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Meanings Attributed by Students of the Integrated Course of a Federal Institute on Chemistry Teaching

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ABSTRACT

Background: Due to the problems in chemistry teaching, several teachers sought to build more attractive and contextualised educational practices, which has been the target of numerous studies in the literature. In this perspective, research works that address the meanings attributed by students and the degree of difficulty in learning themes commonly taught in this subject are of great importance. **Objective:** To understand the meanings attributed by the students of an integrated course of a federal institute on chemistry and evaluate the degree of difficulty they attributed to the subjects taught. **Design:** Research with mixed methods and convergent design. **Setting and participants:** 90 students from the first, second, and third years of an integrated chemistry course at a federal institute participated in the research. **Data collection and analysis:** Questionnaires were applied to know why students think it is good or bad to study chemistry. The students also mentioned difficulty learning some of the subjects taught. **Results:** According to the students, it is good to study chemistry because it addresses everyday issues and helps us to get to know the world. The negative points are the difficulty and complexity of theoretical themes and the involvement of calculations. **Conclusions:** Themes that are difficult to visualise or those in which the chemical language is not contextualised are the most difficult to learn.

Keywords: Chemistry teaching; Integrated course; Perceptions; Contextualisation.

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Significados atribuídos por estudantes do curso integrado de um instituto federal sobre o ensino de química

RESUMO

Contexto: diante dos problemas enfrentados no âmbito do Ensino de Química, uma parcela dos professores tem buscado a construção de práticas educativas mais atrativas e contextualizadas, sendo esse aspecto alvo de inúmeros estudos na literatura. Nessa perspectiva, são de grande importância as pesquisas que abordam os significados atribuídos pelos estudantes e o grau de dificuldade de aprendizagem de temáticas comumente ensinadas nessa disciplina. **Objetivo:** compreender os significados atribuídos pelos alunos do Curso Integrado de um Instituto Federal sobre a Química, assim como avaliar o grau de dificuldade atribuído por eles para as temáticas ensinadas. **Design:** pesquisa com métodos mistos e design convergente. **Ambiente e participantes:** participaram da pesquisa 90 alunos do 1º, 2º e 3º anos do Curso Integrado de Química de um Instituto Federal. **Coleta e análise de dados:** foram aplicados questionários sobre porque é bom e ruim estudar Química. Os estudantes pontuaram, também, sobre a dificuldade da aprendizagem de algumas temáticas ensinadas. **Resultados:** segundo os estudantes é bom estudar química por abordar assuntos do cotidiano e porque ajuda a conhecer o mundo. Os pontos negativos são a dificuldade e a complexidade das temáticas teóricas e o envolvimento de cálculos. **Conclusões:** as temáticas de difícil visualização ou aquelas nas quais a linguagem química não é contextualizada são as mais difíceis de aprender.

Palavras-Chave: Ensino de Química; Curso Integrado; percepções, contextualização.

INTRODUCTION

Scientific and technological advances, together with changes in society, have shown the potential of chemistry in promoting the development of humankind and have given rise to the need for teaching and learning processes focused on scientific knowledge and its repercussions on society. From this perspective, processes of reflection and discussion arise, such as the science-technology-society (STS) approach, essential for understanding the modern world, given the attention to social issues and citizenship education (Nascimento et al., 2021; Silva et al., 2019; Silva, Nunes & Dantas, 2021; Sousa & Ibiapina, 2021; Sousa & Nunes, 2021).

It is opportune to comment that the STS approach started from the social implications caused by the development of science and technology, such as wars and constant environmental degradation (Nascimento et al., 2021). The STS movement proved to be a valuable proposal for rethinking the political, economic, environmental, and other implications caused by scientific

productions and the use of artifacts from 1960 to 1970. Based on this proposal, education has changed to put forward a teaching model capable of preparing students for the challenges presented today. This model is proposed by the STS approach, which sees it as adequate to form the critical, active student, and, whenever possible, capable of transforming the environment in which they live (Fidelis & Carvalho, 2021; Silva, Nunes & Dantas, 2021).

In this perspective, it is essential to carry out studies that agree with the suggestion that chemical knowledge has the potential to broaden the student's understanding of nature and the technological processes that permeate society, something essential for the student to be able to make a new interpretation of the world around him. Therefore, the objective of this article is to know the meanings and difficulties students of an integrated chemistry course at a federal institute attribute to learning what they are taught in class, given the need to build contextualised and integrative educational practices of science and societal issues.

