



How do teachers assess primary school students' science academic performance: An in-depth interview with 23 primary school science teachers

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ABSTRACT

The purpose of this paper is to explore the current situation and challenges of assessing science learning achievement in primary school. We interviewed 23 primary school science teachers from 17 schools in an East metropolitan area of 10 million people in China. Drawing from a grounded theory study, our findings revealed a generally favorable disposition among primary school science teachers toward the assessment on scientific academic performance. But the current primary school science assessment is still lacking in standardization. Considering assessment methods, paper-based test method is the most commonly used in primary school science academic assessment, and is also considered to be the most effective method. The current academic assessment method is mainly based on teacher assessment and supplemented by student assessment. Assessment on science academic performance also faced several challenges, including undiversified assessment methods, a heavy workload for teachers and students, a lack of financial support and a lack of assessment instruments.

1. INTRODUCTION

Nowadays, citizen science literacy has become a growing concern, with policy documents in many countries, including the United States and Canada, emphasizing the importance of citizen science literacy (Yacoubian, 2018). Meanwhile, "Cultivating citizens with science literacy" has become the ideal goal of science education worldwide, and has important guiding significance for science education (Zhang & Campbell, 2012). It shows that the science achievement gap is already significant in early childhood, especially in third grade. (Morgan et al., 2016). The earlier children are exposed to science, the more positively correlated it is with higher academic achievements. In view of this, attention should be paid to science education from an early age, especially at the primary level (Tavares et al., 2021). In particular, assessment on academic performance of students has been considered one of the most important activities for teachers to improve the students' learning effectiveness (Cizek, 2010). Through assessment, teachers can obtain information about students' knowledge and skill level, so as to develop more effective teaching strategies. At the same time, teaching methods can be adjusted according to the individual needs of students to build a suitable learning atmosphere (Cizek, 2010). Studies have shown that the combination of self-assessment, peer assessment and teacher assessment can help improve EFL learners' writing ability (Birjandi & Tamjid, 2012). Another study pointed out that the results of academic performance assessment can provide concrete feedback for teachers to improve their teaching (Mohiuddin et al., 2019). Therefore, it is very important to probe into the practice and problems encountered by primary school teachers in assessing students' achievement in science learning.

2 LITERATURE REVIEW AND RESEARCH QUESTIONS

2.1 Contents of assessment on science academic performance

The core of scientific evaluation includes an insight into

the nature of science, an understanding of scientific methods, and an examination of scientific attitudes.

In exploring the concept of NOS, various models and frameworks have been developed to measure students' insights on NOS (Mohan & Kelly, 2020). McComas and Olson (1998) identified 13 core concepts of NOS in eight international science education literature. Further, 23 authorities agreed on nine key themes, including the nature of scientific knowledge, the process of inquiry, and the behavior of scientists as a social group (Osborne et al., 2010). These common characteristics are also reflected in the Next Generation of Science Standards (NGSS Lead States, 2013). NOS is broad, and Orchin assesses students' perceptions of the nature of science by analyzing current events and historical cases (Allchin, 2011).

The ability of students to accurately apply the scientific method in scientific enquiry is also assessed. Teachers are expected to assess students appropriately in the course of their scientific enquiry. The investigation reveals that teachers' guidance in exploratory science education plays a key role in improving pupils' academic achievement (Heppt et al., 2022). As an educational strategy, the scientific method encompasses an orderly sequence of observations, questioning, experimentation, inference, and communication (Purwanto et al., 2021). This coherent process has evolved and is now seen as a core element that inspires innovative learning (Zulfakar, 2020). Teachers' ability to integrate the scientific method in curriculum design is reflected in planning teaching activities that coincide with the scientific steps, and their skill in applying the scientific method is reflected in how to guide students' practical activities in accordance with these steps (Jahidin et al., 2023).

More recently, with more students showing waning interest in careers in science, more attention has been paid to the effect of attitudes. (Guzey et al., 2015). Different researchers have different dimensions for assessing attitudes towards science. The "My View of Science "(MATS) scale covers four areas: emotional predispositions to scientific topics, intentions to become a scientist, the social value of science, and perceptions of scientists (Hillman et al., 2016). On the other hand, the BRAINS (Behavior, Relational Attitudes,

and Scientific Intentions) questionnaire deals with attitudes toward science, beliefs about scientific behavior, intentions to engage in science, and normative and controlling beliefs (Summers & Abd-El-Khalick, 2018). In addition, Wang and Berlin (2010) designed a tool to assess fourth - and fifth-grade students' attitudes to science for use in Asian school Settings, focusing on the enjoyment of science, self-confidence, and the significance of science in the classroom experience. Another study designed an assessment tool for 8 - to 11-year-olds in Northern Ireland that consisted of three elements: a fondness for science, an understanding of its importance, and a perception of their own scientific competence (Murphy and Beggs, 2003).

