

Views, Concerns and Actions About Chemistry: Instrument Development and an Initial Synthesis of Students' Opinions

Visões, Preocupações e Ações Sobre a Química: Elaboração de Instrumentos e Síntese Inicial das Opiniões dos Estudantes
Visiones, Preocupaciones y Acciones Sobre la Química: Instrumentos y Síntesis Inicial de Opiniones Estudiantiles

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Abstract

This article presents the development, validation, application, and initial synthesis of two instruments designed to investigate high school students' views on Chemistry and Natural Sciences, their concerns regarding socioscientific themes, and their reported actions in response to social, environmental, technological, and health-related problems. The study dialogues with the STSE approach, socioscientific themes, and research on student voice. The construction of the instruments was supported by themes identified in Chemistry textbook collections approved by PNLD/2018, the São Paulo State Curriculum, and previous instruments, such as VOSTS, ROSE, and derived questionnaires. Related instruments were developed, combining open-ended questions and Likert-type scale items, and were submitted to content and semantic appraisal by specialists, as well as to internal consistency analysis, with Cronbach's alpha values of 0.953 and 0.870. The application took place in Minas Gerais and São Paulo, in both in-person and remote modalities. The results indicate that participants recognize the social importance of Chemistry but show low interest in scientific careers; express concerns about sustainability, health, safety, education, the economy, and violence; and report predominantly individual actions, with lower collective and political participation. It is concluded that the instruments support pedagogical diagnoses and research that articulate youth interests, socioscientific themes, and STSE practices in Science Education.

Keywords: Science Education, Chemistry Education, STSE, socioscientific themes, student voice

Resumo

Este artigo apresenta a elaboração, a validação, a aplicação e uma síntese inicial de dois instrumentos destinados a investigar visões de estudantes do Ensino Médio sobre a Química e as Ciências da Natureza, preocupações diante de temas sociocientíficos e ações declaradas frente a problemas sociais, ambientais, tecnológicos e de saúde. O estudo dialoga com a abordagem CTSA, as questões sociocientíficas e pesquisas sobre voz dos estudantes. A construção foi subsidiada por temas identificados em coleções de Química do PNLD/2018, pelo Currículo do Estado de São Paulo e por instrumentos prévios, como o VOSTS, o ROSE e questionários derivados. Foram desenvolvidos instrumentos articulados entre si, com questões abertas e itens em escalas tipo Likert, submetidos à apreciação de conteúdo e semântica por especialistas e à análise de consistência interna, com alfa de Cronbach de 0,953 e 0,870. A aplicação ocorreu em Minas Gerais e São Paulo, nas modalidades presencial e remota. Os resultados indicam que os participantes reconhecem a importância social da Química, mas demonstram baixo interesse por carreiras científicas; expressam preocupações com sustentabilidade, saúde, segurança, educação,

economia e violência; e relatam ações predominantemente individuais, com menor participação coletiva e política. Conclui-se que os instrumentos subsidiam diagnósticos pedagógicos e pesquisas que articulam interesses juvenis, temas sociocientíficos e práticas CTSA no Ensino de Ciências.

Palavras-chave: Ensino de Ciências, Ensino de Química, CTSA, temas sociocientíficos, voz dos estudantes

Resumen

Este artículo presenta la elaboración, validación, aplicación y una síntesis inicial de dos instrumentos destinados a investigar las visiones de estudiantes de Educación Secundaria sobre la Química y las Ciencias Naturales, sus preocupaciones ante temas sociocientíficos y las acciones que declaran realizar frente a problemas sociales, ambientales, tecnológicos y de salud. El estudio dialoga con el enfoque CTSA, los temas sociocientíficos y las investigaciones sobre la voz de los estudiantes. La construcción se basó en temas identificados en colecciones de Química del PNLD/2018, en el Currículo del Estado de São Paulo y en instrumentos previos, como el VOSTS, el ROSE y cuestionarios derivados. Se desarrollaron instrumentos relacionados, con preguntas abiertas e ítems en escalas tipo Likert, sometidos a apreciación de contenido y semántica por especialistas y a análisis de consistencia interna, con alfa de Cronbach de 0,953 y 0,870. La aplicación se realizó en Minas Gerais y São Paulo, en modalidades presencial y remota. Los resultados indican que los participantes reconocen la importancia social de la Química, pero muestran bajo interés por carreras científicas; expresan preocupaciones sobre sostenibilidad, salud, seguridad, educación, economía y violencia; y declaran acciones predominantemente individuales, con menor participación colectiva y política. Se concluye que los instrumentos subsidian diagnósticos pedagógicos e investigaciones que articulan intereses juveniles, temas sociocientíficos y prácticas CTSA en la Enseñanza de las Ciencias.