CHEMISTRY TEACHING

Official documents of national education, such as the National Education Guidelines and Framework Law (LDB) and the National Curriculum Parameters for High School (PCNEM), have curriculum proposals that include an integrated approach to scientific, technological, and social aspects. These documents consider relevant to promote the approximation of the student with knowledge and technological developments. The PCNEM provides for the care schools should take to not address chemical knowledge without contextualising it with the student's reality. The students must acquire knowledge that raises thoughts and attitudes aimed at critical participation and understanding of the problems of the environment in which they are inserted (Bouzon, Brandão, Santos, & Crispino, 2018; Brasil, 2011; Melo, Santos, & Araújo, 2020; Silva, Nunes, & Dantas, 2021).

The Nacional Common Core Curriculum (BNCC, 2018) ratifies that chemistry for high school is based on engaging students in learning scientific and technological processes, practices, and procedures in such a way that they can broaden their understanding of life, the planet, and the universe, and their ability to reflect, argue, propose solutions, and face personal and collective, local, and global challenges. They are part of the competencies and skills that must be developed in chemistry teaching, "representation, communication, investigation, understanding, and sociocultural contextualisation" (Brasil,

2018, p. 9). Nascimento et al. (2021) comment that the general competencies defined by the BNCC establish that education for life begins with the construction of the integration of human development with knowledge, considering the contextualisation and participation of students in educational processes.

The federal institute (FI), as a public education unit, has its pedagogical political project based on those official documents and on the curriculum guidelines of the Ministry of Education, which propose an education that interacts with technology, providing citizen and professional education consistent with social and labour demands. In this sense, the integrated curricula of the chemistry course at the FI propose that students study all the curriculum components of high school together with laboratory classes, through educational activities aimed at ensuring the integration between work, science, culture, and technology, with the use of selected themes and the interrelations between them, considering the curriculum organisation (Brasil, 2018; IFS, 2013).

Despite the new proposals for chemistry teaching, many high school students find it hard to appropriate concepts and do not feel motivated to learn the topics covered. They feel as if the language proposed by the subject is their first contact with scientific language. Moreover, when some themes are integrated with mathematics, they find it even harder to understand and apply knowledge in everyday life (Carvalho, Santos, Rodrigues & Melo, 2020; Fernandes, 2019; Silva et al., 2019).

In the classrooms, themes are often taught with traditional methodologies without much concern with the contextualisation proposed by the STS. In such practices, there are many theoretical and practical subjects of high complexity due to the level of abstraction they present, being little tangible, with a great distance between the themes taught and the students' daily lives. For students who master the knowledge of the Portuguese language subject and operations and mathematical concepts, learning the concepts of chemistry is easier, but for the vast majority, they are difficult to apply in their day-to-day (Klein & Lüdke, 2019; Melo, Santos & Araújo, 2020).

We observe that many intrinsic and extrinsic factors hinder chemistry learning. These factors may be associated with the cognitive load inherent to the themes, the teaching methodology used in the classroom, and other aspects. Classes are usually taught with a focus on theory, which often appears out of context with the students' reality, causing disinterest, demotivation, and difficulties in the learning process. It is a fact that the particular way of seeing

the world proposed by chemistry represents a scientific worldview that is difficult to understand. It is common for a high school student not to be very interested in studying and understanding the basic concepts of that curriculum component, which ends up making it difficult to abstract and acquire knowledge (Fidelis & Carvalho, 2021; Klein & Lüdke, 2019; Melo, Santos & Araújo, 2020).

Considering that the methodology used in the classroom, according to Silva, Farias, and Alves (2020) and Silva (2020), is still based on activities that excessively seek the memorisation of information, the learning ends up limited to solving activities the educator proposed, which may contribute to the student's demotivation with the subject. This method goes against the propositions of contextualisation and critical formation for citizenship, pedagogical trends proposed by STS education. Knowing the difficulty of some themes can mean an alternative to assist educators in creating their own resources and seeking new methodological conceptions to bring chemistry closer to the students' reality, making science palpable to them.