In 2022, China's Ministry of Education introduced the Compulsory Education Curriculum Standards (2022 Edition), which divides the evaluation system of scientific learning achievement into four areas: scientific concept, scientific thinking, inquiry practice, and attitude and responsibility. Scientific concepts involve understanding objective things based on scientific principles and refining the understanding of these principles (Ministry of Education, 2022). Inquiry practices refer to the capability to engage in scientific inquiry, technological and engineering practices, and independent learning. Scientific thinking emphasizes students' ability to apply scientific methods and systematically think about problems; attitude and responsibilities refer to the gradual development of a scientific mindset and social responsibility, considering the nature of science and its role in technology, communities and the ecological environment.

2.2 Methods of assessment on science academic performance

According to the subjects involved in academic assessment, the methods of assessing science learning achievement in primary schools can be summarized as teacher assessment, peer review and self-assessment.

Teacher assessment is the most prevalent method of assessing students' achievement of intended learning outcomes, employing a range of assessment methods and tools (Gronlund, 2006). The

methods of teacher assessment include paper-based tests, classroom quizzes, assignments, portfolio assessment and so on. The power of teacher assessment lies in its ability to support and enhance student learning and motivation (Alkharusi et al., 2014). However, relying on these means alone may not fully understand the inner mind of students (C Chang et al., 2012). Nitko (1996) pointed out that teachers should use diversified evaluation strategies to obtain reliable evidence of student learning, and evaluation should be aligned with teaching objectives and give valuable feedback to students. Barbera (2009) proposed a concept based on student collaboration, netfolio, to construct a continuous joint review mechanism, in which teachers participate in the process of mutual review, but do not directly intervene in decision-making.

As highlighted by the National Research Council's Committee on the Conceptual Framework for New Standards in K-12 Science Education, self-assessment is decisive for science literacy and has been integrated into the next generation of science standards (NGSS Lead States, 2013). The methods for student self-assessment include self-assessment of homework, self-assessment of classroom performance, journal writing and so on (Birjandi & Tamjid, 2012). Besides, Tan (2008) summarizes students' self-assessment into five conceptions as follows: students evaluate their own behavior through self-evaluation activities; They measure their knowledge in practice; They set and assess personal standards in their course of study; They make independent judgments about their mastery of the curriculum; Moreover, students went beyond classroom learning in evaluating their self-assessment abilities.

Peer assessment is considered as a strategy for giving effective feedback to learners (van Zundert et al., 2010). This involves students evaluating each other's grades, learning outcomes, or performance (Sari et al., 2016). There is evidence that peer assessment improves academic achievement compared to no assessment and teacher assessment alone (Double et al., 2020). Further research comparing the effects of giving and receiving assessments on writing performance shows that the process of evaluating others leads to more improvement than being evaluated (Lundstrom & Baker, 2009). Peer assessment promotes the

development of students' lifelong ability to assess and provide feedback to others, as well as enhancing their skills in self-assessing and improving their own work (Lundstrom & Baker, 2009). Combining different assessment methods in assessment would be beneficial. Research has shown that students who choose formative assessments achieve better academic performance than those who choose final assessments (Oliva et al., 2011). Research by Sari et al. (2016) reveals the dual role of self-assessment and peer assessment in education, not only as a means of evaluation, but also through feedback communication to help students hone their professionalism, decision-making skills, and independence. Chang and Tseng (2011), in their exploration of Web portfolio evaluation, integrate three evaluation methods to reflect the essence of authentic evaluation. Similarly, Netfoliot integrates teacher, peer, and self-assessment to shape a framework for progress together (Barbera, 2009). It is worth noting that teachers' evaluation practices and students' understanding of evaluation are intertwined and have an impact on students' beliefs about academic self-efficacy, a view that brings unique insights into current classroom evaluation discussions (Alkharusi et al., 2014).