Palabras clave: Enseñanza de las Ciencias, Enseñanza de la Química, CTSA, temas sociocientíficos, voz estudiantil

Introduction

In light of the changes taking place in society and the need to address different situations in everyday life, science education researchers and teachers have argued that teaching and learning should not be reduced to the mere transmission of scientific content (Auler, 2007; Carvalho, 2018; Santos, 2011; Silva & Marcondes, 2010). Beyond the acquisition of such content, schools must foster education for citizenship and the development of competencies and skills, enabling students to engage in inquiry and problem-solving processes, formulate hypotheses and possible solutions, express opinions, and make decisions (Akben, 2020; Auler, 2007; Carvalho, 2018; Gordillo, 2006; Santos, 2011; Silva & Marcondes, 2010; Strieder & Kawamura, 2017).

In Brazil, education for citizenship is established as an objective in national curriculum documents, including the National Education Guidelines and Framework Law (Lei de Diretrizes e Bases da Educação [LDB]), the National Curriculum Parameters (Parâmetros Curriculares Nacionais [PCN]), the National Curriculum Parameters for Upper Secondary Education (Parâmetros Curriculares Nacionais para o Ensino Médio

[PCNEM]), and the National Common Core Curriculum (Base Nacional Comum Curricular [BNCC]). To foster critical and informed education that enables students to understand rights and responsibilities, exercise judgment, and make decisions in society, different approaches may be employed, including contextualization and teaching through relationships among Science, Technology, Society, and Environment (STSE) (Aikenhead, 1994; Auler, 2007; Gordillo, 2006; Santos, 2011; Silva & Marcondes, 2010; Sousa & Ibiapina, 2023; Strieder & Kawamura, 2017).

Contextualization is an approach aimed at developing scientific concepts in connection with technological, political, environmental, and ethical dimensions. In this approach, teaching and learning take students' social contexts as a starting point and value their experiences and lived realities (Finger & Bedin, 2019; Raupp et al., 2020; Silva & Marcondes, 2010; Sousa & Ibiapina, 2023). When teachers connect scientific concepts with students' everyday lives and make learning meaningful, they create opportunities for students to understand the importance of science and perceive relevance in what they study (Finger & Bedin, 2019).

The STSE perspective in science education may be understood as a curricular and pedagogical orientation that moves teaching away from an organization based solely on the discipline's conceptual sequence toward an approach in which scientific knowledge is mobilized in dialogue with social, technological, environmental, ethical, political, and economic problems (Aikenhead, 1994). From this perspective, themes do not function merely as motivating examples or illustrations of content; rather, they serve as starting points through which students can make sense of scientific concepts, understand science and technology as socially situated constructions, and develop capacities for analysis, argumentation, positioning, and decision-making. STSE education thus seeks to overcome both neutral, salvationist, and deterministic views of science and technology and a preparatory conception of schooling (Auler, 2007), in which knowledge is learned only for future use. Therefore, it aims to foster science education connected to students' present lived experience, critical readings of reality, social participation, and the development of commitments toward collective problems (Aikenhead, 1994; Auler, 2007; Santos, 2011; Strieder & Kawamura, 2017; Sousa & Ibiapina, 2023).

Contextualization and STSE education are grounded in principles related to students' contexts and to social themes that reflect their interests or are socially relevant. Accordingly, understanding the opinions, views, concerns, actions, and relationships that students establish between school science and everyday life can support the development and revision of teaching materials, bringing scientific content closer to issues that are meaningful to students. Investigating these perceptions can also help teachers identify difficulties in connecting science with everyday life and plan practices with a greater or lesser STSE emphasis according to the needs of each class.

In science education, there is a substantial body of scholarship on STSE, including literature reviews, curricular discussions, teaching proposals, analyses of instructional materials, studies of teachers' conceptions, and investigations of the implementation of

pedagogical practices (Cavalcanti et al., 2024). Established instruments also investigate students' views, opinions, interests, and attitudes toward science and technology, including VOSTS (Views on Science-Technology-Society), the ROSE project (Relevance of Science Education), and their adaptations in Brazilian research. Nevertheless, studies that take student voice as a starting point and integrate three complementary dimensions within the same methodological pathway remain less common: students' views of Chemistry, their concerns regarding socioscientific themes, and the actions they report taking in response to such situations. This integration represents the contribution proposed in this article because it makes it possible to identify whether students recognize the importance of Chemistry or school science, understand which problems in the world concern them, and examine the individual or collective forms of action they associate with those problems. Against this background, this article aims to present the development of instruments designed to investigate high school students' views, concerns, and actions regarding Chemistry, and to discuss an initial synthesis of the opinions obtained, highlighting possibilities for using these instruments in science/Chemistry education research and in planning pedagogical practices informed by STSE education and socioscientific themes (Aikenhead & Ryan, 1992; München et al., 2015; Strieder & Kawamura, 2017).

