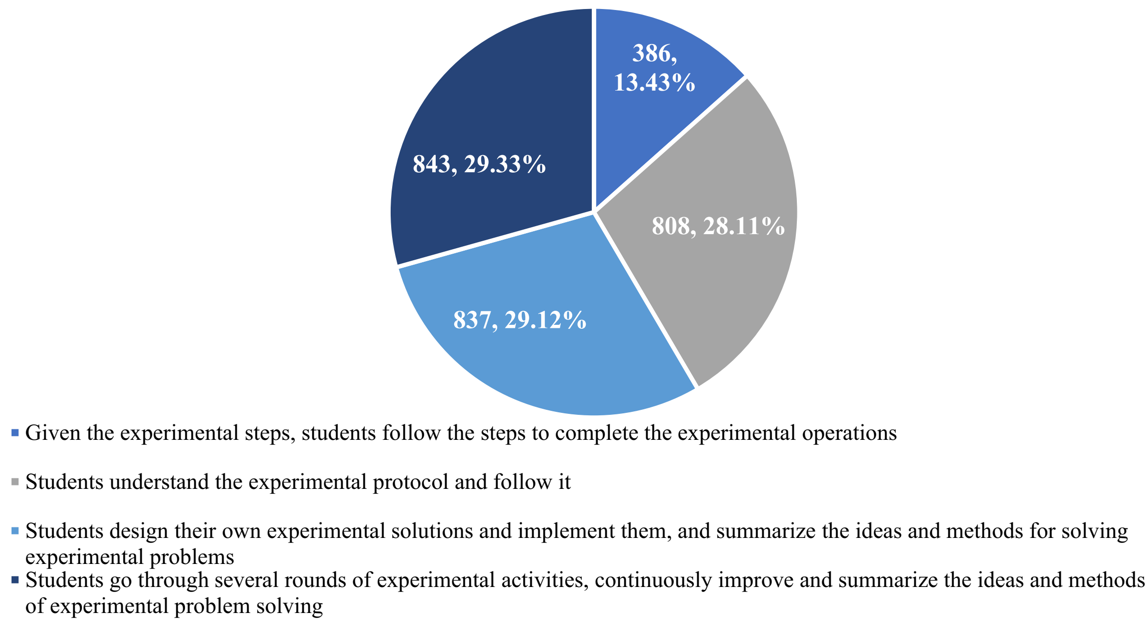

Fig. 6 How are the student's needed experiments done

Table 9 Students' evaluation of the special columns of new textbooks

		Increase the interest in learning chemistry	Promote the integrated application of the knowledge learned	Improve students' ability to analyze and solve practical problems	Total
Micro-project	Sample	1993	1993	1993	1993
	Mean	4.32	4.32	4.33	4.32
	SD	0.75	0.74	0.75	0.73
Research & practic	Sample	881	881	881	881
	Mean	4.46	4.46	4.47	4.46
	SD	0.72	0.71	0.72	0.70

column, while more than 60% of users often or sometimes read them.

Furthermore, we wanted to know if students wanted their teachers to implement these microprojects or "research & practice" projects in chemistry classes. It was found that more than 80% of students were eager or very eager to implement the projects under the guidance of teachers. Then, did chemistry teachers implement them in teaching? Our survey found that more than 90% of chemistry teachers implemented microprojects or "research & practice" projects, but they dealt with them in diversified ways. In class, 34.6% and 29.6% of teachers offered guidance on microprojects and "research & practice" projects respectively, followed by those who introduced them in new lessons and those who implemented them both in class and out of class. Less than 10% of teachers included these projects in review lessons or when offering guidance on the exercises.

