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STATISTICAL MODELING FOR ANALYSIS OF SCIENTIFIC CULTURE ELEMENTS IN INCOMING STUDENTS OF BRAZILIAN UNIVERSITIES MODERATION MODELS

A modelagem estatística na análise de elementos da cultura científica de estudantes ingressantes em universidades brasileiras: modelos de moderação

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Abstract

Public Understanding of Science and Technology (S&T) researches highlights what the population knows, understands and practices about Science, and provides indicators that assist public policies education and S&T. In this work, we develop a quantitative study based on a theoretical model and previously validated instruments with a goal of carrying out an investigation into the conception of the students about S&T. 317 incoming students participated in the research in natural science courses of a Brazilian public university. The statistical treatment responses' is due in two stages: the first consists in dimensional reduction using principal component analysis (PCA), index construction and internal consistency assessment (Cronbach's alpha); The second we execute some bivariate and multivariate dependency tests through of linear regression and correlation, as well as an analysis of the effect of moderation. Among the results, we note a positive correlation between interest and information in S&T, dependence of self-efficacy in relation to science classrooms, as well as the influence of moderating science classrooms in the relationship between interest and information in S&T. We emphasize the use of statistical modeling as potential for other social groups in order to build standard indicators of Public Understanding of Science.

Keywords: Public Understanding of Science; Multivariate Analysis; Scientific Culture and School; Moderation Models; Indicators.

Resumo

As pesquisas de percepção da ciência e tecnologia (C&T) destacam o que a população conhece, entende e pratica sobre Ciência e fornecem indicadores que auxiliam na proposição e avaliação de políticas públicas em educação e C&T. Neste trabalho, desenvolvemos um estudo quantitativo com base em um modelo teórico e instrumentos previamente validados, com o objetivo de realizar uma investigação sobre a concepção de estudantes acerca de C&T. Participaram dessa pesquisa 317 estudantes ingressantes nos cursos da área de Ciências da Natureza de uma universidade pública brasileira. O tratamento estatístico das respostas se deu em duas etapas: a primeira consistiu na redução dimensional e construção de índices usando a análise de componentes principais e avaliação da consistência interna (alpha de Cronbach); na segunda, realizamos testes de dependência bivariadas e multivariadas por meio de regressão linear e correlação, além de análise de efeito de moderação. Dentre os resultados, salientamos que houve correlação positiva entre interesse e informação em C&T, dependência da autoeficácia em relação às aulas de Ciências, bem como a influência da moderadora aulas de ciência na relação entre interesse e informação em C&T. Ressaltamos a potencialidade de utilizar a modelagem estatística para estudo de outros grupos sociais a fim de construir indicadores estáveis de Percepção Pública da Ciência.

Palavras-Chave: Percepção Pública da Ciência; Análise Multivariada; Cultura científica e escola; Modelo de Moderação; Indicadores.

INTRODUCTION

Public Understanding of Science' researches allow us to understand what the population knows, understands and practices about Science, and is of utmost importance to understand how the impact of its production is viewed by society. Furthermore, in order to propose public policies that meet the needs of the population, it is necessary to know the attitudes and opinions about the relationship between science and society (Castelfranchi, Vilela, Lima, Moreira, & Massarani, 2013).

Research such as ROSE (The Relevance of Science Education), PISA (Program for International Student Assessment) and the Public Understanding of Science conducted in Brazil by CGEE (Center for Strategic Studies and Management) seeks to provide indicators that can be used to support public policies, with the aim of spreading science widely, knowing the motivations of students and their performance in large-scale evaluations (Schreiner & Sjoberg, 2004; OCDE, 2018; CGEE, 2019). These indicators can serve as evaluators of these policies, and also allow for cross-country comparisons and longitudinal analyses. In research such as ROSE and PISA, which are student-specific, aspects that can contribute to curricular evaluation and reformulation are also highlighted, since they contain questions that involve the subjects students are interested in studying, perceptions about science and technology (S&T) and the environment, and proficiency in skills such as reading, math and science, etc.

In this context, it is important to analyze the students who enter the universities, since Higher Education is an essential formative stage for professionals in various areas, who deal with decision-making that involves the relationships contained in the relations between Science, Technology and Society (STS), in addition to the training of human resources and the making of science-based opinions. We believe it is necessary to know the conceptions about S&T of these students who have just entered university, including those who will undergo undergraduate training and will teach in the future.

It is necessary to have a brief discussion about the terms *perception* and *conception*, since there are multiple definitions. From the studies of Vygotsky's Cultural-Historical Theory, we understand that perception considers different elements and is part of a "*complete and integrated and not only perceptual thought process*" (Cunha & Giordan, 2012, p.115). Even so, perception is something simple, which does not indicate that the individual reasons by means of generalizations and abstractions, which characterize the concept. In adolescence, we have what Vygotsky (2001) defines as a transitional phase, which indicates that more simplified thoughts (syncretic or by complexes) are replaced by the formation of abstract and rational concepts, which do not require experience.

> *"This means that, in order to work at the abstract plane, formulations of concepts are necessary, understood as a complex, dynamic, and interfunctional act, constructed through the individual's performance and insertion in culture, mediated by relations with other people. In this sociocultural environment, the individual appropriates knowledge through formal and non-formal learning that promotes aids for the construction of scientific and everyday concepts" (Fonseca-Janes & Lima, 2013, p.229).*

In this way, conception would be a thinking that includes the formulation of concepts, that is, of greater complexity than perception. Our understanding is that this choice of terminology use (conception/perception) should consider the interviewed audience which, in our case, is made up of students who have just entered university, indicating that they are capable of appropriating concepts through formal and non-formal means of learning. Thus, we consider that conception refers to more elaborate thinking, and is an appropriate term for our audience, with a completed basic level of education. Since we are dealing with general population surveys, the term perception is broader and will be kept when referring to the research instruments and investigations of the area.

Based on the need to develop studies to understand what students think about science and technology, comparing it with other aspects of their personal and school life, we propose an investigation of the freshmen students' conception of S&T through a questionnaire, grouping the similar variables using Principal Component Analysis (PCA), to build indexes that can correlate the students' conception of S&T and statistically evaluate the theoretical models built from the correlations between the indexes obtained in the previous step.

The following specific objectives of this work are thus unfolded: Adapt a theoretical model based on discussions around conceptions of S&T, information habits on S&T topics, experiences with science classes, and sociocultural relations; build a statistical model from dimensional reduction of the constructs, using PCA and techniques for building new composite variables; analyze the level of interest and information in S&T and the conceptions of university freshmen about science classes, as well as self-efficacy in scientific knowledge; verify whether science classes influenced the relationship between interest and information about S&T, using the statistical technique of moderation.

THEORETICAL BACKGROUND

Since the Second World War, science and technology have begun to play an increasingly predominant role in the economy, politics, society, public affairs, and personal life. Virtually every sphere of social life in general is influenced by S&T, such as the discussion about environmental pollution and climate change, as well as the disputes between countries over the generation and disposal of pollutants from industrialization.

At the same time, complex and profound relationships were being established between knowledge production, technology, economics, and politics. The forms of appropriation of scientific knowledge, intellectual property rules, and processes of public participation have undergone transformations, together with the relationships between production, circulation, communication, and conduction of scientific knowledge. Technological innovations confronted democracies with controversial and highly complex issues, involving the knowledge of experts who were not directly active in politics, but who were consulted for government decision-making. (Polino & Castelfranchi, 2015).

Along with this, in the post-war context, there were debates in the social spheres that questioned the alleged scientific neutrality. One of these movements was the Frankfurt School's Critical Theory of Society, when in the book Dialectic of Enlightenment, written in 1944 by Adorno and Horkheimer during exile in the United States of America (USA), they made several criticisms of technical rationality, positivism, and the construction of scientific knowledge that followed the interests of the ruling class. Later on, we highlight the release of books such as Rachel Carson's Silent Spring, considered one of the milestones of the beginning of the STS movement. In general, these books represent the thinking of social movements of the time that questioned the directions of science in relation to problems such as food scarcity and the use of pesticides, the space race, its contribution to military development, and its development aligned with the interests of capital.