2.3 Research questions

The science curriculum in China began in 1903, with students primarily learning basic life knowledge (Li, 2003). In the late 1970s and early 1980s, the "Primary School Science Curriculum Guidelines for Full-Time Ten-Year Compulsory Education Schools" were introduced, shifting the science curriculum towards emphasizing experimental exploration without corresponding assessment (Pan, 2021). It was not until 2017 that the Primary School Science Curriculum Standards (2017 edition) were promulgated by the Ministry of Education, which elevated science to one of the four core courses in primary school (Liu, 2017). Since then, teachers have become increasingly aware of the need to evaluate science education. A semi-structured interview was conducted with 23 primary school science teachers in order to explore the current status and difficulties in assessing science learning achievement in primary school. The core issues of this study are as follows:

Inquiry Focus 1: What are the views of primary school science educators on assessing the achievement of primary school students in science learning?

Focus 2: What is the current picture of the assessment of science academic achievement of primary school students?

Focus 3: What are the main difficulties faced in the assessment of primary school students' science learning effectiveness?

3 METHODOLOGY

3.1 Participants

In this study, we interviewed 23 primary school teachers from 17 schools in an East metropolitan area of 10 million people in China. 14 of the teachers teach in urban areas now, and 9 of them teach in rural areas. Participants ranged in age from 24 to 51 years, with a mean age of 33.17 years and a standard deviation of 5.34 years. The length of their teaching career ranges from two to thirty-two years (mean 9.91, SD 6.36). The demographic information for the interviewees was provided in Appendix (Table S1).

3.2 Data collection

Members of a research team, including the principal researcher and two research assistants, conducted interview individually between February and March 2023. These assistants were education master students who received a 3-hour training conducted by the principal researcher on interviewing techniques (e.g., understanding the extent to which questions are likely to trigger teachers to give socially acceptable answers) and an introduction to semi-structured interview guidelines (Gudkova, 2018). All subjects were explicitly informed of the voluntary nature of the study and that they could choose not to participate or withdraw at any time. A semi-structured interview with five questions was designed. The first question was about the teacher's attitude toward assessment on science academic performance, including their belief,

willingness, and feelings. The second question involved the index and weight of assessment on science academic performance. The third question asked teachers to describe the subjects and methods they normally use to conduct assessment on science academic performance. The fourth question was whether they experienced any challenges during assessment on science academic performance. The interview process was conducted in Chinese and the average duration was 40 minutes.

3.3 Data analysis

In this study, data were coded using the software package Nvivo 14 to identify themes and categories that built a grounded theory. Firstly, the recorded data were transcribed verbatim. Secondly, the transcribed data are studied in depth and repeatedly, aiming to fully understand the overall context of the data. Third, a preliminary coding framework is selected, which responds to the core issues of the study in the form of concise statements or narrative paragraphs. In the context of this study, we used 77 preliminary codes to start the analytical journey of the data and explore potential patterns in the data by comparing similarities and differences between events (Greene et al., 2007). Fourth, we refine the unit of analysis and summarize it into 34 intermediate codes. At this stage, raw data begins to be transformed into more abstract concepts, gradually promoting the natural generation of theory from the data (Chun Tie et al., 2019). Fifth, the codes were divided into subcategories based on differences and similarities, this process was called advanced coding. Finally, the theoretical codes constitute the culmination of the refinement of the core theory, and the major categories are gradually formed by merging those subcategories with similar meanings (Graneheim & Lundman, 2004; Markkanen et al., 2019), as shown in Table S2

3.4 Credibility and consistency

Regarding credibility, all participants had been teaching science in primary school for a long time. Their age, teaching experience, gender, and types of school varied, which increased the credibility of obtaining information on the topic from various aspects.

In order to ensure the rigor of the analysis, the whole process is elaborated in detail. At the beginning of the analysis, the data is coded and categorized, and then another researcher encodes the abstract units of meaning, sub-categories, and major categories. Consensus was reached in all sub-categories and major categories, although some disagreements arose at the coding stage, but were discussed and resolved in depth. In this study, theoretical sampling is seen as a key step to ensure theoretical saturation, so as to ensure that the established grounded theory has sufficient theoretical integrity (Charmaz & Thornberg, 2021).

4 FINDINGS

4.1 Teachers' attitudes toward assessment on science academic performance of primary school students

In general, primary school science teachers hold positive attitudes toward assessment on science academic performance of primary school students, but they present different feelings when evaluating. When asked if it was necessary to conduct the assessment on science academic performance, all 23 respondents believed that academic assessment was necessary. For example, 22 respondents indicated that they were willing to participate in seminars and trainings about academic assessment. 20 teachers all suggested that the results of assessment could help them adjust teaching strategies and improve their teaching skills. For example, participant H said,

The assessment results can help me understand the knowledge that students have not mastered well. I will adjust my teaching strategies and teaching content in the following class. For example, I will repeat students' weak knowledge, so as to help them strengthen their memory, until they absorb all the knowledge.