Challenges in the Teaching and Learning of Chemistry

Although Chemistry contributes to understanding everyday phenomena and problems, learning it involves difficulties related both to the organization of teaching and to the discipline's inherent complexity. These include practices centered on the transmission and memorization of content, curricula poorly connected to students' realities, the need to move among the macroscopic, representational, and submicroscopic levels, and mastery of a specific symbolic language (Carvalho, 2018; Johnstone, 1982; Quílez, 2019; Talanquer, 2011).

Difficulties are also recurrent in understanding the nature of matter, distinguishing physical from chemical changes, establishing quantitative relationships, and interpreting formulas, equations, and molecular structures (Pozo & Crespo, 2009; Silva et al., 2021). These obstacles may be intensified when content is presented with limited contextualization and remains disconnected from students' experiences (Finger & Bedin, 2019; Sousa & Ibiapina, 2023).

Accordingly, investigating how students perceive Chemistry and relate their knowledge to everyday life is important for understanding the meanings they attribute to the subject and for informing contextualized pedagogical practices consistent with STSE perspectives. This need is reinforced by studies showing that recognizing the importance of school science does not necessarily imply interest in science subjects or science-related careers (Cardoso & Colinvaux, 2000; Gouw, 2013; Pinafo, 2016; Salta & Tzougraki, 2004; Tonin et al., 2021).

Studies Investigating Students' Views

Students' opinions, attitudes, interests, and views regarding science and technology have been investigated through different instruments and studies in science education. Prominent initiatives include VOSTS, developed to examine students' views of relationships among Science, Technology, and Society; the ROSE project, designed to investigate the relevance of science education from the perspective of young people's interests and attitudes; and the Barometer, an adaptation developed in Brazilian and international research to analyze opinions, interests, and attitudes toward science and technology (Aikenhead & Ryan, 1992; Gouw, 2013; Oliveira, 2015; Pinafo, 2016; Schreiner & Sjøberg, 2004). These studies provide important foundations for research seeking to understand students' relationships with school science, although they do not always integrate views of Chemistry, socioscientific concerns, and reported actions in response to social, environmental, technological, and health-related problems.

One of the earliest studies to investigate how students establish and recognize relationships among Science, Technology, and Society was conducted by Aikenhead and Ryan (1992) using the VOSTS questionnaire. The study was developed over six years with Canadian students aged 17 to 19. The original instrument comprised 114 multiple-choice questions organized into eight dimensions and addressed the influence of science and technology on society, the characteristics of scientists, and the nature of scientific knowledge.

The questionnaire was also used in the study by München et al. (2015), involving 28 undergraduate students enrolled in a Chemistry program leading to teaching and bachelor's degrees at a public university in Brazil's Center-West region. The authors selected 11 VOSTS questions, and participants chose the option that most closely represented their viewpoint from five alternatives for each question. Three additional response options were provided: I do not understand; I do not have enough knowledge to make a choice; and none of the preceding statements corresponds to my viewpoint.

Students' responses were analyzed using the categories Simplistic, Plausible, and Realistic. The first category encompassed responses regarded as naive or inappropriate, the Plausible category included partially adequate responses, and the final category indicated a more appropriate understanding of STSE interactions. One noteworthy finding concerned a question about the social responsibility of technicians and scientists for the effects of their research: fifteen undergraduates provided responses classified as Simplistic because they did not consider that science may be influenced by social factors such as politics, economics, ethics, religion, and others (München et al., 2015).

To investigate students' perceptions of science, researchers in Norway developed an international research project to understand students' views of science and technology education. The project sought to address young people's lack of interest in science and science careers. The researchers developed an instrument comprising 245 questions, known as ROSE, which collected data on students' attitudes, interests, and emotions regarding science and technology (Schreiner & Sjøberg, 2004).

The ROSE questionnaire was administered in Brazil by Gouw (2013) to 2,365 students. The instrument comprised 245 closed-ended items answered on a Likert-type scale. Among the main findings, the author reported that students held optimistic attitudes toward science and technology and were concerned about environmental problems, although they believed that solutions to these issues could be found.

Building on the experience of the ROSE project, the questionnaire was adapted to the Brazilian context. Oliveira (2015) and Pinafo (2016) reduced the number of items and added questions on religion and biological evolution. In their studies, the authors used an instrument called the Barometer, developed with the collaboration of Italian and Brazilian experts. Its adaptations were assessed through internal consistency tests, and the instrument was administered in both countries.