It was in this tension between the interests of science and organized social groups that discussions about the Public Understanding of Science began. In the mid-1950s, the US established the National Science Foundation, with the aim of advancing discussions in the field of scientific progress. Research on Public Understanding in that country emerged in 1973 with the General Social Survey (GSS), which conducts basic scientific surveys on the structure and development of American society, monitoring social changes within the country. This survey contains a standard set of demographic, behavioral, and attitudinal questions, as well as topics of special interest, with many remaining unchanged in order to facilitate longitudinal studies as well as replication of previous findings (NORC, 2016).

In addition to the GSS, other US surveys have been created, such as the Survey of Public Attitudes Toward and Understanding of Science and Technology which collected and evaluated during the period from 1979 to 2001 topics such as sources of information, interest, visits to museums and science outreach centers, general attitudes, attitudes toward government spending on education, science, mathematics, and animal research (NSB, 2018). The Various Ongoing Surveys, organized by the Gallup Institute, applied surveys between 1982 and 2013, including questions about federal priorities, public attitudes towards environmental protection, climate change, nuclear power, alternative energy, animal research, stem cell research, and the quality of science and mathematics education in US public schools. The Pew Research Center has conducted polls on attitudes toward the news media and media credibility (1985-2012); information sources, internet use, attitudes toward national policy on climate change and energy, the environment, and attitudes toward government spending on scientific research (2008-2013); public beliefs about S&T, issues, and benefits of science for societal well-being (2009) (NSB, 2018).

The European countries began to stand out in the studies on S&T perception from the project called Eurobarometer. In 1972, the first data was collected, and after two years the results were published. The initial intention of the survey, which is still conducted annually, was to track the evolution of public opinion in countries of the current European Union, assisting their respective parliaments in making decisions about the direction of S&T. The survey has different fronts and seeks, in general, to measure the level of satisfaction of citizens with regard to all aspects of their lives, specifically involving topics such as agriculture, nature protection, and scientific research (European Commission, 2008). Although this project is of a general nature, some specific public perception surveys of S&T have been produced, such as the Special Eurobarometer version 340: Science and Technology, aimed at assessing the general attitudes of European citizens towards science and technology, as well as the interest and level of information on S&T, the image and knowledge of science and technology, attitudes towards science and technology, the responsibilities of scientists and politicians, the role of women and young people in scientific studies, and the effectiveness of European scientific research (European Commission, 2011).

In Latin America, the application of surveys on public perception of S&T began in 1987 in Brazil, with funding from the National Council for Scientific and Technological Development (CNPq) in partnership with the Gallup Institute, which among other questions concluded that 70% of surveyed Brazilians living in urban areas are interested in science and technology (CNPQ & Gallup, 1987). This type of study was not conducted again until 2006, with the Ministry of Science and Technology being responsible for this and subsequent studies (2010, 2015, and 2019). These surveys investigated topics such as cultural habits, familiarity with Brazilian science, their degree of knowledge appropriation, interest, and attitudes about S&T, as well as their access to information about S&T (CGEE, 2019).

Still on the perception studies on S&T developed in Latin America, we can highlight Mexico, which conducted 11 surveys, the first one in 1997 and every two years since 2001. Other Latin American countries have also initiated such research, such as Colombia (1994), Argentina (2003), Ecuador (2006), Chile (2007), Venezuela (2007), Uruguay (2008), and Paraguay (2015) (Polino & Garcia Rodríguez, 2015).

In the case of Brazilian studies, when evaluating the historical series, the interest of Brazilians in topics such as medicine and health, environment, science and technology stands out. Despite the great interest, a decrease in the cultural habits index was observed, that is, the number of declarants who indicated that they had visited a science and technology museum dropped by half in 2019. Moreover, consistent with low access to information about S&T and low participation in cultural outreach activities, the fraction of Brazilians who were able to mention the name of a scientist from the country and a Brazilian institution that conducts research remains low (CGEE, 2019).

These data are a counterpoint to the hypothesis that the acceptance of technologies or the perception of their risks are related to the level of education or information declared or accessed by people on the subject. In the work of Castelfranchi and colleagues (2013), one can see through the evaluation of data from CGEE, that individuals with scarce information have, in general, positive attitudes. Whereas people with more education and access to information have diversified attitudes, optimistic about some aspects, but more critical about others.

The surveys mentioned so far had as audience the population over 18 years old, seeking demographic as well as ethnic, social class, profession, age, and region representativeness. In analyzing large-scale surveys aimed at the audience of our research interests - higher education students - we find surveys that aim to understand and evaluate both their scientific knowledge and their motivations, topics of interest, experiences, perceptions about S&T and the environment, among others. An important project was ROSE, coordinated in Norway and developed in approximately 40 countries for students aged 15, between 2002 and 2006, and in Brazil the instrument was adapted and applied to 652 students in two cities (Tolentino-Neto, 2008). Due to sampling issues, this survey does not bring representative results for the whole of Brazil, but promotes reflections on the opinions of students in different contexts.

One of the main goals of the ROSE project is, based on empirical data, to promote theoretical discussions about priorities and alternatives regarding S&T content in order to promote the relevance, attractiveness, and quality of S&T education, meeting the hopes and aspirations of young people. The questionnaire consists mostly of questions about experiences already done or that they are interested in furthering, conceptions about S&T and the environment, empathy about science classes, etc. Most of the work resulting from the ROSE project has analyzed the difference between gender, age and countries by grouping variables or item by item (Sarjou, Soltani, Afsaneh, & Mahmoudi, 2012; Cavas, Cavas, Tekkaya, Cakiroglu, & Kesercioglu et, 2009; Jidesjö, Oscarsson, Karlsson, & Strömdahl, 2009; Lavonen, Byman, Uitto, Juuti, &

Meisalo, 2008; Tolentino-Neto, 2008; Vasquez & Manassero, 2008; Schreiner & Sjøberg, 2004).

On the subject of my science classes, the article by Jidesjö *et al.* (2009) presented results from a survey of 751 high school students in Sweden and made comparisons between gender and choice of specificity at that level of education: "*health and care (14% of those surveyed); industry, construction and engineering (13%); social sciences, arts and communication (35%); and science and technology (27%)*" *(Jidesjö et al., 2009, p. 217, free translation).* Only students in the fourth group (science and technology) agree with most of the statements about science classes. The means were analyzed item by item and significant differences were found between the prospective S&T students and the other groups, except for the statement *Science school taught me to take better care of my health*, which showed no significant difference. Students in the first three groups provided means below 2 for many affirmations (at the agreement level, for a 4-point scale), such as the affirmation about work – *school Science has opened my eyes to new and exciting jobs* – and the one about liking Science – *I like school Science more than most other subjects.*

Another important program aimed at evaluating the educational system is PISA (Program for International Student Assessment), which is considered the main international exam in education. It measures, every three years, the performance of students between 15 and 16 years old who are at the end of the basic education cycle, from 79 countries, 37 of which are members of the OECD (Organization for Economic Cooperation and Development) and 42 partner countries. PISA aims to assess whether these students are able to understand a text, formulate, use and interpret mathematical knowledge in different contexts, and understand scientific concepts, data, and phenomena. In addition to questions related to knowledge in areas such as reading, math and science, PISA collects socioeconomic and cultural information, such as age, mother's level of education, items in the home with a focus on studying (e.g., desk, own study place, computer, and educational software and books), parents' employment, among others (OECD, 2019), which allows correlation studies to be conducted between constructs of different dimensions.

PISA also has an index associated with students' perception of their ability to perform specific tasks in particular contexts that require skills acquired mainly in science classes, which is referred to in official reports as *self-efficacy in Science* (OCDE, 2015). This term is discussed by Bandura (1997), who proposes that "*self-efficacy theory acknowledges the diversity of human capabilities. Thus, it treats the efficacy belief system not as an omnibus trait but as a differentiated set of self-beliefs linked to different realms of functioning*" (Bandura, 1997, p.36). The author complements this affirmation by indicating that better performance in science has as a result high levels of self-efficacy and, on the other hand, students who have low self-efficacy tend to have low performance in this area of education. This was observed in the official PISA report (OECD, 2015) for students in all countries except the Dominican Republic (which has a negative correlation between performance and self-efficacy) and Algeria (whose variation in average performance among students in that country was irrelevant). The index referring to self-efficacy was obtained from eight questions, whose students indicated their level of ease in performing certain tasks, such as, for example: *describe the role of antibiotics in treating disease, identify two explanations for the formation of acid rain, and interpret scientific information on food labels.* Brazilian students generally have an easier time recognizing the science issue involved in a news report about a health problem, and a harder time *discussing how new evidence might lead them to change their understanding about the possibility of life on Mars.*

The contents investigated in this block of questions deal with themes widely discussed in the media, in addition to being interdisciplinary or transversal contents of the school syllabus. Topics such as these have the potential to combine the scientific content of the classroom with social aspects and their dissemination in the media, and to introduce the student to discussions about how science works and the role of the scientist. In this aspect, through the teacher's mediation, the[1] student is introduced to the scientific culture, privileging the formation of his or her criticality and values through the discussion of socio-scientific issues, for example. A theoretical model that can collaborate with this understanding and discuss the teacher's role in promoting scientific culture has been proposed by Lima (2016), shown in Figure 1.