According to Fernandes (2019), an appreciation for the subject helps build significant pillars regarding how to conduct some activities in the school environment. The school environment comprises students with different levels of knowledge, personalities, and desires, and they usually expect much from the knowledge acquired through professional education.

METHODOLOGY

The study was conducted in a federal institute, with the participation of 90 students from the first, 2nd, and third years of an integrated chemistry course. We aimed to understand the students' difficulty with the themes and the meanings they attributed to studying chemistry. For data collection, we opted for the application of questionnaires whose script consisted of open questions: First, "Why is it good to study chemistry?" Second, "Why is it not good to study chemistry?" and a third question where the students had to mark the degree of difficulty of some themes, answering whether they were: "very easy; easy; neither easy nor difficult; difficult; very difficult". We investigated: the separation of mixtures, pure substances and mixtures, atomistics, the periodic table, chemical bonds, oxidation number, balancing, chemical functions, chemical reactions, and chemical and stoichiometric calculations, as they are common to the three classes. On the scheduled day, one of the researchers applied the questionnaires to the students during class.

The data obtained were organised in tables to help us understand the results. The answers to the open questions were grouped, forming categories, and the most representative ones were highlighted in the results composing a content analysis (Bardin, 2011). A portion of the results was analysed through the frequencies of answers dealing with the difficulty of learning specific themes. The fact that it integrates quantitative and qualitative components characterises the present investigative process as a research with mixed methods, carried out through a convergent design (Dal-Farra; Fetters, 2017).

Concerning ethical and legal aspects, this research was approved by the Research Ethics Committee with opinion n. CAAE 29849320.5.0000.5349.

RESULTS AND DISCUSSION

Initially, we characterised the study participants considering the variables of sex and age; of the total number of students, 65.5% were female. Most participants were aged 15-17, representing 70% of the total.

Next, we sought to know: Why is it good to study chemistry? The answers obtained were grouped into categories based on the presence of keywords found and the meanings of the expressions, aiming to build convergence between the answers. In Table 1, we organised the first-year students' answers. One student did not answer the question.

According to the information highlighted in Table 1, the most frequently cited argument is the answers that express the conceptual question and understanding of everyday phenomena, such as:

Because you can acquire knowledge (23.3%).

In the same line, some answers cite:

Because you can understand everything (20%);

To understand physical and chemical phenomena (13.3%);

Because it is interesting (13.3%);

Because you can learn about life (10%).

Table 1

Why studying chemistry is good – first-year students of the integrated chemistry course of the federal institute

Categories	Representative excerpts	N. of students
Because it is interesting	*-Interesting, because everything is chemistry;* *-Interesting to study the transformations and the "why" things happen.*	04 (13.3%)
Because you can understand everything	*-Understand everything;* *-Understand/understand the world;* *-All around us;*	06 (20%)
Understand physical and chemical phenomena	*-Understand physical and chemical phenomena;* *-Know about chemical elements.*	04 (13.3%)
It is part of our everyday life	*- They are part of our daily lives;* *- It is in our daily lives;* *- Is it present in our daily lives.*	03 (10%)
Because you can acquire knowledge	*- Knowledge;* *- Learn about matter, its structure, formation;* *-Structure of substances, composition, and properties of materials.*	07 (23.3%)
It is essential for human development	*-Human development.*	02 (6.7%)
Because you can learn about life	*-Learn about life* *-That is just life* *-Important in our lives.*	03 (10%)

These categories together account for almost 80% of the total answers obtained. A reduced number of students mentioned that it is good to study chemistry for personal development: "essential for human development (6.7%)".

The only answer that did not fit the highlighted aspects, as it was not included in any of the relevant categories for the analysis, is transcribed in full:

> *It's good to study chemistry because I studied it in the first year and it gives us a direction of what to choose in the future* (Student 16).

The predominant ideas of the students of the first integrated year of the FI show that they believe that studying chemistry is good, as the subject brings important knowledge. The students mentioned aspects such as understanding chemical and physical phenomena and elements, learning about matter, its structure, formation, substances, composition, properties and transformations, and understanding the reason for things. For some students, the subject is more interesting because it contributes to constructing scientific knowledge and knowledge of reality.