Pinafo's (2016) study investigated the interests, opinions, and attitudes of Brazilian and Italian young people toward science and technology, involving 2,368 Brazilian students and 3,503 Italian students. Among the main findings, students showed considerable interest in school science, particularly in topics related to health and the human body, but did not wish to pursue scientific careers. Regarding career aspirations, students showed greater interest in self-employed occupations in which they could manage their own businesses.

The study also found that students recognized scientific concepts learned in science classes in their everyday lives and agreed that these concepts were important and useful. However, they did not perceive that science helped them take better care of their health. Another notable result was that participants showed little interest in visiting science-related spaces such as science centers, exhibitions, and museums, and were also uninterested in seeking scientific information in books, magazines, television, and films (Pinafo, 2016).

Development of Research Instruments

The instruments presented in this article were developed within two master's studies in science education conducted in the Interunit Graduate Program in Science Education at the University of São Paulo (PIEC-USP). Although they share theoretical and methodological foundations, they are not treated here as successive versions of the same questionnaire. They are two distinct instruments, developed in autonomous studies but derived from a common design framework intended to investigate high school students' views, concerns, and actions regarding Chemistry, the Natural Sciences, and socioscientific themes. Accordingly, the instruments include continuities, reused and adapted items, as well as differences in structure, question format, response scales, and administration procedures.

The study is empirical and qualitative in approach, complemented by Likert-type items and a descriptive-interpretive treatment of the data. It was conducted in schools in the states of Minas Gerais and São Paulo, with in-person administrations in 2019 and remote administrations in 2021. This article does not seek to provide an

exhaustive analysis of the results generated by the instruments; rather, it focuses on their development, appraisal, and refinement, together with an initial synthesis of students' opinions, to demonstrate their potential use in research and pedagogical practices informed by STSE education and socioscientific themes.

An initial survey identified socioscientific themes in instructional and curricular materials related to Chemistry education. The aim was to identify themes that, because of their recurrence in textbooks and curriculum documents, might be present in students' schooling and in socially relevant discussions associated with Chemistry. The instruments were developed with support from four sets of sources: (i) Chemistry textbook collections approved by the 2018 Brazilian National Textbook Program (PNLD/2018); (ii) the São Paulo State Curriculum; (iii) instruments previously used in studies of science, technology, society, attitudes, and youth interests, such as VOSTS, ROSE, and questionnaires adapted to the Brazilian context based on them; and (iv) international documents addressing social and environmental problems, especially the Sustainable Development Goals. Each source served a specific purpose: the textbooks and curriculum supported the identification of themes potentially addressed in school; previous instruments informed the definition of investigative dimensions, item types, and response scales; and the SDGs supported the development of items concerning individual and collective actions in response to social, environmental, technological, and health-related problems.

The textbook collections were selected from works approved under PNLD/2018 because they had been evaluated nationally and could potentially be used in different school contexts. The selection was not restricted to the collections adopted by the participating schools because the instruments were developed before the final study settings were defined and before the researchers entered the schools. The aim was therefore to construct instruments with broader thematic coverage, encompassing themes recurrent in instructional and curricular materials rather than only those found in a single school or textbook collection. This decision is nevertheless acknowledged as a methodological limitation because the instruments do not make it possible to affirm that every theme investigated had actually been addressed by each participating teacher or class.

In this article, the expression socioscientific themes is used in a broad sense to refer to themes related to science, technology, society, and environment and associated with historical, political, ethical, economic, cultural, and environmental dimensions. This understanding is informed by Socioscientific Issues (SSI) (Ratcliffe & Grace, 2003; Ribeiro & Marcondes, 2020), Socioscientific Aspects (SSA) (Mortimer & Santos, 2009; Mundim & Santos, 2012), and STSE approaches (Aikenhead, 1994; Aikenhead & Ryan, 1992; Auler, 2007; München et al., 2015; Santos, 2011; Sousa & Ibiapina, 2023; Strieder & Kawamura, 2017), without being restricted to formally delimited controversies.

Word cloud of the identified socioscientific themes



After the themes had been identified, they were classified into 15 categories: Agriculture, Water, Food, Metals, Atmosphere, Fuels, Human Body, Cosmetics, Drugs, Electricity, Waste, Chemical Products, Nanotechnology, Petroleum, and Radioactivity. This survey was essential for guiding the selection of themes and situations that could be included in the instruments because it indicated topics recurrent in the instructional and curricular materials analyzed and potentially connected to students' everyday lives.