23 interviewees stated that they usually provided feedbacks on the results of assessments to their students. The feedbacks involved grades and writing comments on students' homework, verbal praise about students' exploration and practice abilities in the

classroom, and separate conversations with students. 13 teachers mentioned that the results of assessment not only provided students with a clearer understanding of their studies, but also made them more confident in learning. For example, participant I mentioned,

Students can clearly know how well they have mastered what they have learned through assessments. If they obtain good assessment results, their interest in learning will also increase.

Nevertheless, respondents showed clear differences in their feelings about the evaluation of students' achievements in science. 7 teachers stated that assessing science academic performances is a burden for them. One reason is that Chinese primary teachers have heavy teaching tasks, and conducting assessment on science academic performance would take up much their time and energy. For example, participant P mentioned in the interview:

Assessment is definitely burdensome. The more specific your assessment of students, the greater the workload will be.

Although the assessment process takes up too much of their time, most teachers still indicate that assessment is still necessary. But they have low self-efficacy in assessing students' science academic performance. They worry that inappropriate assessments will reduce students' motivation to learn science, which also places a psychological burden on them. For example, participant C represented,

I have my own assessment system, and when there is not much homework in school, I usually assess students' scientific academic performance. If I fail to promptly assess their performance, meaning if they perform well but are not rewarded, their enthusiasm will be dampened.

On the contrary, 11 teachers pointed out that assessment on science academic performances did not burden them, because it is an important part of their work. Participant T said in the interview:

As a teacher, assessing students' performance is a commonly encountered situation, and you may aspire to assess their abilities in a more scholarly manner. As many children nowadays are apprehensive about making mistakes when they answer questions, we advocate that teachers provide students with constructive feedback and assessment to motivate them to show their abilities. This is not only a right but also a responsibility of teachers, and it should not be perceived as an additional burden. When assessing children, our aim is to foster their growth and progress.

4.2 Methods of assessment on science academic performance of primary school students

All the interviewees used Paper-based tests as the main method of assessment in science academic performance. The majority of the teachers believed that Paper-based tests are the most effective, convenient and fair assessment method, but they all recognize the limitations of paper exams. In particular, parents attach great importance to the results of written tests. In addition, there is a significant resource gap between urban and rural schools, with rural schools lacking the necessary equipment for process assessment. As a result, they are limited to using traditional Paper-based tests as their assessment method.

21 teachers believed that although the assessment method of Paper-based tests is not comprehensive in assessing students' abilities, it is the most efficient and fair method. For example, participant B, who has been teaching for 14 years, mentioned,

A Paper-based test can only be considered the most expedient option. To assess students' experimental abilities, teachers must spend a lot of time, but this condition is not available in reality. Because we do not have as many class hours to examine students' experimental operations. Furthermore, no primary school has enough laboratories and equipment is equipped to test every student's experimental skill in class. Although Paper-based test is not the most ideal choice, it is the most suitable assessment method at present.

While acknowledging the limitations of Paper-based tests, most teachers also underscore their drawbacks. Paper-based assessments primarily evaluate students' scientific knowledge, however, science courses differ significantly from other subjects as they necessitate not only comprehension of key concepts but also independent application and exploration through hands-on experimentation. Consequently, relying solely on Paper-based tests fails to adequately gauge a student's scientific literacy in the present context. Furthermore, it is imperative for primary school teachers at lower grade levels to prioritize fostering students' scientific curiosity and nurturing their critical thinking abilities. Meanwhile, at this stage, children's scientific proficiency cannot be accurately reflected solely through paper-based tests. In interviews with 16 science teachers, they proposed their own opinions on assessing scientific academic performance and suggested combining traditional paper-based tests with other assessment methods in daily teaching. While acknowledging the continued importance of paper-based tests in current education, science teachers emphasized the need for flexible use of multiple assessment methods to ensure accurate assessment of students' true scientific level. For example, participant C mentioned in the interview:

When introducing experimental courses, I will demonstrate the experiments in class and assign follow-up tasks for students to complete outside of class. During task assignments, I will provide assessment plans to guide their work. Interested students can upload videos or pictures of their completed experiments to my designated mini program for review and feedback. Based on the assessment results, I will award them with "scientific stars". As a sixth-grade teacher, my assessments are divided into two parts: one based on the number of scientific stars earned throughout the term, which determines rewards at the end; and another based on written exams administered by the school.