The correlation between students' use of the new textbooks and their interest and attitudes

Students' interest and attitudes

Participants' interest and attitudes were investigated and measured from three dimensions: attitude towards learning; interest in learning; and attitude towards chemical science. Through descriptive statistics (see Table 10), we found that the average score of students' interest and attitudes was 2.78, with a standard deviation of only 0.34, an excellent result. In the above-mentioned three subdimensions, the average score of students' attitude towards chemistry learning was the highest (2.78), followed by that of their interest in chemistry learning (2.32), and that of their attitude towards chemical science (2.66). Based on the Friedman algorithm, the difference test of K correlation sequences (i.e. the two-way Friedman test) was calculated, and the progressive significance value was 0.000

Table 10 Descriptive statistics of students' performance on various dimensions of interest and attitudes in learning chemistry

	N	Min	Max	Mean	SD	*p*
Attitude toward learning	250	1.00	3.00	2.78	0.41	0.000
Interest in learning	250	1.00	3.00	2.32	0.35	
Attitude toward chemical science	250	1.00	3.00	2.66	0.54	
Total	250	1.00	3.00	2.78	0.34	

(< 0.05), indicating that there were significant differences among the scores in the three dimensions.

The correlation between students' use of textbooks and their interest and attitudes

The options for each question in the "Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks" were coded according to the principle that "the higher the recognition of the status and value of the textbook, the higher the evaluation, the more intrinsic the motivation for using the textbook, the more non-utilitarian the purpose of using it, the more time it is used, the higher the frequency of use, and the more sufficiently it is used, the higher the evaluation score will be". After the total score of each dimension was calculated, it was converted into a Z score (standard score). That is, the standard score of the ith case is equal to the ratio of the difference to the standard deviation after the case value is subtracted from the mean value. In other words, we need to calculate how many times the difference between the case value and the mean is the standard deviation. The data from the "questionnaire on general high school students' interest and attitudes in the context of the new curriculum" were also converted in this way.

After the "one-sample Kolmogorov–Smirnov test" was conducted on all data, we found that the p values of the variables were all less than 0.05 and showed a nonnormal distribution. Therefore, Spearman correlation analysis was performed on the variables involved in the study to examine the correlation between them. The results are shown in Table 11.

As seen from Table 11, students' use of textbooks was significantly correlated with their interest and attitudes performance in learning chemistry, attitude towards chemistry learning, interest in learning chemistry, and attitude towards chemical science at the level of $\alpha = 0.01$, and all correlation coefficients were positive. More specifically, the highest correlation was found between students' use of textbooks and their interest and attitudes performance in chemistry learning with a correlation coefficient of 0.483, followed by the correlation with interest in chemistry learning with a correlation coefficient of 0.518,the correlation with attitude towards chemical science with a correlation coefficient of 0.462, and finally, the correlation with attitude towards chemistry learning, with a correlation coefficient of 0.374.

To further investigate the correlation between the dimensions of students' use of textbooks and their interest and attitudes, we conducted a Spearman correlation analysis between the dimensions of textbook use and the dimensions of their interest and attitudes, and the correlations are shown in Table 12.

Table 12 shows that all the subdimensions of students' use of chemistry textbooks were significantly correlated with the subdimensions of their interest and attitudes at the level of $\alpha = 0.01$, with all the correlation

Table 11 Spearman's correlation coefficient between the variables

		Use of textbook	Interest in and Attitudes toward Chemistry Learning	Attitude toward learning	Interest in learning
Interest in and Attitudes toward Chemistry Learning	Correlation Coefficient	0.483[a]			
	Sig.	0.000			
Attitude toward learning	Correlation Coefficient	0.462[a]	0.671[a]		
	Sig.	0.000	0.000		
Interest in learning	Correlation Coefficient	0.518[a]	0.746[a]	0.730[a]	
	Sig.	0.000	0.000	0.000	
Attitude toward chemical science	Correlation Coefficient	0.374[a]	0.911[a]	0.495[a]	0.520[a]
	Sig.	0.000	0.000	0.000	0.000