Instrument 1 was structured predominantly around closed-ended items using Likert-type scales. Instrument 2 drew on part of the thematic and conceptual framework previously developed but introduced changes to its structure and specific objectives: it broadened the investigation of views on Chemistry, incorporated open-ended questions to elicit students' concerns, and subsequently used those concerns to inform the development of a specific instrument on actions and attitudes. Thus, although the two instruments include identical or adapted items, they should not be understood as the first and second versions of the same questionnaire, but as distinct instruments connected by a common foundation and complementary purposes.

The following subsections present the development of Instrument 1 (Ribeiro, 2022) and Instrument 2 (Silva, 2022) separately, detailing their sections, item types, response scales, participants, administration procedures, and the main modifications made in each research process.

Instrument 1: Views, Concerns, and Actions Using Likert-Type Scales

Instrument 1 comprised four sections: I - Views on Chemistry and Natural Sciences Education; II - Situations that raise concerns; III - Your actions and attitudes for a better society; and IV - About you. Each section included questions through which students could express their opinions, concerns, reported actions, and sociodemographic information (Ribeiro, 2022).

In the first section (I), students were presented with statements concerning Chemistry, Natural Sciences subjects, the connections they established between the school subject and everyday life, and the concepts learned in the classroom. The statements in this section were based on and adapted from instruments such as ROSE (Schreiner & Sjøberg, 2004), the instrument regarding Attitudes toward Chemistry (Salta & Tzougraki, 2004), and the questionnaires developed by Leite et al. (2018) and Romero (2020).

Students responded to the statements using a four-point Likert-type scale: Strongly Agree (SA), Partially Agree (PA), Partially Disagree (PD), and Strongly Disagree (SD). They could also select “I do not know” when they were unable to express an opinion or did not understand the statement (Vieira, 2009).

A Likert scale is a method used in research to assess opinions and attitudes. Likert-type scales may vary in the number of response points and in whether they include a neutral option. In Instrument 1, a four-point scale was used to encourage respondents to take a position on each statement, while the “I do not know” option was retained for cases of lack of understanding or absence of a formed opinion (Vieira, 2009).

The second section focused on situations that could raise concerns among the students. In Instrument 1, the term “concerns” referred to the set of worries, sources of discomfort, or problems that could mobilize students in relation to social, environmental, technological, and health-related themes. This section was developed from the 210 themes identified in the documentary survey and encompassed the 15 thematic categories created. Sixty statements concerning socioscientific themes were formulated; students responded using a five-point scale ranging from 1 to 5, indicating lower or higher levels of concern. A midpoint was retained in this section because it measured concern rather than agreement.

The third section (III), entitled “Actions and Attitudes Required for a Better Society,” consisted of three questions. The first investigated what students did when faced with questions related to the Natural Sciences and presented seven possible courses of action; the second examined, through six items, how they conducted internet searches and evaluated the information they found; and the third comprised 31 individual and collective actions related, among other aspects, to sustainability, consumption, health, social coexistence, and civic participation. Students indicated how frequently they

performed these actions on a five-point scale: Never, Rarely, Sometimes, Often, and Always. The actions included in the third question were inspired by the United Nations Sustainable Development Goals and were intended to identify practices that students associated with building a better society (Organização das Nações Unidas, 2015; Ribeiro, 2022).

The final section of the questionnaire (IV) included questions on age, sex, paid employment, place of residence, place of study and work, mother's and father's educational attainment, and total family income, with the purpose of characterizing respondents' sociodemographic profiles. An open-ended question was also included so that students could express their views of the questionnaire.

Instrument 1 was completed by 200 students from schools in the state of São Paulo. The schools had no professional, administrative, or pedagogical ties to the researchers. Access to these settings was established through Chemistry teachers who had participated in continuing education activities in science/Chemistry education and volunteered to collaborate with the study, facilitating contact with the classes and organizing the administration. Participation by the schools, teachers, and students took place with institutional authorization, in accordance with ethical procedures for research involving human participants, and following approval by a Research Ethics Committee. The instrument was administered in person in 2019 to high school students in four different cities in the state of São Paulo, during a Chemistry class lasting approximately 45 minutes, and all sections were completed in the same session.

Instrument 2: Views on Chemistry, Open-Ended Concerns, and Reported Actions

Instrument 2 (Silva, 2022) retained parts of the structure of Instrument 1 but introduced adaptations to deepen the identification of students' concerns and strengthen the relationship between those concerns and their reported actions. The two proposals should be understood as distinct instruments connected by the same theoretical and methodological trajectory, rather than as unrelated or contradictory questionnaires.

Instrument 2 included an open-ended question (Section I) asking students to list between five and ten situations that might cause them concern. This number was requested to encourage students to identify more than one concern. The open-ended question allowed respondents to use their own words, without prompts predetermined by the researchers, and to describe concerning situations whether or not they were related to Chemistry or school (Gunther & Lopes Júnior, 1990). This type of question also makes it possible to obtain responses that researchers had not anticipated, thereby generating broader data for the investigation (Vieira, 2009).