In China's educational environment, both students and parents generally agree that the written test plays a central role in the admission process of high school and college, and its importance surpasses other evaluation methods,

As a parent and educator, I agree that high school and college entrance exams still have a prominent place in the current social system, where academic achievement is highly valued. Additionally, primary education lays the foundation for future learning, making it crucial to assess students' understanding of scientific concepts early on. While there may be limitations to relying solely on knowledge assessments, as a parent, I find comfort in my child's success in these exams. Despite this, it would be beneficial to explore alternative methods of assessment within the constraints of national policies.

4.3 Contents of assessment on science academic performance of primary school students

When assessing the performance of primary school students in science subjects, the assessment criteria mainly refer to the Chinese Science Curriculum Standards, covering scientific concept understanding, scientific thinking ability, experimental inquiry practice, and cognition of attitude and responsibility. However, teachers are faced with the problem of lack of specific evaluation indicators. At the same time, they argue that assessments should focus more on the student's learning journey, but it is difficult to implement.

Among the survey respondents, 17 respondents believe that the effectiveness of students' science learning should be measured according to the key competencies in the curriculum standards. Notably, 21 individuals prioritize scientific concepts, while 14 emphasize scientific abilities and 14 value attitude and responsibility. For example, participant A proposed,

I think that when it comes to assessing science knowledge, we should focus on four key areas. Personally, I believe that two aspects are particularly important. Firstly, students should understand how to apply the scientific method in experiments. While the specific topics they learn may change, it's crucial for them to grasp concepts like comparative experiments where only one condition is altered and investigation experiments where they need to develop a hypothesis, plan their experiment, carry it out and analyze the results. Secondly, students should cultivate a sense of responsibility by staying informed about current events

and social issues.

But all 23 respondents stated that they have not set clear indicators for assessment on science academic performance. Five teachers pointed out that this is due to the limitations of the assessment method assessment. For example, participant F pointed out in the interview,

Our school mainly uses Paper-based tests for scientific academic assessment, and it is difficult to assess students' attitudes and responsibilities through test papers.

4 teachers have emphasized the importance of assessing students' scientific proficiency during the learning process, and subsequently implementing a reward system in accordance with timely assessments conducted within the classroom setting. Given the large class sizes, it is difficult for teachers to fully assess the progress of each student. In addition, there is a lack of appropriate assessment indicators. Therefore, it is hard to assess students' science ability in the learning process. For example, Teacher P, who participated in the interview and has seven years of teaching experience, *During the experimental process, teachers are unable to provide individual attention to every student and may only focus on exceptional students. Consequently, due to the large class size, it becomes challenging for teachers to comprehensively evaluate students' experimental operation abilities.*

4.4 Challenges of assessment on science academic performance of primary school students

Due to the influence of high school entrance examination and college entrance examination system, written examination is generally used as the main assessment means in primary school. Therefore, teachers pay more attention to the teaching of knowledge but ignore scientific skills or scientific thinking, because the Paper-based tests mainly examines scientific knowledge. The results of Paper-based tests sometimes hurt students' learning enthusiasm. 20 teachers mentioned this issue assessment, such as participant H mentioned,

Some students have deeper scientific thinking and are interested in exploring, which cannot be shown in Paper-based tests. For example, if a student is careless, he may not do well on the Paper-based test, but he actually knows how to master the scientific abilities and knowledge. I hope that my students can truly fall in love with science from the bottom of their hearts, rather than falling in love with the Paper-based test results.

In China, Paper-based tests have always been required for Chinese, mathematics and English. In recent years, primary schools in some areas began to test science by Paper-based tests, which caused some parents to pay attention to their children's science learning. However, most parents only concerned the results of Paper-based tests, rather the experimental abilities or the attitudes toward science. Participant J said in the interview,

Generally speaking, parents do not value science in primary schools. Only the final exam lets them know their children's performances in science. Sometimes, when I assign some science homework after class that requires parental assistance, parents just ignore it.

The heavy workload of teachers and students is also issues in assessment. 70.1% primary school science teachers in China are part-time science teachers (Zheng et al., 2023). Part-time science teachers have 12~15 Chinese or math classes per week and only 1~2 science classes, thus inevitably neglecting the assessment on science academic performances. R, who has been teaching Chinese for 32 years, repeatedly mentioned the problem of insufficient number of science teachers in the interview, and pointed out her confusion in the assessment,

I am currently devoted to science education, but feel pressed for time. Many times, I am unable to assess students in a timely manner and the assessments lack detail. This is also why I struggle to provide comprehensive feedback on assessment results to both students and parents.