Gallon *et al.* (2018) studied the first notions of high-school first graders about the relevance they perceived in chemistry. They observed that when entering high school, the students have fragmented knowledge. They believe chemistry is a ready-made science that only needs to be better assimilated, which leads to a distorted view of this branch of knowledge if we consider the different aspects that contribute to the construction of a science.

In the study by Silva, Farias, and Alves (2020), high school students from a public school in the countryside of Rio Grande do Norte stated that they liked studying chemistry and were interested in the curriculum component for passing the entrance exam. Regarding how students perceived the subject, Galon et al. (2018, p. 08) found that the study participants think chemistry is essential for understanding everything. For these authors, such answers mean that students are not sure about chemistry as a science. Other answers obtained by Galon et al. (2018, p.08) on chemistry were about: matter that has coloured liquids that explode with mixed elements. The authors understood these answers as scarce attempts to bring chemistry closer to everyday life, with some students demonstrating that they knew few topics associated with the subject.

Unlike the results we obtained from the first-year students, Galon et al. (2018, p.09) got mainly references about the component that addresses "chemical reaction, table, chemical elements, such as to form bases and acids and transform elements" and "I see it as a subject that does several projects involving chemical elements". For those authors, it appears that the participants' knowledge was focused only on nomenclatures, loose terms, scarcely related to everyday life, and the association of the subject with everyday phenomena and facts.

Next, the first-year students were asked: Why is it not good to study chemistry? The answers obtained were grouped into categories based on the presence of keywords found in them. Table 2 organises the students' answers.

Table 2

Why it is not good to study chemistry – first-year students of the integrated chemistry course of the federal institute

Categories	Representative excerpts	N. of students
Because it has calculations	*- Complicated calculations;* *- The evil of chemistry is the calculations;* *- Difficulty with calculations;* *-It involves a lot of calculations.*	12 (40%)
I don't understand	*- I just don't understand sometimes.*	01 (3.3%)
I don't know	*- I don't know.*	02 (6.7%)
Enough content	*- Because it is a lot of content;* *- It is a lot to study.*	02 (6.7%)
It is complex	*- It is a very complex matter;* *- Due to its complexity;* *- Because it is a very complex subject.*	05 (16.7%)
I like it/It is not bad	*- It is good to study chemistry;* *-There is no bad side.*	08 (26.7%)

Information highlighted in Table 2 shows that the most frequently cited arguments were those that point to the presence of the term calculations (40%), followed by answers from students who stated:

I like it/it's not bad to study chemistry (26.7%).

It was also mentioned that it is:

Complex (16.7%).

Others replied:

Plenty of content (6.7%).

It appears that the answers obtained are, in part, similar to the results obtained by Fidelis and Carvalho (2021), Silva, Farias, and Alves (2020), Klein and Lüdke (2019) and Melo, Santos, and Araújo (2020). According to Gallon

et al. (2018), the reduced fondness of students for the subject was also associated with the presence of calculations. The authors believe students transfer their difficulties from one subject to the other. Silva, Farias, and Alves (2020) state that, among the subjects taught, both in elementary school and in the first grade of high school, chemistry is associated with abstraction and complexity.

It is opportune to comment that, even though considered difficult and complex, the students have a good relationship with chemistry in class. To almost 27% of the research participants, there is nothing bad about studying chemistry, finding no reason to dislike the subject. Silva, Farias, and Alves (2020) also found that the class generally agrees that they like to study the subject, i.e., it is difficult and complex, but they like the challenge.

Rodrigues et al. (2018), analysing data about chemistry collected from high school first-graders of a public school in the city of Belém-PA, found that 45% liked the subject, and 55% did not. Still, 77% of the participants also revealed having difficulty with the subject, whereas only 8% of the students gave examples of where they could perceive the chemical processes in their daily lives.

In Table 3, we organised the answers from the second-year students, considering arguments cited about why it is good to study chemistry.

As shown in Table 3, the second-year and first-year students' answers are quite similar. Most students like studying chemistry because it addresses day-to-day issues (30%). The answers indicate that students understand there is a relationship of chemistry with their daily lives, i.e., it can be applied in real life, it is complicated, but it is possible. These are the full answers:

> *It involves everyday life and makes us understand things that we think are complicated, but are actually easy* (Student 2),
>
> *It goes beyond the classroom* (Student 7),
>
> *It is gratifying to pick up a product that we use daily and understand whether it is good for us or not, or whether it is in good condition for use* (Student 9).