[a] At the 0.01 level (two-tailed), the correlation is significant

Table 12 Spearman's correlation coefficient between the dimensions

		Overall Awareness of Textbooks	Actual Use of Textbooks	Use of textbook
Interest in and Attitudes toward Chemistry Learning	Correlation Coefficient	0.470[a]	0.411[a]	0.483[a]
	Sig.	0.000	0.000	0.000
Attitude toward learning	Correlation Coefficient	0.461[a]	0.385[a]	0.462[a]
	Sig.	0.000	0.000	0.000
Interest in learning	Correlation Coefficient	0.509[a]	0.440[a]	0.518[a]
	Sig.	0.000	0.000	0.000
Attitude toward chemical science	Correlation Coefficient	0.369[a]	0.315[a]	0.374[a]
	Sig.	0.000	0.000	0.000

[a] At the 0.01 level (two-tailed), the correlation is significant

coefficients being positive. One of the subdimensions of textbook use, "Overall Awareness of Textbooks", was significantly correlated with "Interest and Attitudes" and its subdimensions at the level of $\alpha = 0.01$, with all correlation coefficients ranging from 0.36 to 0.51. Another sub-dimension, "Actual Use of Textbooks", is significantly correlated with "Interest and Attitudes" and its subdimensions at the level of $\alpha = 0.01$, with all correlation coefficients ranging from 0.30 to 0.45.

Having clarified the correlations among the variables, we further used regression analysis to investigate the causal relationship between students' use of textbooks and students' interest and attitude. The results of the data indicated that the regression model significantly predicted students' performance on the students' interest and attitudes [$F = 77.404$, $p < 0.000$]. The independent variable, Use of textbook, added significantly to the prediction ($p < 0.05$). The coefficient of determination (R2) is a measure of the proportion of variance in the dependent variable (the students' interest and attitudes performance) that is explained by the independent variables (Use of textbook). The R2 for the model was 23.8%, with an adjusted R2 of 23.5%. These data was acceptable according to Cohen (2013). The regression equation can be expressed as follows: Students' interest and attitudes performance $= 2.545e^{-16} + 0.488 \times$ Use of textbook + error ($SE_{B(\text{the students'interest and attitudes performance})} = 0.055$, $SE_{B(\text{Intercept})} = 0.055$).

Correlation between students' use of textbooks and their academic achievements in chemistry

Students' academic achievements in chemistry

The Rasch model was used to obtain the chemistry proficiency values for each sample of students, and the statistics are shown in Table 13.

The correlation between students' use of textbooks and their academic performance in chemistry

The options for each question in the "Questionnaire on the Use of the 2019 Edition of General High School Chemistry Textbooks" were coded according to the principle that "the higher the recognition of the status and value of the textbook, the higher the evaluation, the more intrinsic the motivation for using the textbook, the more non-utilitarian the purpose of using it, the more time it is used, the higher the frequency of use, and the more sufficiently it is used, the higher the evaluation score will be". After the total score of each dimension was calculated, it was converted into a Z score (standard score). That is, the standard score of the ith case is equal to the ratio of the difference to the standard deviation after the case value is subtracted from the mean value. In other words, we need to calculate how many times the difference between the case value and the mean is the standard deviation. Student achievements in chemistry is characterized by student proficiency values.

Table 14 shows that there is no significant correlation between students' use of chemistry textbooks and their achievements in chemistry (sig. > 0.05). For the correlation between the dimensions of students' use of textbooks and students' achievements in chemistry, the table shows that there is also no significant correlation between the dimensions and achievements in chemistry (sig. > 0.05).

Discussion and conclusion

Discussion

In this paper, we report on Beijing and Shandong students' use of the 2019 edition of chemistry textbook, and we attempt to explore the correlation between students' use of the textbook and their interest, attitudes and their academic achievements in chemistry.