Although some teachers only teach science in primary school, they also face the problem of teaching

workload. 4 teachers pointed out that they had to teach many classes, with even more than 200 students. Therefore, while it is desirable to diversify assessment methods, this means spending more. For example, participant J stated,

Our school has four classes in one grade, and I am the only professional science teacher. assessment I have to teach many classes, some at different grade levels, and I feel very overwhelmed by the teaching load. I feel exhausted just organizing experimental equipment and materials, let alone spending time on assessment.

Moreover, the heavy learning tasks of students also make it difficult to carry out assessment. In the first and second grades, there is too little time for science, with most schools setting only one science lesson per week. As some assessment methods require time outside of the class, they cannot be utilized for assessment. Participant E pointed out in the interview:

The students have to learn science as well as Chineses, mathematics, English, and so on. They are really too busy, especially at the end of the semester.

The assessment of scientific skills is an important part of the assessment of science academic performance of primary students. However, many primary schools currently do not even have available laboratories for students to conduct experiments, and most schools lack of experimental materials and equipment. 6 teachers stated that the lack of financial support is also a problem in assessment of science academic performance. For example, participant I said,

If science assessments conduct experimental tests, a considerable amount of funding is needed. Adequate laboratories should be available and each student needs a set of materials.

One of the difficulties encountered in the evaluation process is the lack of effective evaluation mechanism. As many as nine respondents highlighted the importance of high-quality and practical evaluation tools to ensure the impartiality of evaluations. Participant N mentioned in the interview,

The assessment content of the Paper-based tests is not comprehensive. Although the evaluation of experimental skills is highly expected, teachers are faced with the dilemma of lack of corresponding operational evaluation methods.

5 DISCUSSION

With the aims of understanding current situation and challenges of assessment on science academic performance of primary school students, We conducted structured semi-open-ended interviews with 23 primary school science teachers. These findings are expected to improve the understanding of policy makers, curriculum designers, educators, and primary school teachers about the difficulties of assessing science learning. Such an understanding will facilitate assessment-related professional development programs to respond more effectively to the needs of science teachers. Although the context of this study is the Chinese education system, its exploration of science academic assessment may have implications for the rest of the world, as countries share practical challenges faced by teachers who use traditional assessment methods. Therefore, the insights from this study can also provide valuable references for other teachers internationally when conducting science learning assessments. The following chapters will discuss in detail the issues raised in this study.

5.1 What are the attitudes of primary school science teachers toward assessment on science academic performance of primary school students?

Teachers generally hold a positive attitude towards the assessment of academic achievement in primary science courses. From the interview results, it is evident that all 23 respondents hold a positive attitude towards the assessment of primary school science academic performance. This view is reflected in a study by Brown and Gavin (2004) involving New Zealand and Queensland, Australia. They note that when assessment results are applied to school accountability tracking, and when formative assessments are used to promote learning progress and students' self-responsibility, teachers view such

assessments more positively than just focusing on the results of terminal assessments. The data shows that teachers who are passionate about assessment are more likely to see it as valuable and more frequently use assessment information to adjust their teaching strategies, compared to teachers who are less passionate about assessment (Sayac & Veldhuis, 2022). The assessment of students' academic performance in primary school science teaching is considered to be a crucial aspect in promoting youth science education (Darling-Hammond et al., 2014). Past records show that data from student evaluations are integrated into schools' reform design, implementation, evaluation, and optimization processes (Ward DeJoseph, 2012). Training teachers' academic assessment abilities can effectively enhance their assessment enthusiasm and promote their professional development, which is consistent with previous academic findings, which prove the positive effect of training and professional development activities on improving teacher effectiveness (Ferreira & Morais, 2020; White, 2010). However, the low quality of science teacher education and training has somewhat diminished teachers' enthusiasm to participate in assessment, which is similar to the current situation of science education in Pakistan (Hali et al., 2020).

5.2 What is the current situation of assessment on science academic performance of primary school students?

It is not difficult to find that the academic assessment of primary school science is gradually improving under the guidance of the policies of the Ministry of Education, however, there is still a need to explore better assessment mechanisms.

Firstly, from the perspective of assessment content, 20 out of 23 respondents clearly pointed out that their current primary school science academic assessment focuses on the four aspects of science key competencies in Science Curriculum Standards for Primary school (2022 Edition). Consistent curriculum standards enable people to monitor educational progress based on these standards by focusing on students' efforts, teachers' efforts, and schools' efforts, thereby influencing student achievement (W, 1995).