[1] Here we deal with mediation according to Vygostski's Sociocultural Theory (2000), which is not related to the statistical model of mediation, which will be presented next.

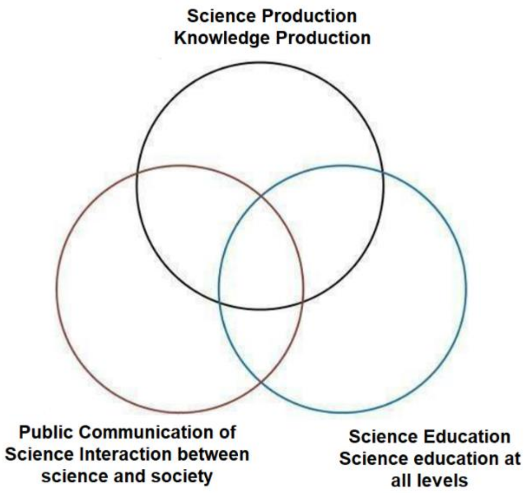

Figure 1 - Model of Scientific Culture practices. Source: Lima (2016).

The model of interaction of scientific culture practices, proposed by Lima (2016), suggests that most of the activities that constitute Scientific Culture occur permeating three correlated spheres: the production of knowledge arising from scientific production, the public communication that arises from the interaction between society and science, and finally science education, related to science teaching at all levels. Lima (2016) states that scientific culture, as a product of human activity, is not restricted to itself, but suffers influences and impositions from other spheres of ideological creation, such as art, popular knowledge, religion, the cultural industry, among others. It is also necessary to consider this plurality of contexts in a dialectical relationship with scientific culture.

Thus, we agree with the Scientific Culture model addressed by Lima (2016) and believe that the formation of S&T conceptions by students occurs within the general scope of Scientific Culture, being influenced by the spheres mentioned above. From this point of view, we understand that there is an intersection from different points of view that contribute to the formation of students, that is, the relationship is neither direct nor linear. Therefore, we justify in a theoretical way the importance of statistical modeling, because it is not trivial to understand the correlations of complex data and constructs without considering the multiple relationships that compose them.

The work of Bertoldo (2019) proposes a theoretical model that aims to analyze the S&T conceptions of students of some undergraduate courses of a Brazilian public university. The model was built from assumptions of Critical Theory of Society (Adorno & Horkheimer, 1985) related to research on the Public Understanding of Science (PISA, ROSE and MCTI), teacher training (Redefor), Brazil Economic Classification Criterion (ABEP, 2015) and digital literacy, based on Hargittai (2008) and Hargittai & Hsieh (2012) and proposes relationships with aspects of the formation of conceptions in the classroom. This model served as the basis for testing our hypotheses and is available in Figure 2.

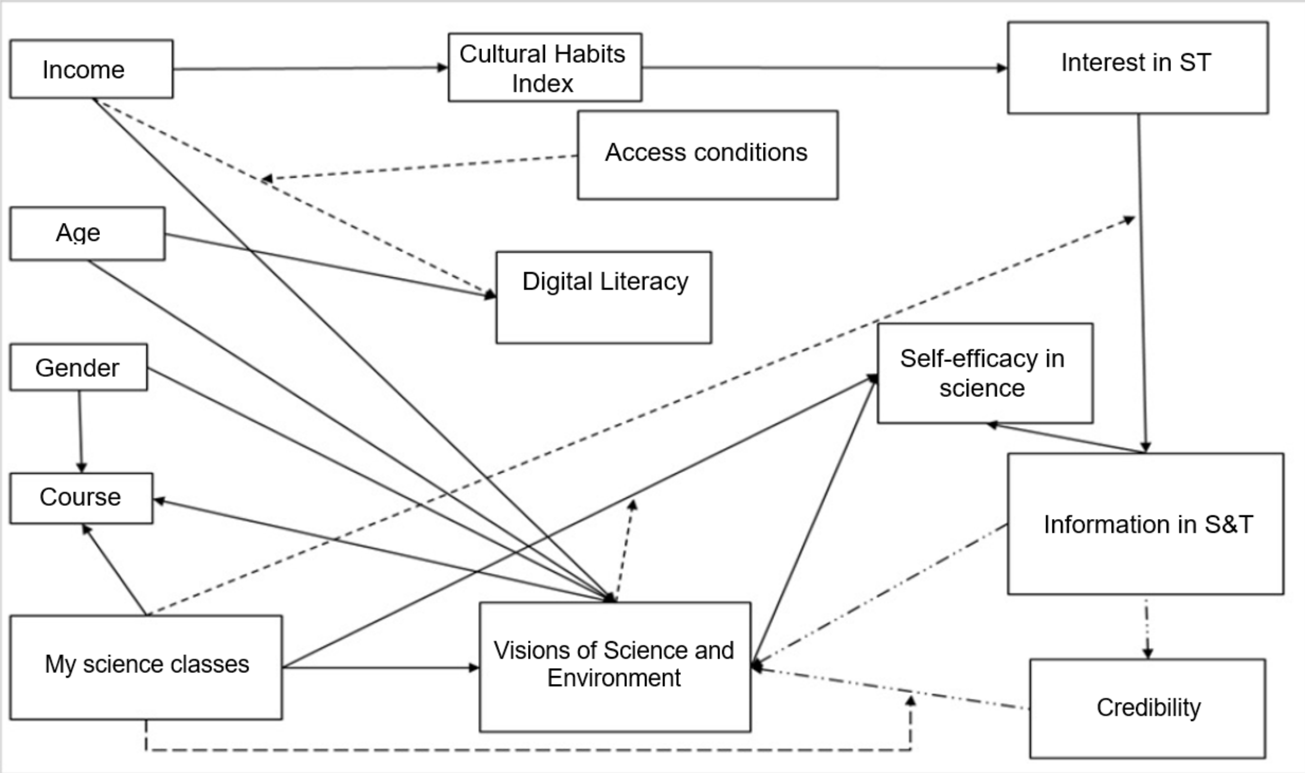

Figure 2 - Theoretical model built by Bertoldo (2019, p. 77). The direct relations (DV and IV) are represented by arrows with solid strokes, the moderation relations are indicated by dashed arrows, and the mediation relation is expressed by the dash and dot (model in the lower right corner).

Each of these relationships has been tested as proposed in the model, however in this paper we will present only a few relationships, which we call submodels. Thus, we present in Figure 3 part of the above model, indicating only the submodels presented in this article, which indicate the relationships between topics such as *interest in S&T, information in S&T, self-efficacy in science knowledge, and my science classes.*

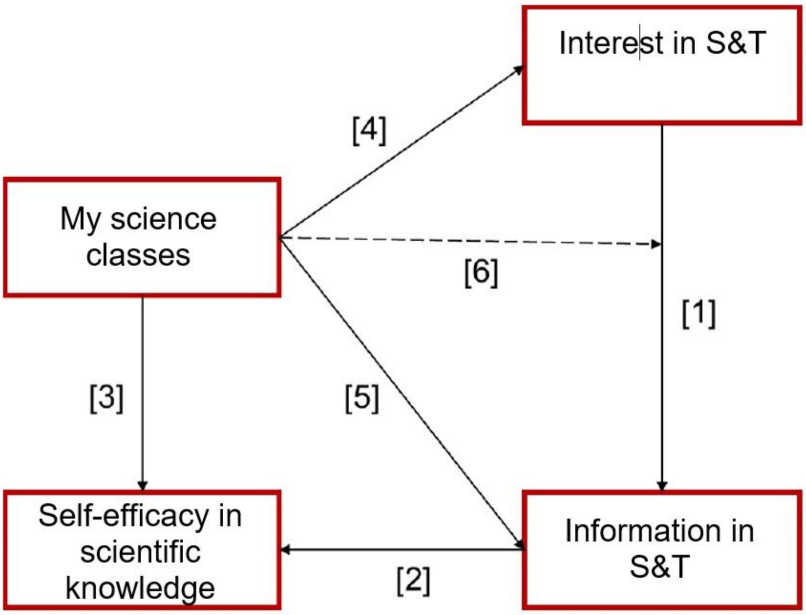

Figure 3 - Theoretical model proposed to analyze conceptions of S&T.