Table 13 Chemistry proficiency values for students

Proficiency Value	Percent (%)	Proficiency Value	Percent (%)	Proficiency Value	Percent (%)	Proficiency Value	Percent (%)
-7.01	0.4	-1.33	0.4	-.50	1.2	.32	0.4
-6.11	0.4	-1.31	1.2	-.47	2.0	.35	0.4
-4.39	0.4	-1.28	0.8	-.45	0.4	.37	0.8
-3.99	0.8	-1.24	0.4	-.42	3.2	.38	0.8
-3.63	0.4	-1.23	1.2	-.38	0.4	.42	0.8
-3.16	0.4	-1.22	1.6	-.33	1.6	.44	0.4
-2.53	0.4	-1.21	0.4	-.26	0.8	.46	1.2
-2.42	0.4	-1.15	0.4	-.25	0.4	.49	0.4
-2.36	0.4	-1.14	1.2	-.24	3.2	.53	0.4
-2.21	0.8	-1.12	0.8	-.22	0.8	.55	1.2
-2.12	0.8	-1.11	0.4	-.20	1.2	.62	0.4
-2.10	0.4	-1.04	0.8	-.19	0.8	.63	1.2
-2.07	0.4	-1.02	0.4	-.18	0.4	.64	2.0
-1.99	0.8	-.99	0.8	-.16	2.0	.71	0.4
-1.97	0.4	-.97	0.4	-.15	0.4	.74	2.0
-1.93	0.4	-.95	1.6	-.10	0.4	.78	1.2
-1.89	0.8	-.94	0.4	-.08	0.8	.80	0.4
-1.87	0.8	-.92	0.8	-.07	2.0	.84	0.4
-1.84	0.8	-.89	1.2	-.06	0.4	.91	0.4
-1.80	0.4	-.86	1.2	.02	2.0	.94	0.8
-1.76	0.4	-.84	0.4	.04	0.4	.98	0.4
-1.75	0.4	-.83	0.8	.05	0.4	1.04	0.4
-1.68	0.4	-.77	0.8	.09	0.8	1.15	0.4
-1.65	0.8	-.76	0.4	.10	1.2	1.25	1.2
-1.63	0.4	-.68	1.2	.12	0.4	1.32	0.4
-1.56	1.6	-.65	0.4	.13	0.8	1.46	0.4
-1.54	1.2	-.63	1.2	.15	0.4	1.57	0.4
-1.51	0.4	-.59	1.6	.19	0.8	1.60	0.4
-1.48	0.4	-.58	0.4	.20	0.8	1.78	0.4
-1.44	0.4	-.56	0.8	.21	0.8	2.04	0.4
-1.42	0.8	-.55	0.4	.25	0.4	2.57	0.8
-1.38	0.4	-.51	0.4	.28	3.2	**Total**	**100.0**

Table 14 Correlation coefficients between academic achievement in chemistry and textbook use

		Overall Awareness of Textbooks	Actual Use of Textbooks	Use of textbook
Academic Achievement in Chemistry	Correlation Coefficient	0.112	0.085	0.047
	Sig.	0.077	0.183	0.460

Students rate the new textbooks highly, but there is still much room for improvement in the value of the new textbook functions. Textbooks are irreplaceable in students' minds, but they do not blindly worship textbooks

For students' attitudes towards textbooks, the research results showed that textbooks were still the most important learning materials in the minds of most participants, and cannot be replaced by teachers' courseware, study plans, or extracurricular tutorials. Currently, however, students look at textbooks more objectively and rationally, without blindly worshiping them. Students realize that there may be errors or defects in textbooks, but this does not affect the authoritative position of textbooks in their minds.

Students have a good overall view of the new textbook, but the evaluation value of "evaluation design" needs further consideration

After using the new textbooks to complete the needed courses for the College Entrance Examination as required by the curriculum standard, users' average score of satisfaction with the new textbooks was as high as 8.5. The lowest score (3.5) was given to the dimension of evaluation design in the new textbook. After 2–3 years of use, most respondents said that the new textbooks can meet or fully meet their learning needs. On the one hand, users' good evaluation of the new textbook was a recognition of and encouragement to the writing team. On the other hand, to improve the new textbook, the writing team should further consider the dimensions with low scores, such as the dimension of evaluation design, and they must determine the reason for users' dissatisfaction or whether such dissatisfaction was because they did not give full play or sufficient consideration to the textbook's functional value.