In addition to the open-ended question, students were presented with statements divided into sections (I.1, I.2, I.3, and I.4), with minor wording changes intended to facilitate comprehension. They indicated their level of agreement on a four-point scale: 1 (strongly disagree), 2 (partially disagree), 3 (partially agree), and 4 (strongly agree). An "I do not know" option was also available when students were unable to express an opinion.

Section I.1 included fifteen statements concerning the presence of Chemistry in students' everyday lives and addressed processes and contributions of Chemistry to daily life. Section I.2 comprised sixteen statements concerning the Chemistry content learned at school, the need for the subject, and perceived difficulties and ease in the teaching and learning process.

Section I.3 comprised twenty-five statements about Chemistry classes, investigating students' participation in lessons and activities and the contribution of the subject to stimulating interest in science. Section I.4 included ten statements on students' preferences among the Natural Sciences subjects (Chemistry, Physics, and Biology) and on relationships with other areas of knowledge, such as Portuguese, Mathematics, and the Humanities. Finally, Section II presented socioeconomic questions, including age, gender, and parents' or guardians' educational attainment (Silva, 2022).

After the first part of Instrument 2 had been administered, the concerns identified by students were used to construct a complementary questionnaire on actions and attitudes. This questionnaire contained sixty-six statements concerning individual and collective actions that could be taken in response to the situations identified as concerning. Students reported how frequently they performed each action using a five-point scale: (1) Never, (2) Rarely, (3) Sometimes, (4) Often, and (5) Always. The first part of Instrument 2 was completed in person in 2019 by 97 students in one city in the state of Minas Gerais. The second part was completed remotely in 2021, because of restrictions imposed by the COVID-19 pandemic, by 65 students from three cities in the state of São Paulo, during class periods of approximately 45 minutes.

Instrument Validation Procedures

Instrument validation was understood as a process of gathering evidence regarding the adequacy of the items to the research objectives, rather than as a single procedure (Vieira, 2009). Three complementary dimensions were considered: content validity, face/semantic validity, and analysis of the internal consistency of the scales.

Content validation sought to determine the theoretical relevance of the items to the dimensions investigated—views, concerns, and actions—as well as their coherence with the STSE approach and socioscientific themes. Face and semantic validation focused on the clarity of the statements, linguistic appropriateness for high school students, absence of ambiguity, and comprehensibility of the scales and questions.

Hayashi et al., (2019) argue that research validity is an ongoing process extending from the earliest stages through publication and cannot be understood as a single test or measure. According to these authors, the validation process may encompass project design, organization of data collection, coding, analysis, discussion of the findings, and a return to theory. Furthermore, O'Connor and Joffe (2020) and Tracy and Hinrichs (2017) argue that validation procedures help reduce subjectivity in qualitative research and enhance transparency and communicability.

Internal consistency was estimated using Cronbach's alpha, which assesses coherence among the items in a scale. The values obtained were 0.953 for Instrument 1 and 0.870 for Instrument 2, indicating satisfactory internal consistency. These coefficients, however, should not be understood as sufficient evidence of validity, but as reliability indicators that complement evidence of content validity and semantic adequacy (Vieira, 2009).

Questionnaire validity is associated with evidence that an instrument is appropriate for the purpose for which it was developed. Torlig et al. (2022), as well as Vieira (2009), note that expert appraisal may generate recommendations concerning vocabulary, item reformulation, the removal or addition of questions, and the coherence among objectives, items, and the target population. Researchers must assess these recommendations, decide whether to incorporate them, and justify the decisions made during instrument development.

Both instruments were appraised by the Chemistry Education Research Group (GEPEQ) at the Institute of Chemistry, University of São Paulo (IQ-USP), which comprised researchers at different stages of academic training and with experience in Chemistry education, research instruments, and the STSE approach. The recommendations included adjustments to question wording, reduction of ambiguities, adaptation of the language for high school students, removal or replacement of technical terms, and rewriting of statements considered excessively abstract or broad. Expert appraisal therefore contributed to the semantic and content refinement of the instruments, although it did not exhaust other possible forms of validation, such as factor analyses or further large-scale administrations. The instruments developed and the data collected are openly available in a public GitHub repository, whose URL is provided in the "Data and Materials Availability" section.

Main Findings

The primary objective of this article is to present the development of instruments designed to investigate high school students' views, concerns, and actions regarding Chemistry. The findings are presented synthetically and exploratorily to illustrate the types of data generated by the instruments and their analytical possibilities, without exhausting the analysis of the responses.