The students do not mention chemical concepts, but most understand how important the curriculum component is to explain everyday life transformations. Adding the percentages of the categories in common highlighted in the answers about everyday life and presence in everything, 43.3% of the total number of participants think that studying chemistry is good

because the themes are related to phenomena that occur in their real lives, as stated by a student:

> *About learning how the food and pharmaceutical industries work, things present in everyday life* (Student 15).

Table 3

Why it is good to study chemistry – first-year students of the integrated chemistry course of the federal institute

Categories	Representative excerpts	N. of students
Addresses everyday/day-to-day issues	*- It involves everyday life;* *- Our daily life, that is, chemistry goes beyond the classroom;* *- We use it in everyday life;*	09 (30%)
Laboratory classes	*-Experiences in the laboratory.*	02 (6.7%)
ENEM exams	*-The subject is present in many important assessments, like ENEM;* *-It helps pass entrance exams.*	02 (6.7%)
It is important for future profession	*-Future profession;* *-Grow professionally in this area.*	03 (10%)
It is present in everything	*- World around us* *-It is everywhere* *-It is present in everything;* *-See everything around you in a different way than before.*	04 (13.3%)
Because it is interesting	*- Because it is interesting;* *- It is interesting to see what mixing elements can do;* *-I find it very interesting* *-Subjects are interesting.*	04 (13.3%)
Different subjects instigate curiosity	*-Knowing "invisible" processes;* *-Different subjects.*	02 (6.7%)
Others	*-Because it is an important subject, bringing several contributions to science (Student 14).* *-Because, in addition to understanding a little about the origin of things, it is an extremely valuable subject for society (Student 24).* *-I am comfortable with the subject, and I like several scientists in the area (Student 27).*	04 (13.3%)

The data collected from the students of the second year demonstrate what Sousa and Ibiapina (2021) also found since students of the institution think chemistry is fundamental so that students can have citizenship formation and awareness of the phenomena around them. They did not specifically verbalise the expression "citizen formation", but in their speeches, we feel the themes are good because they are important for the formation in terms of life and daily life.

Gonçalves, Câmara, and Dal-Farra (2015) also obtained in the students' answers the perception of the importance of chemistry for society, technology, and the improvement of the quality of life. Secondary school students progressed in establishing relationships between chemistry and their life experiences, referring to improvement in their conceptions of chemical knowledge.

The chemistry teaching that promotes the education for citizenship must, from the acquisition, production, and reformulation of knowledge, allow the student to understand the chemical processes in everyday life, analyze the social effects of technologies belonging to chemistry, perceive the construction of scientific knowledge, and develop the ability to give a critical opinion (Sousa & Ibiapina, 2021, p. 211).

The mentions of laboratory classes (6.7%) show what Silva, Farias, and Alves (2020) discuss about the importance of practical classes in those environments, as they motivate students' interest in constructing knowledge. The citation of the ENEM tests (6.7%) and the future profession (10%) also bring motivations similar to those cited by Santana (2018) related to the greater focus on preparing the student only to face the entrance exam/ENEM. Sousa and Ibiapina (2021) state that it is not new that the entrance exam is seen as one of the main factors distorting educational practice.

In Table 4, the answers obtained from the second-year students of the integrated chemistry course of the FI are organised, considering the categories built on why it is not good to study chemistry.

Just like with the first-year students, we could see the difficulties that students have when using calculations:

> *Not that it's bad, because I like it, but in my opinion, the bad thing about chemistry is the calculations* (Student 14)

Because of the calculations, sometimes it makes me feel stupid (Student 9).

Questions related to the teachers' methodology and the difficulties inherent to the subject, such as the issue of terminology, were also mentioned. Silva et al. (2019, p. 2241) noted that the representations should be learned in context with the phenomenological and theoretical aspects to bring the chemical language closer to the common language. This is because it is difficult for the student to understand, without contextualising, hermetic subjects, typical of chemical science, which has symbologies and nomenclatures that are difficult to understand. Rote learning is not the way to learn; only those who can transcribe from Portuguese to chemical language can transcribe from chemical language to Portuguese.