From the model presented above, we can investigate the following relationships: 1 - between how *interested and informed* students are about S&T topics; 2 - whether how *informed* they are has a direct relationship with *self-efficacy* in answering S&T; 3 – whether *science classes* have a relationship on *self-reported efficacy in scientific knowledge*; whether *science classes* influence 4 – *interest in S&T*; 5 – *information in S&T*; 6 – the relationship between *interest and information in S&T.* By means of statistical analysis, which will be described next, we will verify if these relationships are in line with hypotheses to be tested and if they are in accordance with our theoretical model.

METHODOLOGY

In this article, we will present the research methodology in two stages: in the first we describe the data collection and systematization, while in the second we deal with the data analysis strategy. In the latter, we present the data dimensionality reduction technique from the Principal Component Analysis (PCA), which generates indexes for building the statistical model for subsequent statistical analysis of the relationships indicated by the theoretical model, including moderation models, which will be presented at the end of the second stage.

Data collection

The audience adhering to this research were freshmen students from a Brazilian public university, who chose one of the following courses: Environmental Sciences, Biological Sciences, Sciences, Chemical Engineering, Pharmacy, Chemistry - BSc, and Industrial Chemistry.

Data was collected using the validated instrument of Bertoldo (2019), organized from 24 multiple choice or Likert-type scale questions[2]. Next is the general structure and the origin of the questions used in the poll divided into ten sections, whose complete questionnaire can be found as supplementary material to this article:

1 - *Candidate identification.*

2 - Candidate's personal information, containing three questions including age, gender and course;

3 - Attitudes and Views on S&T and the environment: includes five questions on benefits and harms of S&T for mankind, statements involving their views on ethics, perspectives and public participation, conception about the direction of science. These assertions were taken from the MCTI and ROSE [3]questionnaires. In this block, there are also questions about the concern with environmental issues highlighted in the debates in society (such as global warming and deforestation in the Amazon), from the MCTI questionnaire, as well as the vision of the respondent regarding the collective and the solution of environmental problems (ROSE questionnaire).

4 - My science classes and self-efficacy: includes two blocks of assertions, the first of which, from the ROSE questionnaire, deals with conceptions about the science that the respondent learned in school. The second block, taken from the PISA questionnaire, proposes a self-analysis of students' ability to perform specific tasks in contexts that require science skills.

5 - Interest and information on S&T: in this section, adapted from the MCTI questionnaire, there are four questions that address the degree and level of interest and information of the respondent regarding subjects such as medicine and health, environment, S&T, politics, religion, art and culture, sports, fashion, and economy. It also asks about the frequency and means that the student uses when searching for information about S&T.

6 - Digital literacy: a question that aimed to evaluate the respondent's familiarity with internet and web terms and concepts. The questions about digital literacy were built on research already conducted and presented in Hargittai (2008) and Hargittai & Hsieh (2012).

7 - Digital media access habit: two questions about the frequency of performing different activities such as listening to music, radio, podcast, reading and writing using digital media, accessing social networks, watching videos on streaming platforms, among others. These questions were taken from the surveys applied by the research group to teachers in continuous training in the area of science teaching in the São Paulo Teacher

[2] Scale that expresses the degree of agreement or levels to which a behavior suggested in a statement fits.
[3] In the survey production, the questions from ROSE and PISA were translated into Brazilian Portuguese.

Training Network - Redefor (Paulo, 2016).

8 - Socioeconomic profile: the respondent answers questions that include items of comfort in the family residence, level of education of the head of the household, and whether there is piped water and paved roads in the residence. The sociocultural questions are composed by the Brazil Economic Classification Criterion 2015 (developed by the Brazilian Association of Research Companies - ABEP).

9 - Credibility in S&T: section joining two questions, adapted from the MCTI questionnaire, that inquire about the degree of trust the respondents have in the media for S&T research and in professionals as a source of information.

10 - Cultural habits: a question about the frequency of participation in visiting places or public events such as a science fair, art museum, botanical garden, among others. The questions were adapted from the MCTI questionnaire and the polls applied in the Redefor project.

The questionnaires were given to the students together with an Informed Consent Form (ICF), in which they were informed of the research objectives, as well as the procedures to which they would be subjected, their risks and benefits. The average response time for the questionnaires was 60 minutes. The responses from the data collection instrument were gathered and organized in a matrix, with 317 rows (total respondents) and 205 columns (assertions). Each student was identified with a number to ensure confidentiality in the survey. Data plotting and analyses were performed with the aid of IBM® SPSS® Statistics software (version 20). For this article, we will use the students' answers from 49 assertions, referring to the six questions in the questionnaire.

Data analysis

In the data analysis, we followed four steps (Figure 4), the first being the use of Principal Component Analysis (PCA), the second the evaluation of the consistency of the new variables, the third the construction of the indexes, and finally the proposition of the statistical model of analysis, including the indexes calculated in the previous step.

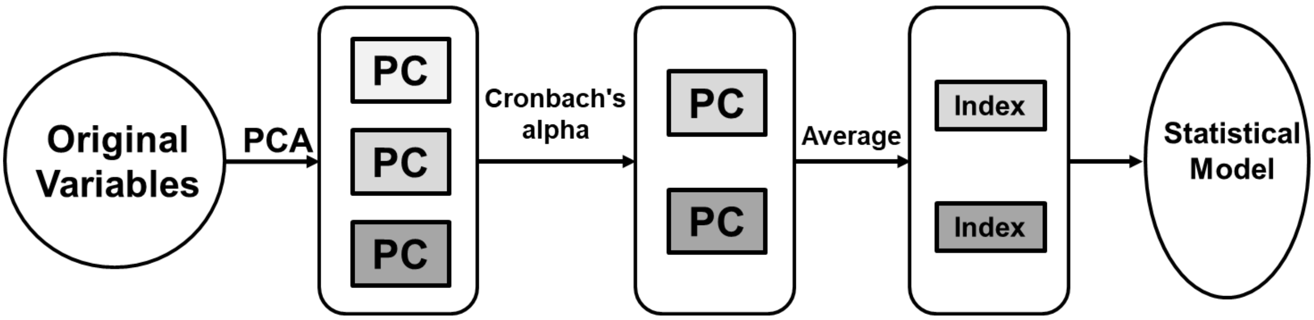

Figure 4 - Data analysis scheme for a question from the data collection instrument.

From the scheme in Figure 4, we start the analysis by reducing the size of the data matrix, using PCA. To do this, the original data set of correlated variables is linearly transformed into another set with a smaller number of uncorrelated variables that retain most of the information from the original set. These new uncorrelated variables are called principal components or factors (Jolliffe, 2010).

Thinking of the cut-off made for this work, we use this statistical tool in each question separately, totaling six PCA models. All analyses were conducted using the SPSS Statistics program, version 20, using varimax rotation. The criteria used in each model were: - Kaiser-Meyer-Olkin (KMO) greater than 0.6; - Bartllet's test of sphericity significant; - Choice of components (CP) with eigenvalue greater than or equal to 1; - Commonality greater than 0.5; - Explained Variance greater than 50%; Values of the components in the rotated matrix greater than 0.5.

Note that all these criteria are evaluated to define the number of components that will be extracted in the PCA, however, this type of analysis fundamentally considers the theoretical coherence between the items of each component, as Hair and collaborators indicate that it is "*the researcher's responsibility to ensure that the patterns observed are conceptually valid and adequate for studying factor analysis*". (Hair, Anderson, & Babin, 2009, p. 109). In other words, we emphasize that PCA requires the researcher to find theoretical coherence among the items in the analysis while observing the fit of the assay to the statistical criteria. We thus emphasize that several assays were conducted in order to obtain a matrix that met the different statistical requirements and had theoretical coherence and, thus, we observe that at some moments it was necessary to readjust some statistical criteria for certain items. Also, for the matrix analysis, we used the varimax rotation technique, an orthogonal rotation method, which assumes that the components are independent of each other and therefore focuses on optimizing the organization of the variables in the column (Hair et al., 2009).