However, not all respondents set corresponding indicators for the content of academic assessment, indicating that the current assessment of primary school science lacks standardization. This research finding contradicts international scientific assessments, which typically employ clear assessment indicators (Cansiz & Cansiz, 2019; Lay & Chandrasegaran, 2016).

Secondly, from the perspective of assessment methods, the Paper-based test method is still the mainstream of primary school science academic assessment, and is also considered the most efficient and fair assessment method (Shang & Qiu, 2018). In recent years, many educational institutions are undergoing a transition from traditional paper-based assessments to online assessments (Genc, 2012; Hsiao et al., 2012). However, according to this study, there is no significant difference in the effectiveness of paper-based tests and online tests (Jungjohann et al., 2023; Saleh et al., 2022; Wang et al., 2008). Hakim (2018) pointed out that when understanding and applying the research findings, it is necessary to consider the computer proficiency of the current generation, who are accustomed to using computers and are satisfied with the convenience brought by them. Scientific academic assessments around the world, such as PISA, TIMSS and NAEP, have generally adopted computerised forms of testing. Science courses not only require students to comprehend the key concepts but also necessitate their ability to independently practice and explore the essence of phenomena through hands-on experiments. In the future, enhanced machine testing methods can be utilized in scientific academic assessments to assess students' experimental skills.

Thirdly, in the investigation of primary school science learning evaluation, we observe that the executive body of evaluation shows a certain diversity. Most of the teacher respondents pointed out that in the current teaching evaluation practice, teacher evaluation plays a dominant role, while student evaluation plays a secondary role. A very few teachers even introduce parental assessment into student assessments, which is consistent with previous reports on academic assessments (Alkharusi et al., 2014; Birjandi & Tamjid, 2012; Chang et al., 2012; Sari et al., 2016).

5.3 What are challenges of assessment on science academic performance of primary school students?

Firstly, 23 respondents pointed out that the current assessment method in primary schools mainly relies on Paper-based tests, this was supported by Duncan's research (Duncan & Buskirk-Cohen, 2011). The fact that Paper-based tests mainly assess students' mastery of scientific knowledge leads teachers to focus more on imparting knowledge during the teaching process in order to improve students' grades, while neglecting the cultivation of students' scientific skills and thinking abilities. However, the core goal of evaluation should be to promote effective learning for students now and in the future. (Boud & Falchikov, 2007; Carless & Zhou, 2015) In fact, well-designed terminal assessment processes can also foster formative assessment methods, such as peer review, student self-evaluation, and teacher feedback (Rawlusk, 2016). At the same time, teachers should constantly assess students in classroom teaching. As assessment expert Stiggins (Stiggins & Richard, 1999) said, "If classroom assessment practice activities cannot be effectively carried out, then conducting other levels of student academic assessment activities is completely a waste of time and money."

Secondly, the content of scientific academic assessment is not comprehensive. All 20 teachers stated that the current primary school science academic assessment cannot comprehensively assess students' scientific learning ability in terms of content. Science education in primary school is faced with a serious problem of shortage of specialized teachers, whose professional quality is not enough to build an efficient science teaching collective, and this phenomenon is also reflected in Pakistan (Hali et al., 2020). Teachers have heavy daily workloads and face high teaching pressure, which makes it difficult for them to find additional time and energy to effectively comprehensively evaluate the content of scientific studies. Additionally, the heavy workload of students also poses challenges for academic assessment. It is necessary to reduce students' academic burden and provide teachers with more time to evaluate their performance. However, Tofe-grehl and Callahan (2017) point out that for gifted students, they tend to perform

well in high-load learning tasks that emphasize a lot of independent exploration and research-based learning.

The lack of funding support for implementing scientific academic assessment not only limits the assessment process and prevents teachers from using experimental assessment methods, but also hinders effective improvement of teaching quality and impacts students' academic development. The level of recognition regarding the importance of scientific assessment in primary schools by the education management department determines the amount of funds invested in the assessment system. Due to limited educational resources, if some teachers and managers are unaware of the funds required for implementing scientific academic assessment during the process, it will result in a lack of priority and relevance related to scientific academic assessment in fund allocation and utilization, directly affecting the normal progress of scientific academic assessment.