Table 4

Why it is not good to study chemistry – 2nd-year students of the integrated chemistry course of the federal institute

Categories	*Representative excerpts*	N. of students
It involves calculation	*-Many moments involve calculation;* *- Difficulty with mathematics and calculations;* *-Difficult calculations.*	12 (40%)
Terminology	*-Know some nomenclatures by heart.*	02 (6.7%)
Teacher's methodology/didactic	*-Teachers scarcely encourage students.*	06 (20%)
Theoretical subject, many topics to memorise	*- The subject has too many issues;* *-Memorise the multiple concepts;* *-Very theoretical, microscopic, and there is no use of a laboratory.*	03 (10%)
Complex matters, not so easy to learn	*- Matter requires a lot of effort;* *-Some subjects are not so easy;* *- It is a very complex matter;* *- Completely new world, which makes it difficult to understand;*	06 (20%)
It does not have a bad side	*- It does not have a bad side.*	01 (3.3%)

There is an emphasis on the issue mentioned in relation to the teacher (20%). However, when analysing the speeches that mention the teachers, we must emphasise that this was the only class to have raised the issue. It is also essential to reflect that the teaching work is also mentioned as a positive aspect related to the students' liking the subject, i.e., the fact that they like chemistry, as demonstrated in the previous questions, has an intrinsic relationship with the teachers' work.

Campos et al. (2019, p.10) show that studies that describe students' conceptions of their relationship with school themes and teachers' work are necessary to awaken their critical and creative spirit, something that should always be happening and considered, as it is essential "to start listening to them, understanding their opinions and ideas better, and alerting educators about the need for contextualising the content better". Melo, Santos, and Araújo (2020) warn against discouraging classes that offer many subjects in a fragmented, abstract, and meaningless way. For Campos et al. (2019), the difficulty in assimilating chemistry themes, the lack of stimulation, and the creation of obstacles to learning may indeed be related to the way it is presented in the classroom. The following issues were also mentioned:

Complex matters, they are not so easy to learn (20%).

Theoretical subject, many topics to memorise (10%).

Such aspects had been cited by first-year students. A term found in some answers was the issue of nomenclature. According to Silva et al. (2019), when the student does not understand a topic, the educator is also responsible. As the authors indicate, although the BNCC recommends that educators approach chemical language, the issue remains undervalued or superficially addressed in classes. Although some first and second-year students have stated that chemistry does not have a bad side, it is necessary to reflect on how the teaching and learning of chemical symbology are taking place in high school (Silva et al., 2019, p. 2234). About the meanings of "because studying the subject is good" answered by the students in the third year of the integrated chemistry course of the FI, Table 5 presents the categories constructed with the answers.

As can be seen in the answers in Table 5, it seems the prevalence of the expressions:

"Chemistry allows us to know our daily life (23.3%)",

"Having knowledge, understanding the composition of things (20%)",

"Chemistry is in everything around us (13.3%)".

Table 5

Why it is good to study chemistry – third-year students of the integrated chemistry course of the federal institute

Categories	Representative excerpts	N. of students
It opens professional doors	*-Several professional areas, opening more job opportunities.*	02 (6.7%)
Understand the world	*-How the world around me works;* *-Understanding of the world, the subject, and the processes involved;*	05 (16.7%)
Chemistry is all around us	*-Because chemistry is in everything, ...among us;*	04 (13.3%)
Chemistry allows us to know our daily life	*-Notion of the things that are present in our daily lives,* *-Understand how many things in my day-to-day work;*	07 (23.3%)
It allows you to understand the phenomena around you	*- Greater clarity of the phenomena around us;* *-How different phenomena occur.*	05 (16.7%)
Having knowledge, understanding the composition of things	*-Dive into the world of knowledge and discovery;* *-Be a little more aware of what some things are composed of;* *-Knowledge of the formation and composition of various things;* *-To have better-developed knowledge due to the teacher's teaching.*	06 (20%)

These expressions above reinforce the meanings given by the analysed classes that it is good to study this subject because its themes allow them to be aware of the phenomena, transformations, and processes that happen daily in life and around the world.

They mentioned professional life, which the second-year students also cited. All the other answers pointed out the motivation to learn about everyday life, phenomena, transformations, and everything else about life. As discussed

above, these meanings demonstrate awareness of everyday events and discernment to understand the things that move the world. The last organised answers are from the third-year students about the meanings associated with the question: Why is studying chemistry not good? The answers were organised into categories that can be seen in Table 6.