Once the best solution that meets the theoretical and statistical criteria is defined, the next step is to verify the feasibility of building the indexes by calculating Cronbach's alpha, which is an "*estimate of internal consistency from the item variances and test totals per subject*" (Maroco & Garcia- Marques, 2006). In other words, Cronbach's alpha measures the reliability of a questionnaire or a group of items from its internal consistency and the variance between responses. The alpha value can range from 0 to 1, and the closer it is to 1, the greater the reliability of the survey instrument or group of items. In this work, we chose to use this calculation to evaluate if a certain group of questions grouped in a certain principal component (in the step described above - PCA) show similarity among themselves, in order to indicate if we can perform tests involving multivariate statistics with the questions we deem pertinent. The minimum accepted values for Cronbach's alpha is 0.7 and can be reduced to 0.6 in some cases as exploratory research (Hair et al., 2009). After obtaining the group of items of the dimensions proposed by the PCA, we calculated the alpha to proceed with construction of the indexes and later the tests. Thus, in the second step of the data analysis schematized in Figure 3, we evaluate how similar the original variables grouped in each principal component are, from the calculation of Cronbach's Alpha (Cronbach, 1951).

Only the components with good internal consistency, that is, with α values greater than 0.7, were used for the construction of indexes described in the subsequent step. From Figure 4, we can see that not always all principal components will be converted into an index, since some of them may not have enough similarity to have a good internal consistency. In this way, we ensure that the simple average of the original variables grouped in a principal component shows similarity between them.

Going back to the questions in the data collection instrument, we observe that they did not present an identical number of items for all the questions. For easy understanding of which original questionnaire variables were grouped together to generate an index, we constructed Table 1. This table provides the information for each index that will be covered in this work, including code, name of the respective index, question, and variables used for its construction.

Table 1 - Detailing of the indexes built from the data collection instrument.

Code	Index name	Cronbach's Alpha	Variables
Index_8.1	Learning science stimulates curiosity, leads to an understanding of the world, and a love of nature	0.804	6,10,11, 12,15
Index_8.2	Learning science improves your career, helps you take care of your health, and opens your eyes to new and exciting jobs	0.633	4,8,13
Index_10.1	Degree of information about S&T, medicine and health, environment.	0.746	2,3,4
Index_11.1	Self-efficacy in scientific knowledge	0.851	All
Index_14.1	Information habits in S&T	0.702	1,2,4.5
Index_17.1	Information habits in medicine and health	0.760	All

Source: S&T Conception, LAPEQ-2020.

After constructing each index, we went back to the theoretical model proposed in Figure 3 and added each index that we thought pertinent in each theme to be investigated (Figure 5).

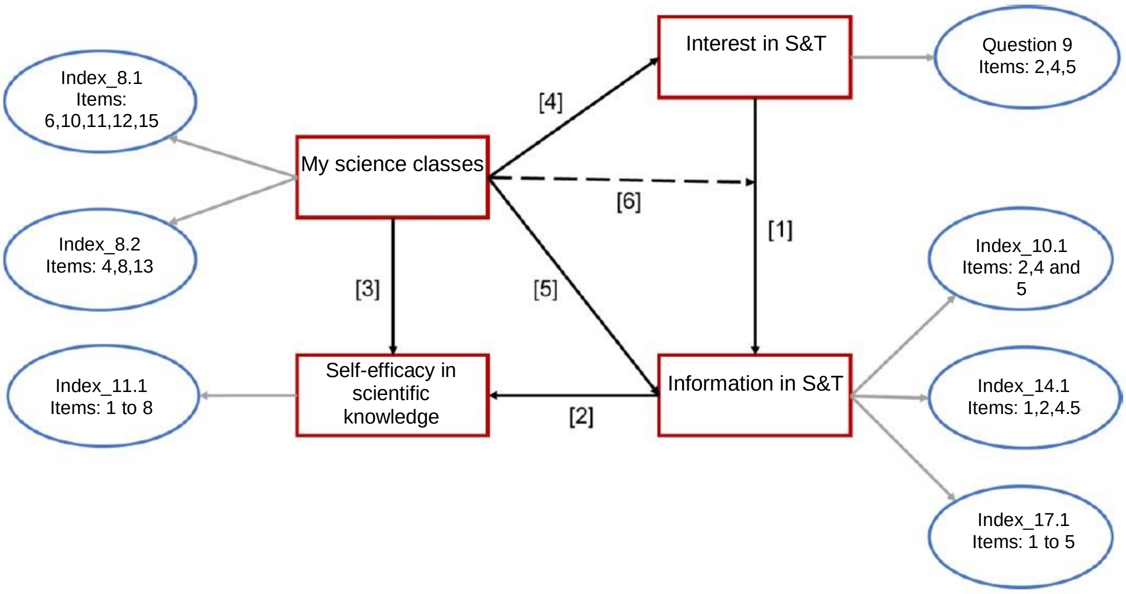

Figure 5 – Research analysis model. The dashed arrow represents the moderation model. Source: S&T Conception, LAPEQ-2020.

To systematize and facilitate the understanding of how the choice of the analytical method for each submodel was made, we built Table 2, including the nature of the independent and dependent variables. Note that at this point the submodel related to moderation was excluded because, due to its complexity, it will be detailed later.

From Table 2, it is possible to see that most of the dependent and independent variables are indexes obtained by the PCA of the questions in the data collection instrument. For all indexes, it was assumed that the nature of the variable was quantitative, since the metric was obtained from an instrument and generated numerical values (Hair et al., 2009). On the other hand, for question 9 of the questionnaire, the responses from the 10-point ordinal scale were used, since it did not generate an index with adequate internal consistency, but is theoretically important for the model.

In this case, we evaluated each item individually because we believe that the relationship between the degree of interest and the extent to which the respondent is informed about S&T topics brings us important discussions, since we argue that science popularization products strongly influence the formation of S&T conceptions. The relationship between *interest and information* was portrayed by Castelfranchi and colleagues (2013), as a paradox between information and attitudes about S&T in the view of the Brazilians surveyed.

Table 2 - Details of the variables, their nature and the method of analysis for each submodel[4].

	Submodel	Independent Variable	Nature IV (x)	Dependent Variable	Nature DV (y)	Method of Analysis
1	Interest in S&T to Information in S&T	Q09V02 Q09V05 Q09V04	Ordinal	Q10V02 Q10V03 Q10V04	Ordinal	Spearman's Rho Correlation
2	Information in S&T to Self-efficacy in scientific knowledge	Index_10.1 Index_14.1	Quantitative	Index_11.1	Quantitative	Multiple linear regression

[4] The variables were originally named according to their nature, which could be an index (as detailed in Table 1) or ordinal variable of the QxVy type, where x is the question and y the corresponding statement. For example, Q09V02 corresponds to question 9/item (variable) 2, which expresses the respondent's degree of *interest in Medicine and Health*.

	Submodel	Independent Variable	Nature IV (x)	Dependent Variable	Nature DV (y)	Method of Analysis
3	My Science classes to Self-Efficacy in Scientific Knowledge	Index_17.1 Index_8.1	Quantitative	Index_11.1	Quantitative	Simple linear regression
4	My Science classes to Interest in S&T	Index_8.1 Index_8.2	Quantitative	Q09V02 Q09V05 Q09V04	Ordinal	Spearman's Rho Correlation
5	My Science classes to Information in S&T	Index_8.1 Index 8.2	Quantitative	Index__10.1 Index_14.1 Index_17.1	Quantitative	Multiple linear regression

Source: S&T Conception, LAPEQ-2020.

After defining the nature of the dependent variables (DV) and independent variables (IV), we chose the appropriate method of analysis for each submodel. Simple linear regression was used in all cases where a quantitative IV was available, as in submodel 3. Multiple linear regression was used when you had more than one quantitative IV, as in submodels 2 and 5. Whereas Spearman's Rho correlation was applied to submodels 1 and 4, since these presented at least one of the variables of ordinal nature (Field, 2009).