Finally, the lack of assessment instruments is another issue. The content of scientific academic assessment involves multiple aspects, and designing and constructing a scale that meets the current standards for academic assessment is highly challenging. Insufficient assessment tools can result in inaccurate outcomes in scientific academic assessment (Anggraeni & Mundilarto, 2020; Slott et al., 2008). Moreover, constructing an academic assessment scale requires scientific empirical research and verification, which consumes a lot of time and resources. Therefore, many school teachers lack the corresponding experience and ability to complete it. Moreover, constructing an academic assessment scale requires scientific empirical research and verification, which consumes a significant amount of time and resources. Therefore, many school teachers lack the corresponding experience and ability to complete it.

5.4 Limitations and future studies

There are some limitations to this study. First, the teachers who participated in the interviews were only from a specific region, which may limit the general applicability of the study findings. In order to improve the universality and representativeness of the study, subsequent studies should expand the sample size to include more teachers and participants from different

cities and even countries, so as to enhance its external validity. Second, by focusing primarily on teacher interviews, the study ignores important viewpoints from other stakeholders, including students and parents. The depth of our understanding of the topic would be increased by include interviews with people who represent various backgrounds and positions within the educational system. Thirdly, the study only used interview methodology, which might have limited the amount of data that could be gathered. Future research could use techniques like document analysis or classroom observations to increase comprehensiveness. These additional methods would enhance the study and make it easier to conduct a more thorough investigation of the research question.

Disclosure statement

The authors declare no conflict of interest to be disclosed.

Ethics statement

Study participants were volunteers. At the start of the study, the objectives of the study were made clear to all participants. A total of 23 participants agreed to participate in the study after being informed that their identities would be kept confidential and that the information they provided would only be used for academic research.

Data availability

Data generated and/or analyzed in this study may be made available upon reasonable request by the primary contact author.

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Appendix

Table S1. Demographic information for the participants.

Participant	Age	Teaching Experience (Year)	Gender	Subject taught	Type of school (Rural/ Urban)
A	27	4	Female	Science	Urban
B	35	14	Female	Science and Mathematics	Rural
C	34	8	Female	Science	Urban
D	30	6	Female	Science and Mathematics	Rural
E	36	12	Female	Science	Urban
F	35	10	Female	Science	Rural
G	36	15	Female	Science and Mathematics	Rural
H	34	12	Female	Science and Chinese	Rural
I	36	11	Male	Science	Urban
J	31	9	Female	Science	Urban
K	24	2	Female	Science	Urban
L	26	2	Male	Science	Urban
M	29	4	Male	Science	Rural
N	38	13	Male	Science	Urban
O	29	7	Female	Science	Urban
P	31	7	Male	Science	Rural
Q	33	5	Female	Science	Urban
R	51	32	Female	Science and Chinese	Rural
S	31	10	Female	Science	Rural
T	38	18	Female	Science	Urban
U	32	11	Female	Science and Chinese	Rural
V	37	13	Female	Science and Chinese	Rural
W	30	3	Female	Science and Chinese	Rural

Table S2. Results of coding.

Core Category	Related Categories	Illustrative Examples	Frequency
Methods of Academic Assessment (64)	Summative Assessment	Paper-based tests	27
	Diagnostic Assessment	Experimental Operation Assessment	12
		Daily Learning Achievements	13
Contents of Academic Assessment (111)	Formative Assessment	In-Class Assignment Book	12
	Core Competencies	Scientific Concepts	35
		Scientific Thinking	16
		Inquiry Practices	29
		Attitude and Responsibilities	31
		Teacher Assessment	26
Subjects of Academic Assessment (62)	Stakeholders	Student Assessment	33
		Parent Assessment	3
		Promote Individual Growth Among Students	13
Purposes of Academic Assessment (38)	Promote Growth	Teacher's Instructional Improvement	24
		Educational Supervision and Administration	1
		Academic Assessment is Necessary	34
		Willing to Participate in Assessment	18
		Training Activities	18
Teacher Attitudes (89)	Positive Attitude	Current Assessment Methods are Efficient	20
	Negative Attitude	Assessment Poses a Burden	5
		Desire for Changing the Current Assessment Landscape	12
		Assessment Methods are Limited in Diversity	14
		Assessment Content Is Not Comprehensive	14
Challenges and Suggestions (86)	Challenges	Lack of Assessment Scales	6
		Lack of Educational Resources	15
		Weak Scientific Literacy among the General Population	11
		Promoting Diverse Assessment Methods	11
	Suggestions	Adjusting Class Schedules	1
		Increasing Funding Allocation	5
		Facilitating Teacher Development	9