Table 6

Why studying chemistry is not good – third-year students of the integrated chemistry course of the federal institute

Categories	Representative excerpts	N. of students
Complex/complicated matters	*-Subjects are very complex and require a lot of concentration and commitment;* *- There are a lot of details, specific concepts, formulas, etc.;* *-The subject is very complex and involves a lot of calculation.* *-For me, the discipline is very abstract, making the content difficult...there is a lack of applications in the "real world", which makes learning difficult. In addition, chemistry requires knowledge of mathematics and physics;* *-Contents are less understandable;* *-Complicated subject, I did not find a better argument;*	18 (60%)
Too many subjects/extension/recording contents	*- Because the chemistry is too dense;* *- There are many subjects during the year;* *- Its length, the nomenclatures (which are several and some are difficult) and the lack of basis in elementary education;* *- Record components.*	05 (16.7%)
There are no negative points	*-I do not find defects in this subject;* *-I cannot define a reason why I could say that it is not good to study chemistry;* *-No negative points.*	4 (13.3%)
Difficult and confusing matters	*-If the class is not well taught, it becomes very confusing;*	2 (6.7%)

- It seems confusing.

The expressions show that these and the other students like to learn the themes because they allow them to know about phenomena and transformations of everyday life; however, they find problems because there are complex and complicated topics and because there is much to study.

It appears that, together, these highlighted terms add up to 76.7% of the answers. Considering the meanings of all research participants, we understand that there are problems related to grasping some theoretical subjects in chemistry, considering that expressions linked to difficulty and complexity predominate, making the study and learning of some themes an experience which is partly not good.

Bouzon et al. (2018) explain that this meaning of high school students is caused by the merely propaedeutic way in which some themes of this subject are being taught to students, without a context and in a fragmented way, something that makes it difficult for them to understand the application in everyday life. According to Silva et al. (2019), even though it is a requirement of the BNCC, the chemical language is still being superficially addressed in the classroom. The students need more and better explanations to understand the concepts through the representations that chemistry uses. It is necessary to make the student understand that the structural formulas, equations, graphs, and figures common to this subject are idealised models to explain things in the world; it is the way chemistry "talks".

Considering the meanings based on the two questions asked to the research participants, we understand that, usually, students can see foundation and applicability in what they learn during chemistry classes, so much so that some subjects can be related to everyday life. They can identify some chemical transformations in everyday life and feel encouraged to learn the subject, as it allows them to understand what surrounds them. What was not evident was the study participants' knowledge about understanding the chemical language. However, with regard to the articulation between science and society, they have been able to understand.

Sousa and Ibiapina (2021) also obtained that 51% of the FI students who participated in their study affirmed they study chemistry because it is part of the subjects that contribute to their education as citizens. Nevertheless, they also indicated the need for greater contextualisation, as they do not understand

all the topics; just as in other high school institutions, the themes are difficult to understand.

The students of the integrated chemistry course of the FI participating in this research also answered about the difficulty of some themes that are part of the curricular matrix of the chemistry course. The respondents were asked to score the degree of difficulty in learning with grades 1 to 5: separation of mixtures, pure substances and mixtures, atomistics, periodic table, chemical bonds, oxidation number, balancing, chemical functions, chemical reactions, and chemical and stoichiometric calculations. The levels were: very easy, easy, neither easy nor difficult, difficult, and very difficult. The data obtained were organised in Table 7, which brings the opinion of all the students participating in the study.

Data from Table 7 show that, among the topics surveyed, separation of mixtures was presented as being very easy or easy to learn (91%); pure and mixed substances (74%), periodic table (51%) and oxidation number (42%) were considered easy to learn. In the students' opinion, the tough topics were: chemical bonds (44%); atomistic (52%); balancing (58%); chemical functions (51%); chemical reactions (49%), and chemical and stoichiometric calculations, scored as difficult or very difficult (87%). Those answers reinforce what makes studying chemistry challenging, i.e., what attracts and motivates learning. As stated by the study participants, subjects that adopt nomenclatures, calculations, and formulas are the most difficult and complex to understand and to be contextualised with the student's daily life.