Students make full use of textbooks before and after class, but there is still much room for improvement in the frequency of use

In terms of the actual use of new textbooks, more than 70% of the respondents chose to use them before, in, and after class, but the frequency of use was not very high. Only a few respondents always used textbooks before, during, and after class. In addition, we found that extracurricular tutorials, learning materials distributed by teachers in class, and classroom notes were important reference materials for students.

Students have great expectations for the implementation of the "activity column", "students' required experiment", and "microproject" in the textbook.

It is gratifying that more than 70% of the respondents said that student experiments and activities were carried out in class for approximately 2/3 or all the activity columns in the new textbook. This shows that chemistry class has changed from teacher-dominated to student-centred, where students are deeply involved in related activities, presenting a different vitality and atmosphere. Through the questionnaire survey, we know that students are not satisfied with the evaluation design of the new textbook, the utilization rate of exercises is not high, few students can complete all the after-class exercises, and few teachers offer guidance on all these exercises. In addition, students' active attention to after-class exercises is also extremely low, so it is reasonable to believe that the reason for students' low rating of the new textbook's evaluation design is the fact that neither teachers nor students pay sufficient attention to, and they do not make full use of the exercises in the textbook.

The curriculum standard requires that teachers should carefully organize students to complete the required experiments, and schools with necessary conditions should provide as many opportunities as possible for students to perform hands-on experiments. According to our survey results, there is still a large gap to bridge between the actual implementation of student needed experiments and the requirements of the curriculum standard.

To our surprise, most users of the new textbook, whether the SSTP version or the PEP version, think that "microproject" & "research & practice" are necessary or very necessary, and sometimes or often attract their attention; more than 80% of them hope or very much hope to implement these projects under teachers' guidance. This shows students' interest in and enthusiasm for learning this content. We are happy to see teachers and students actively implement and learn these projects. We also hope that teachers can guide students in implementing these projects in class when conditions permit and develop their ability to solve real problems in real and complex situations.

There is a significant correlation between students' use of textbooks and their interest and attitudes

Through Spearman correlation analysis and regression analysis, we found that there is a causal relationship between students' use of chemistry textbooks and their interest and attitudes. A significant correlation exists between students' use of textbooks and their interest and attitudes. In terms of different subdimensions, interest in and attitudes toward chemistry learning have the highest correlation with the use of textbooks, followed by the attitude towards chemical science, and attitude towards chemistry learning. Therefore, it is believed that the higher students' recognition of the status and value of textbooks is, the higher their evaluation, the more intrinsic their motivation for using textbooks, the more non-utilitarian their purpose of use, the more time they use textbooks, the higher their frequency of use. The more fully the students use the textbooks, the greater their interest in chemistry learning, the more serious their study and the more positive their attitude towards chemical science, that is, the greater their interest in and better their attitude towards chemistry learning. It is consistent with the findings of Pepin and Trouche (2013), Zeng (2016), Son et al. (2017) etc.

There is no significant correlation between students' use of textbooks and their academic achievements in chemistry

A correlation analysis of students' use of chemistry textbooks and their academic achievements in chemistry reveals that there is no significant correlation between them. Such correlation is also not significant in each subdimension. However, the value of textbook use cannot be denied. We can reasonably guess that between students' use of chemistry textbooks and their academic achievements, there are mediating variables or moderating variables (such as students' interest and attitudes, teachers' guidance on students' use of textbooks, etc.). For example, because the use of textbooks affects the interest, attitudes and thus affects students' academic achievements in chemistry, teachers can help students improve their academic achievements in chemistry by regulating their use of textbooks. This is the next question that the researchers plan to study.