For submodel 6, we have a representation of a moderation, of the variable *Interest in S&T* predicting *Information in S&T*, under the influence of the moderator *My science classes*, as shown in Figure 6. Within the framework of correlational analysis, a moderator is the third variable that affects the zero-order correlation between two other variables (Baron & Kenny, 1986).

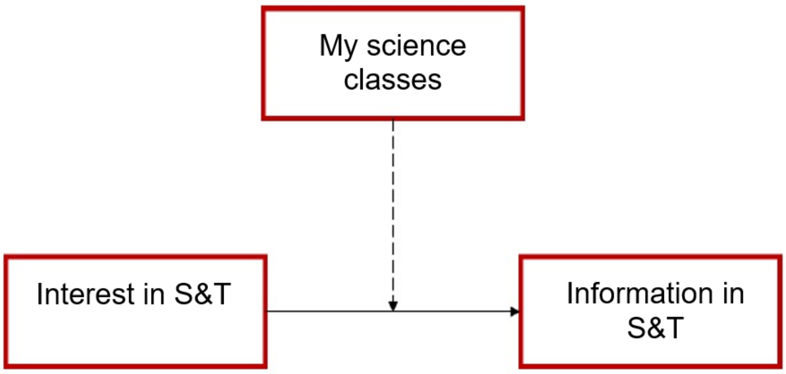

Figure 6 – Submodel 6 moderation theoretical model. Source: S&T Conception, LAPEQ-2020.

The correlations involving the variables in the moderation model are evaluated by means of calculations, which depend on the nature of the variables. For this paper, because the dependent and moderator variables are quantitative and only the dependent variable is ordinal, we chose to treat the data by simple linear regression when the independent variable (X) predicts the dependent variable (Y), and multiple linear regression when the product of the independent variable (X) and the moderator variable (W) predicts the dependent variable (Y). For the moderation model, we used the PROCESS macro made by Hayes for the SPSS program (Hayes, 2017).

RESULTS AND DISCUSSION

In this section, we present the results obtained from the statistical model analysis, which will be presented in two subitems: the first describes the analysis of the correlation and simple and multiple linear regression models, and the second displays the results of the moderation model.

Analysis of correlation and linear regression models

From the theoretical reference, it was possible to build a model (Figure 5) whose hypotheses were tested using different methods of analysis. In submodel 1, we have Spearman's Rho correlation to evaluate whether there is a relationship between *interest and information frequency* (Table 3).

Table 3 - Data obtained by Spearman's Rho correlation from submodel 1.

Topic of interest	Information on S&T, medicine and health, environment
Medicine and Health	0.428**
Environment	0.400**
Science & Technology	0.432**

Note: The correlation is significant at one level when **p<0.01. Source: S&T Conception, LAPEQ-2020.

As expected, when comparing the correlation coefficients between *interest and information* on the same topic, we observed moderate intensity values. In this same trend, when the correlation coefficients between *interest and information* of different subjects were evaluated, the intensity decreased to weak. From Figure 7, we can see that there was a reduction in the percentage of those who are informed compared to the degree of interest on the same topic.

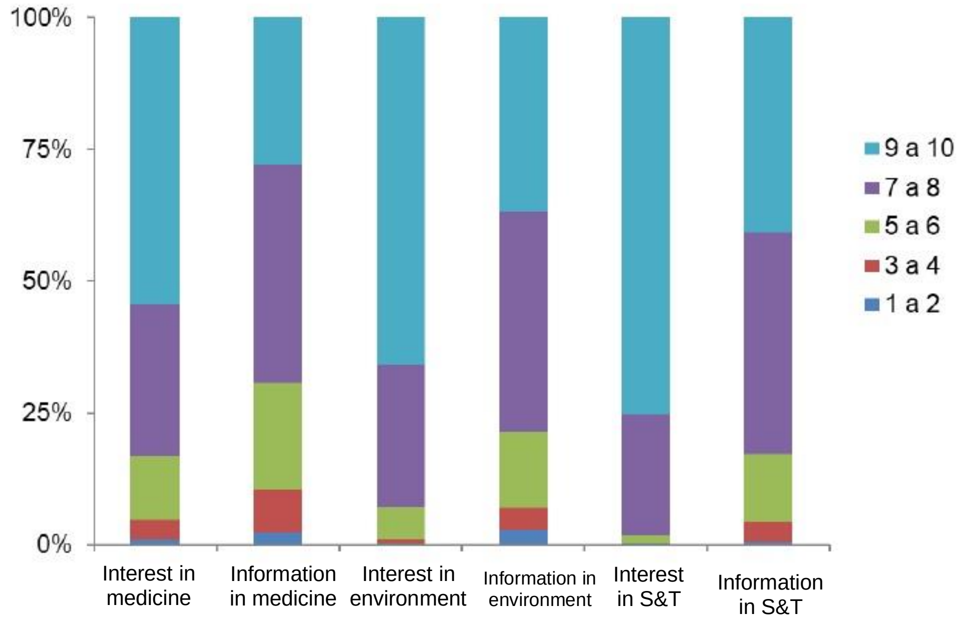

Figure 7 - Distribution of responses of the degree of interest and information in the topics S&T, environment, and medicine and health, whose scale ranges from 1 to 2 for no/low interest to 9-10 for high interest. Source: S&T Conception, LAPEQ-2020.

The initial questionnaire was constructed with a 10-point scale, and to facilitate data comparison, the scales were divided in pairs, with group 1-2 of respondents having no/low *interest/information* and 9-10 being the groups that declared higher *interest/information.* We also noticed that the topic of greatest interest to the respondents, considering the highest level of the chart's scale (9 to 10), was *S&T*, with 75%, followed by *environment* with 66% and *medicine and health* with 54%. As for the level of *information*, the percentages were lower than the declared interest, being 40.6% for the *S&T* topic, 36.8% for *environment* and 27.9% for *medicine and health.* These higher percentages in *interest and information in S&T and environment* may be related to the courses chosen by the respondents, which are in a region considered to be a chemical industrial hub, as well as a campus with studies in the environmental area.

This difference between interest and information, as presented by Castelfranchi et al. (2013) for the Brazilian population, was reported by Cunha (2009), who investigated the topics of interest and information among high school youth from a public school in the city of São Paulo, an audience closer to that of our research interest. However, among the topics surveyed, there was an inversion between environment and S&T, both for interest and for search for information. When we think about a justification of the results obtained regarding the interest and information about topics linked to S&T, we agree with Castelfranchi and collaborators (2013), who point out:

> *"The interesting aspect of this result is that it cannot be explained by a lack of 'sincerity' alone. Some respondents may exaggerate their interest in S&T in order not to disappoint the interviewer or because they don't want to admit a scarce attention to topics considered relevant. However, several indications show that a significant part of the public may indeed have an interest in S&T, but does not actively seek information or is not in a position to do so. (Castelfranchi et al., 2013, p. 1171).*

This is due to the fact that the population is not always able to consume a product from Science Teaching either because of lack of time or because they do not consider the information available in the general program as scientific information, a fact that was not explored in our study. In this perspective, we should reflect on the aspects mentioned regarding the appropriation of scientific culture by students and the contribution of the school in this process, in order to promote the search, criticality and recognition of the different journalistic aspects and the nature of science in a Science Teaching report. Our hypothesis is that in his or her classes, the teacher acts as an organizing agent for the integration between the student and the products of Science Teaching, in order to develop both critical reading, habits of use, and the recognition of these materials as conceptualizers. In this way, the student is able to actively search for information, in order to recognize his or her contribution and participation in scientific culture. To test such a hypothesis, we built a submodel that tests the correlation between the respondents' *degree of information* and *self-efficacy in S&T*, which corresponds to a measure in which the student perceives him/herself capable of performing activities that involve knowledge about topics widely covered in Science Teaching. We thus obtain a construct that considers the student's involvement with scientific culture, considering formal and non-formal education.

To measure this relationship between students' *habits* and *degree of information*, and *self-efficacy,* we used a multiple linear regression, the results of which have been compiled in Table 4, indicating that the model explains close to 33% and is significant, with $p<0.001$.