Figure 2

Main results obtained from the administered questionnaires

Views	Concerns	Actions
Recognize the importance of studying Chemistry.	Express greater concern about shortages of natural and financial resources.	Report predominantly individual actions.
Are not interested in becoming chemists or scientists.	Express less concern about long-term problems and insufficient investment in Health, Education, and Culture.	Show limited participation in collective actions.

Figure 2 summarizes three observed trends: students recognize the importance of Chemistry but show little interest in scientific careers; their concerns focus on social, environmental, economic, and health-related problems; and their reported actions tend to concentrate on individual practices. These findings are relevant because they integrate, within the same research process, students' perceptions of school science, the problems that mobilize young people, and the forms of action they recognize as possible.

Students' Main Views

The findings concerning students' views indicate a pattern that is relevant to Chemistry education: students recognize the social and everyday importance of Chemistry, but this recognition does not necessarily translate into a desire to pursue further study in the field or follow scientific careers. This finding shifts the interpretation away from a presumed simple rejection of the subject and toward a more ambivalent relationship: Chemistry is perceived as useful and socially important, but not always as accessible, understandable, or desirable as an educational and professional pathway (Ribeiro, 2022; Silva, 2022).

This ambivalence is consistent with studies that have investigated students' attitudes and interests regarding science. Studies by Cardoso and Colinaux (2000), Salta and Tzougraki (2004), Gouw (2013), Pinafo (2016), and Tonin et al. (2021) indicate that recognizing the importance of school science does not necessarily imply an affective identification with science subjects or an intention to pursue scientific careers. In Chemistry, this distance may be related both to the conceptual and representational difficulties discussed above, particularly in understanding the nature of matter and interpreting chemical formulas, equations, and structures (Pozo & Crespo, 2009; Silva et al., 2021), and to the way content is traditionally presented, often emphasizing nomenclature, calculations, formulas, and procedures that are poorly connected to students' experiences (Finger & Bedin, 2019; Paz et al., 2010; Quílez, 2019; Silva & Marcondes, 2010).

The data suggest that the issue is not simply whether students "like" or "dislike" Chemistry, but how they make sense of the subject. When students recognize its importance but do not wish to engage more deeply with it, they reveal a relevant tension for curriculum planning: school Chemistry must not only be socially recognized but also experienced as a field for interpreting real-world problems, making decisions, and participating as citizens. In this respect, the STSE approach can contribute by connecting chemical concepts with themes that permeate students' social, environmental, technological, and economic lives, preventing contextualization from being reduced to isolated everyday examples.

Note. (a) Word cloud based on responses collected in person from first-year high school students in Minas Gerais. (b) Word cloud based on responses collected in person from second-year high school students in Minas Gerais. (c) Word cloud based on responses collected remotely from first-year high school students in Minas Gerais. (d) Word cloud based on responses collected remotely from third-year high school students in Minas Gerais. (e) Word cloud based on responses collected in person from high school students in São Paulo.

The word clouds constructed from the responses suggest that students' concerns are organized around socially relevant problems that recur in contemporary public debate, integrating social, economic, environmental, and political-institutional dimensions. Terms such as unemployment, politics, pollution, deforestation, racism, hunger, drugs, violence, education, and litter in the streets indicate that students interpret the world around them through tensions that permeate collective life. This interpretation is consistent with STSE perspectives that advocate incorporating socially relevant problems into science education because such problems require the integration of scientific knowledge, technological choices, social values, economic interests, and public participation (Aikenhead, 1994; Auler, 2007; Santos, 2011; Strieder & Kawamura, 2017).

The environmental concerns mentioned include pollution, inadequate water and sewage treatment, ecosystem destruction, water crises, environmental disasters, the greenhouse effect, global warming, and biodiversity loss. These themes resemble the interests identified by Gouw (2013) in the Brazilian ROSE project, particularly issues concerning access to clean air and drinking water, epidemic control, healthy eating, and environmental problems. Students also mentioned concerns related to health, the economy, and violence, showing that their concerns are not limited to strictly school-related themes but encompass problems involving science, technology, society, environment, health, and citizenship.

Some situations generated lower levels of concern, particularly those whose relationships with everyday life and school science may be less evident, such as nanotechnology, excessive consumption, mineral extraction, modes of transportation, and certain eating habits. Rather than interpreting this finding solely as an absence of concern, it may be understood as indicating themes that require greater pedagogical mediation. Therefore, the instruments make it possible to identify both what concerns students and what may remain less visible to them, supporting the selection of socioscientific themes that begin with young people's concerns and broaden the range of problems subjected to critical analysis.