Integrating quantitative and qualitative data, as advocated in research with mixed methods (Dal-Farra; Fetters, 2017), the issue of calculations is reinforced as a challenge for learning chemistry from the students' perspective, with spontaneous mentions of 40% by first and second-year students. The third-year students mentioned that studying chemistry is not good because it was "complex" or "complicated", although the issue of calculations was also cited.

The students also mentioned, in the qualitative answers, that it is not good to study chemistry when the themes are difficult to "visualise", as one of the students said:

> *It is too theoretical, microscopic, and the laboratory is not used.*

Table 7

The difficulty of each topic according to students of the first, second, and third years of the integrated chemistry course of the federal institute

Topic	Very easy	Easy	Neither easy nor difficult	Difficult	Very difficult
Separation of Mixtures	43%	48%	9%	0	0
Pure Substances and Mixtures	11%	74%	9%	6%	0
Atomistic	10%	28%	10%	52%	0
Periodic table of elements	16%	51%	10%	19%	4%
Chemical bonds	5%	28%	10%	44%	13%
Oxidation number	14%	42%	12%	24%	8%
Balancing	7%	13%	10%	58%	12%
Chemical functions	0	19%	11%	51%	19%
Chemical reactions	10%	19%	13%	49%	9%
Chemical and stoichiometric calculations	0	8%	5%	46%	41%

This result is corroborated by the quantitative component in which 52% of the students stated that studying atomistics is difficult. We also note, with an integrated look at the data collected in general, that themes that are in principle more "palpable", that are "easier to visualise", such as the separation of mixtures and pure substances and mixtures, are considered easier to learn.

As Bouzon et al. (2018) and Fidelis and Carvalho (2021) state, the unusual way chemistry explains things in the world differs much from what students are used to understanding and using. Therefore, making the student understand and use the language of chemistry when approaching their reality is a very complex process. The solution to this problem, as observed by Bouzon

et al. (2018), is the focus of chemistry teaching in STS education, an approach that guides the teaching and learning processes of this subject beyond the school walls, thus promoting the critical formation of the individual. Finger and Bedin (2019) propose contextualising chemistry teaching and learning to qualify and improve the educational process. This action can help students perceive chemistry in their clothes, food, and everyday products in general, awakening this knowledge and, in a positive way, intervening in their social environment.

According to results obtained by Klein and Lüdke (2019), students accept the subject well and feel encouraged to learn; however, the complexity of the subject associated with various factors such as teaching methodology, deficiencies related to other subjects, such as Portuguese and mathematics, content, and language comprehension deficiency hinder teaching and learning.

Campos et al. (2019) reveal the increasing need for studies describing students' conceptions about their relationship with school themes and teachers' work. In this way, teachers can awaken their students' critical and creative spirits; they cannot ignore their world/reality. Therefore, it is paramount to start listening to the students to know their opinions and ideas better. From this perspective, identifying the complexity of the most difficult themes contributes to searching for new contextualised chemical language methodologies capable of bringing complex subjects closer to the students' reality.

CONCLUSION

The purpose of this study was to know the meanings the students of an integrated course of a federal institute attribute to the chemistry curriculum component. When asked why studying the subject is good, the predominant answers were linked to understanding the transformations and explanations of phenomena that are part of everyday life and knowing the world and the composition of everything. We also verified that the students considered, in general, that studying the separation of mixtures, pure and mixed substances, periodic table, and oxidation numbers was "very easy" or "easy".

When questioned about why studying chemistry was not good, the students related little understanding of theoretical themes considered more complex or more complicated. The answers also point out that themes involving calculations are the most difficult to understand.

For the research participants, the topics considered "difficult to learn" were chemical bonds, atomistics, balancing, chemical functions, chemical

reactions, and chemical and stoichiometric calculations. This last theme was considered “difficult” or “very difficult” by almost all students, a quantitative result that corroborates the aforementioned qualitative result of spontaneous mentions regarding difficulties with mathematical processes. Furthermore, the students find it more complicated to understand themes that cannot be visualised.

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AUTHORSHIP CONTRIBUTION STATEMENT

ALSS carried out the field research, data analysis and text writing, and RADF guided the field research and contributed to data analysis and text writing.

DATA SHARING STATEMENT

The data supporting the results of this study will be made available by the corresponding author (ALSS) upon reasonable request.

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