Upon analyzing Table 4, we notice that the indexes *degree of information about S&T, environment and medicine and health; information habits in S&T; information habits in medicine and health* contributed for the respondents developing tasks related to knowledge involving S&T. The model is significant and explains approximately 33% of this relationship, thus accepting our initial hypothesis. Our data indicate that as students declared greater frequency of information in S&T, they also declare greater ease in performing tasks that require scientific knowledge, for example: explaining phenomena such as acid rain, environmental changes, and earthquakes, as well as interpreting news reports, food labels, and others.

Such knowledge, besides being widely disseminated in the media, is part of the topics discussed in science classes, thus corroborating the already mentioned aspects of scientific culture, which proposes the teacher as the organizing agent of the activities and strongly responsible for the insertion of the students in it.

Table 4 - Data obtained by multiple linear regression from submodel 2.

Independent variables	**Dependent variables** Self-efficacy in scientific knowledge *Beta*
Degree of information in S&T, environment and medicine and health	0.198***
Information habits in S&T	0.275***
Information habits in medicine and health	0.242***
Adjusted R^2	0.329***
F (3.311)	50.929

***p<0.001. Source: S&T Conception, LAPEQ-2020.

In this same direction, we tried to test another hypothesis: students who have a higher level of agreement on the contributions of science classes tend to find it easier to perform the previous activities. We proposed submodel 3, in which we used multiple linear regression to test relationship between the composite variables regarding *my science classes* and *self-efficacy in science knowledge*, the results of which are available in Table 5.

Table 5 - Data obtained by multiple linear regression from submodel 3.

Independent variables	**Dependent variables** Self-efficacy in scientific knowledge Beta
Learning science stimulates curiosity, leads to an understanding of the world, and a love of nature	0.270***
Learning science improves your career, helps you take care of your health, and opens your eyes to new and exciting jobs	0.229***
R^2_{adjusted}	0.177***
F(2.314)	34.968

***p<0.001. Source: S&T Conception, LAPEQ-2020.

The proposed model explains approximately 18% of this relationship and is significant, which leads us to reject the null hypothesis and accept alternative hypothesis, i.e., as the level of agreement of the contributions of science classes increases, self-efficacy to perform activities involving S&T increases.

Another hypothesis tested was whether there would be a relationship between *science classes* and indexes related to *information in S&T.* To do this, we used multiple linear regression, the results of which are compiled in Table 6.

Table 6 – Data obtained by multiple linear regression from submodel 5.

Independent variables	Degree of information about S&T, medicine and health, environment *Beta*	Information habits in S&T *Beta*	Information habits in medicine and health *Beta*
Learning science stimulates curiosity, leads to an understanding of the world, and a love of nature	0.298***	0.330***	0.313***
Learning science improves your career, helps you take care of your health, and opens your eyes to new and exciting jobs	0.187**	0.246***	0.140*
R^2 adjusted	0.169***	0.238***	0.154***
F(2.302)	31.097	48.129	28.151

*** p<0.001, **p<0.01, *p<0.05. Source: S&T Conception, LAPEQ-2020.

Analyzing the table, all multiple linear regression models show significant correlation. The values of $R^2_{adjusted}$ on the three dependent variables were greater than 15%, highlighting the test involving the dependent variable *S&T information habits* that had the highest value (23.8%) of variance. The highest beta value (which corresponds to the slope of the line), 0.330, was observed in this variable for the index *learning science stimulates curiosity, leads to understanding the world and liking nature.* Thus, we can conclude that students who have higher agreement with the aspects addressed in this composite variable tend to report higher frequency in the consumption of scientific information.

The last hypothesis of direct relationship suggests that students' *science classes* tend to arouse their interest in topics such as *S&T, medicine and health, and the environment.* Such hypothesis seems simplistic at first, but it is a way to understand how the school contributes to the promotion of the student's scientific culture, in order for science teaching to increase interest in these areas, not being restricted to a content-based and transmission teaching, without relation to its historical, social, and cultural implications. To test this hypothesis, we used Spearman's Rho correlation, from the indexes of *my science classes* and the answers of the assertions of *interest in medicine and health, environment and S&T,* whose results were summarized in Table 7.

The results of the test (Table 7) indicated a significant positive correlation between certain attributes (stimulating curiosity, understanding the world, caring for health, and acting professionally) of *my science classes* and the *interest* of the respondents in topics such as S&T, medicine and health, and the environment. Although the results indicate a weak correlation in most cases, we point out that the correlation is positive and significant, that is, students who agree with statements related to science classes tend to report greater interest in topics such as *environment and S&T*, which validates our third working hypothesis.

Table 7 - Data obtained by Spearman's Rho correlation from submodel 4.

My science classes	Topic of interest		
	Medicine and Health	Environment	Science & Technology
Learning science stimulates curiosity, leads to an understanding of the world, and a love of nature	0.335**	0.374**	0.367**
Learning science improves your career, helps you take care of your health, and opens your eyes to new and exciting jobs	0.281**	0.195**	0.255**

Note: The correlation is significant at one level when **p<0.01. Source: S&T Conception, LAPEQ-2020.

Moderation model analysis

By evaluating the statistically significant correlations between submodel 1 (Interest in S&T → Information in S&T) and submodel 4 (My Science Classes → Interest in S&T), in addition to the multiple linear regression of submodel 5 (My Science Classes → Information in S&T), we realize that other factors may influence such relationships. To analyze this type of situation, we use regression analysis tests from moderation models, discussed in the methodology section, which have been little considered in the area of Science Teaching. With this, we build a new hypothesis: the respondents' conceptions about *science classes* influence the relationship between *interest and information* in science topics. The argument supporting this relationship is again based on the hypothesis that by bringing Science Teaching into the classroom, the teacher promotes the insertion of students into the scientific culture.

From this hypothesis, we have a theoretical model of moderation (Figure 5), which was converted into a statistical model called submodel 6 and evaluated using the calculations described in Hayes (2017). It is thus possible to statistically verify how school influences the (pre-existing) relationship between *interest and information.*

In submodel 6, we have the moderator's evaluation of *my science classes* in the relationship between the degree of *interest in medicine and health* (independent variable) and *information on S&T* (dependent variable). This submodel was split, because there is for each topic than one index associated with it. Thus, the topic *my science classes* unfolded into two composite variables: *learning science stimulates curiosity, leads to understanding the world and liking nature* (submodel 6.1.1); and *learning science improves one's career, helps one take care of one's health, and opens one's eyes to new and exciting jobs*, while the topic information in S&T unfolded into *degree of information in S&T, medicine and health, environment; and habits of information in S&T* (submodel 6.1.2).

For submodel 6.1.1, the effect of the moderator *learning science stimulates curiosity, leads to understanding the world and liking nature* was evaluated with significant result on the relationship between the *degree of interest in medicine and health and the degree of information about S&T, medicine and health, environment.* The model explains 24.6% ($R2 = 0.246$) of this relationship, and this value is significant ($F(3,307) = 33.363$, $p<0.001$). From the results, we observed that the *degree of interest in medicine and health* had a positive effect on the *habit of information about S&T, medicine and health, environment.* This statistically significant relationship demonstrated that the higher the respondents' declaration of *interest in medicine and health*, the greater the tendency to become *informed about S&T, medicine and health, and environment* topics ($B = 0.283$, $t = 6.318$, $p<0.01$, 95% CI = 0.195, 0.371). The results also showed a significant contribution of the moderator in the model interaction ($t = 2.735$, $p< 0.01$), that is, the students' *science classes* collaborated to increase the relationship between *interest and information* of the respondents.

One way to see the phenomenon of moderation in detail is to understand how it occurs on different levels, since moderation does not always display uniform behavior. This can be done from the moderator level plot in predicting the *degree of information in medicine and health, environment and S&T* as a function of the variable *interest in medicine and health* (Figure 8). In this work, the choice of levels was made by calculating the average (medium level), average + standard deviation (high level), and average - standard deviation (low level).