Through this study, we have known students' evaluation of and attitudes toward the textbook, their motivation, purpose, time, frequency of use, and the use of specific contents of the new textbook under the background of new curriculum reform and new textbook use. In addition, through the analysis of textbook use, we obtained a certain understanding of the recent situation in the chemistry classroom.

We found that the value of some content in the new textbook has not been fully utilized, which is inconsistent with the textbook writers' original intention and falls short of students' expectations to some extent. Therefore, textbook writers should strengthen the interpretation of the content that has strong functionality and great significance for students' development, and inform teachers of students' expectations for the implementation and learning of this content to promote the use of relevant content and to give full play to their corresponding functional value. In addition, teachers' guidance on students' use of textbooks is not enough. One possible reason is that quite several teachers take textbooks as important reference materials for classroom teaching and habitually focus on the preparation of courseware, neither realizing that textbooks are also important learning materials for students nor paying sufficient attention to whether students fully and properly use textbooks.

Through this study, we have shown students' evaluation of and attitude towards the textbook, their motivation, purpose, time, and frequency of use, and the use of specific contents of the new textbook against the background of new curriculum reform and new textbook use. We hope that students who use the new textbooks later recognize the status and value of the new textbook, realize the importance of the new textbooks for their learning and development, make full and regular use of the new textbook in their study, and attach great importance to the functional contents in them, such as methodology guide columns and summary columns.

Conclusion

Prior studies on students' use of textbooks have not been sufficient. In this study, we attempt to enrich the research in this field through a quantitative study that was conducted to investigate the use of textbooks by the first two grades of students who used the new textbooks and their relationship with their interest, attitudes, and academic achievements in chemistry. The results of the study revealed the status of students' use of the new textbooks and showed that there is a significant correlation between students' use of textbooks and their interest and attitudes in chemistry, i.e., promoting students' effective use of textbooks can have a significant positive impact on students' interest and attitudes.

It is expected that this study can promote students' awareness that the effective use of textbooks can have a positive impact on their interest in learning chemistry, their attitude towards learning chemistry, and their attitude towards chemical science, and that textbooks are important for learning. Students should try to read textbooks carefully in chemistry learning, find interesting and useful content in textbooks, use them as their motivation to use textbooks, and internalize the use of textbooks as a conscious and active behaviour, thus promoting their interest and attitudes in chemistry learning.

In this study, students were studied as the independent variable, so what are the factors that influence students' use of textbooks? This is a question worthy of further study. Based on prior research, we found that students' use of textbooks is influenced, to a large extent, by teachers' use of textbooks and teachers' guidance on textbook use, but there is no relevant empirical research to prove this influence. Therefore, it is necessary to further explore the influence of teachers on students' use of textbooks. Furthermore, how does students' use of textbooks as an independent variable affect their interest, attitudes and their academic achievements in chemistry? Are there moderating variables and mediating variables in their correlation, i.e., what is the influencing mechanism of these variables? Further exploration of the influencing mechanism can better explain the correlation, and more effectively demonstrate the value of textbook use. This is what we plan to study in the next step.

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Authors' contributions
Conceptualization, Fang, F. L., and Wang, L.; methodology, Fang, F. L. and Wang, L.; validation, Fang, F. L. and Wang, L.; formal analysis, Fang, F. L.; writing original draft, Fang, F. L.; writing—review and editing, Fang, F. L. and Wang, L., supervision and project administration, Wang, L. All authors have read and approved the manuscript.

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Availability of data and materials
The datasets analyzed during the current study are potentially to be used in the author's dissertation, they are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Data were collected following national data protection laws. This study does not involve animal, plant or human data.
The researcher maintains a fair and neutral position regarding the editions of the textbooks, and being the author of the textbook does not have any influence on the interpretation of the results; no comparison of multiple editions of textbooks was involved in this study.

Consent for publication
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Competing interests
The authors declare no conflict of interest.

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