Students' Actions

Among the actions most frequently reported by students were individual practices related to consumption, sustainability, and health, such as avoiding the waste of food, water, and energy and refraining from the use of legal and illegal substances. Although relevant, these actions were less frequently accompanied by forms of collective participation, social mobilization, or demands for public policies. This finding indicates a gap between recognizing social and environmental problems and identifying broader forms of participation in response to them.

The predominance of individual actions may be interpreted in light of discussions of STS/STSE education and social participation. Strieder and Kawamura (2017) emphasize that STS proposals may pursue different educational purposes, ranging from developing perceptions of relationships among science, technology, and society to fostering critical questioning and social commitment. The data from this study suggest that many students recognize problems and report personal actions but indicate a lower frequency of actions associated with collective commitments, public participation, or social intervention. The findings also align with Auler (2007) by highlighting the challenge of overcoming a preparatory model of education in which students learn only to participate in the future, in favor of an education that enables learning through participation.

The initial synthesis of the findings indicates that the instruments can contribute to pedagogical diagnosis in three ways: by helping to understand how students perceive Chemistry and its social relevance; by identifying concerns that can serve as starting points for thematic and socioscientific approaches; and by recognizing the limitations and possibilities of the actions students associate with contemporary problems. This integration of views, concerns, and actions constitutes a methodological contribution of the study because it enables teachers and researchers to connect youth interests, citizenship education, social participation, and the planning of STSE practices in Chemistry education.

Final Considerations

This article aimed to develop, validate, and administer a set of related instruments designed to investigate high school students' views of Chemistry and the Natural Sciences, their concerns regarding socioscientific themes, and the actions they report taking in response to social, environmental, technological, and health-related problems. In relation to this objective, the findings show that the instruments made it possible to characterize three interconnected dimensions of students' relationships with school science: recognition of the social importance of Chemistry, identification of concerns related to contemporary problems, and the predominance of individual actions over forms of collective participation. Methodologically, the study contributes by presenting an instrument-development process grounded in curriculum materials, textbooks, previously used questionnaires, and expert validation, complemented by internal consistency analysis. This contribution is relevant to teachers and researchers seeking to understand student voice before planning STSE proposals or instructional sequences based on socioscientific themes. Empirically, the findings indicate that valuing Chemistry does not in itself imply interest in scientific careers and that concern about social and environmental problems does not automatically translate into collective participation. These findings suggest the need for science education practices that integrate conceptual understanding, critical analysis of controversies, decision-making, and social action.

The limitations of this study must nevertheless be acknowledged. Because the article focuses on the development, appraisal, and initial administration of the instruments, the findings were presented synthetically, which did not allow for a more comprehensive analytical examination of some dimensions, particularly the nuances of collective actions, differences among student groups, and the specific characteristics of each school context. These aspects were explored in greater depth in the dissertations from which this article originated. In addition, some administrations took place in a context shaped by the COVID-19 pandemic, requiring adaptation to a remote format and involving students from different schools, educational systems, states, and data-collection periods. This condition does not invalidate the findings, but it calls for caution when directly comparing the groups and reinforces the need for further administrations in more controlled school settings, across different regions, educational systems, and student profiles.

As a future direction, the instruments should be used in further research and pedagogical practices as diagnostic tools for identifying students' views, concerns, and actions before instructional interventions are planned. Based on this information, teachers and researchers can design activities informed by the STSE approach and socioscientific themes and subsequently investigate whether such interventions contribute to broadening students' understanding of Chemistry, diversifying the range of issues they consider concerning, and strengthening repertoires of collective action, public participation, and socioscientific engagement.

Authors' Contribution

Conceptualization: Silva, R. A., Marcondes, M. E. R.; **Data curation:** Silva, R. A., Ribeiro, M. M., Marcondes, M. E. R.; **Formal analysis:** Silva, R. A., Ribeiro, M. M., Marcondes, M. E. R.; **Funding acquisition:** Marcondes, M. E. R.; **Investigation:** Silva, R. A.; **Methodology:** Silva, R. A., Ribeiro, M. M.; **Project administration:** Marcondes, M. E. R.; **Resources:** Marcondes, M. E. R.; **Software:** Ribeiro, M. M.; **Supervision:** Silva, R. A., Marcondes, M. E. R.; **Validation:** Marcondes, M. E. R.; **Writing – original draft:** Silva, R. A., Ribeiro, M. M.; **Writing – review & editing:** Silva, R. A., Ribeiro, M. M., Marcondes, M. E. R.

Data Availability Statement

The instruments used in both investigations, as well as the supplementary materials necessary to understand their structure, are available in an anonymized public repository on GitHub: <https://github.com/MatheusMarquesRibeiro/dados-vpa>

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