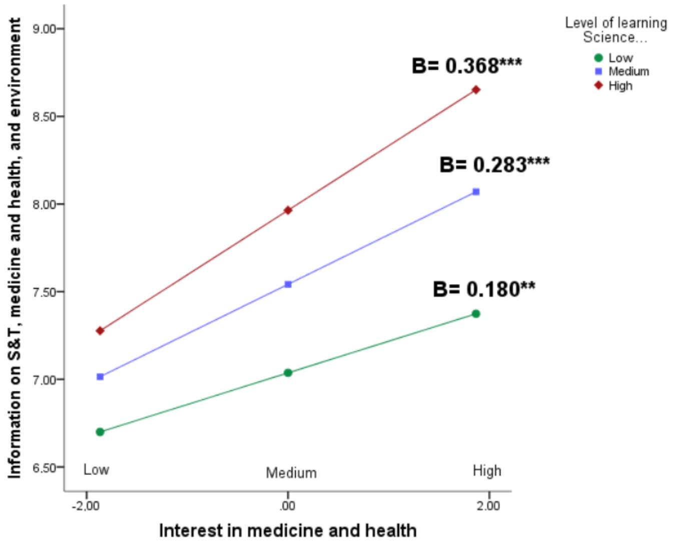

Figure 8 - Moderation of the conception that *learning science stimulates curiosity, leads to understanding the world and liking nature* in the relationship between the *degree of interest in medicine and health* and the *degree of information about S&T, medicine and health, environment.* Source: S&T Conception, LAPEQ- 2020.

From Figure 8, one can see the slope of the straight line increase as the level of the moderator is higher, with values for the low, medium, and high levels, respectively, of B = 0.180, t = 3.341, p=0.001; B = 0.283, t = 6.318, p<0.001; B = 0.368, t = 6.329, p<0.001. Also in this figure, it can be seen that regardless of the level of the moderator, as the respondents' *interest in medicine and health* increases, so does the extent to which they are informed about *S&T, medicine and health, environment.*

In this case, we interpret that the relationship between *interest and information* already exists and is positive, but the moderator enhances this relationship in such a way that at its high level (when students present a higher level of agreement), the slope of the straight line (B) presents twice the value when compared to its low level. This data strengthens the argument that because they have an important influence on the process in which the student goes through scientific enculturation, the products of Science Teaching should be presented to students in the school environment so that they can appropriate the critical reading of this material, as proposed by Bertoldo, Cunha, Strieder & Silva (2015); Lima & Giordan (2018); Pagliarini & Almeida (2015).

For submodel 6.1.2, the effect of the moderator *learning science improves careers, helps take care of health, and opens one' s eyes to new and exciting jobs* was evaluated, which was significant in the relationship between the degree of *interest in medicine and health and S&T information habits*. The model explains 20.1% (R^2 = 0.201) of the variation in *S&T information habits*, and this value is significant ($F_{(3.302)}$ = 25.295, p<0.001). It was possible to see from the results that the *degree of interest in medicine and health* had a positive effect on *S&T information habits.* Thus, the greater the *degree of interest in medicine and health*, the greater the frequency and diversity of *information habits* (B =0.152, t = 2.670, p<0.01, 95% CI = 0.040, 0.265). The results also showed a significant contribution of the moderator in the model interaction (t = 3.513, p= 0.01). From Figure 9, it can be seen that the effect of the degree of *interest in medicine and health on information habits* increases as the conception that *learning science improves one's career, helps one take care of one's health, and opens one's eyes to new and exciting jobs* increases (B = 0.316, t = 3.793, p<0.001, for the high level of the moderator variable).

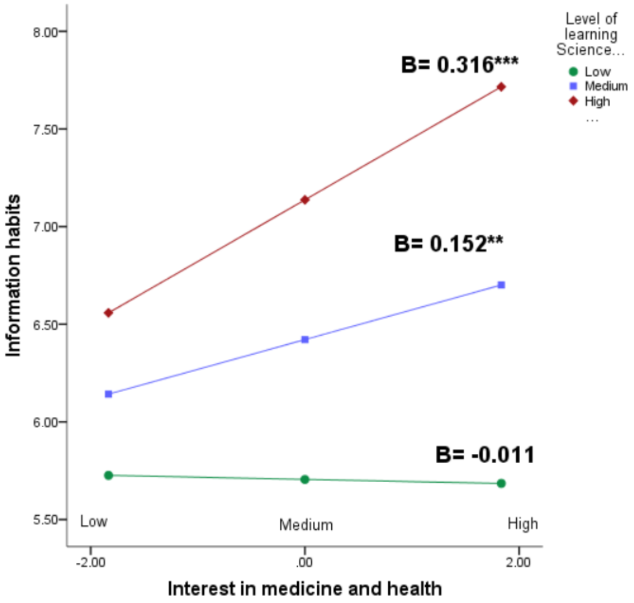

Figure 9 - Moderation of the conception that *learning science improves careers, helps with health care, and opens one' s eyes to new jobs* in the relationship between the degree of *interest in medicine and health and S&T information habits.* Source: S&T Conception, LAPEQ-2020.

The figure above brings us some important reflections and corroborates the Scientific Culture model presented by Lima (2016). By analyzing the slope of the straight line (B), we find that when the level of the moderator variable is high, the relationship between *interest in medicine and health and S&T information habits* also increases with greater intensity. However, the same is not perceived for those who show little agreement in the evaluated aspects of *science classes* (low moderator level), with a practically null influence, that is, the student who does not consider the contribution of science classes to career and health tends not to be interested or informed about science.

CONCLUSIONS

Using a data analysis methodology little explored in literature on the public understanding of S&T, based on the construction and analysis of a statistical model, we sought to understand the conceptions about S&T of students entering a Brazilian public university. We found the presence of significant correlation between *interest and information in S&T* of young students, the relationship of *science classes* with *self-efficacy in science knowledge*, and suggested how the statistical technique of moderation explains the influence of *My Science Classes* on the relationship between *interest and information in S&T.*

Two models were obtained from the moderation analyses that resulted in the use of the composite variables *My science classes* as a moderator. In the first submodel, it can be seen that regardless of the level of the moderator, as the respondents' *interest in medicine and health* increases, so does the extent to which they are informed about *S&T, environment, medicine and health.* The second model, on the other hand, shows an increase in the level of information only for respondents who reported agreement with the moderator's assertions. The effective contribution of certain attributes of *science classes* (stimulating curiosity, understanding the world, caring for one's health, and acting professionally) in forming the *information habits* of the respondents is highlighted, and with this, the relevance of stimulating in the classroom, through the teacher's mediation, the critical consumption of information by students.

More than understanding the relationships surrounding varied student conception rates, this work contributes to expanding the applications of quantitative analysis techniques in Science Teaching. We do not seek here just to treat the data by means of descriptive statistics, but to construct indexes that reflect the respondents' patterns of answers and to test them, based on a previously built theoretical model. In this sense, we used Principal Component Analysis as a technique, already established and used in several areas, which grouped into each component variables with similar response patterns and Cronbach's Alpha to assess the reliability and similarity between these variables grouped into each factor. It is worth noting the importance of building a statistical model that comes from theoretically grounded concepts or knowledge, such as Lima's Scientific Culture model (2016), because, in addition to providing greater security and reliability for the analysis, they allow us to systematize the data analysis according to the research objectives.

The study based on statistical modeling provides several submodel tests and allows the analysis of several aspects that influence the formation of conceptions about S&T. The analysis of statistical models of mediation and moderation makes it possible to verify the relationship between the different aspects involved in scientific culture, and brings indicators that can contribute to discussions about the role of the school in the formation of enlightened conceptions about S&T. Finally, we highlight the potential of using statistical modeling to study other social groups in order to build stable indicators of Public Understanding of Science.

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REFERENCES

Adorno, T.& Horkheimer, M. (1985). *Dialética do Esclarecimento:* fragmentos filosóficos. Translation by Guido Antonio de Almeida. Rio de Janeiro, RJ: Zahar.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. https://dx.doi.org/10.1037//0022-3514.51.6.1173

Bandura, A. (1997). *Self-Efficacy:* The Exercise of Control, Freeman, New York, United States of America.

Bertoldo, R. R, Cunha, M. B da, Strieder, D. M, & Silva, A. S da. (2015). Momentos de Leitura na Escola: Tem Ciência? In M. Giordan & M. B. Cunha da (Orgs.). *Divulgação Científica na Sala de Aula:* Perspectivas e Possibilidades. Ijuí, RS: Unijuí.

Bertoldo, R. R. (2019). Concepções de Ciência e Tecnologia de estudantes ingressantes da Universidade de São Paulo. (Doctoral Dissertation). Graduate Program in Science Teaching (Physics, Chemistry and Biology), University of São Paulo, São Paulo, SP, Brazil. https://dx.doi.org/10.11606/T.81.2019.tde-16062020-171356

Castelfranchi, Y., Vilela, E. M., De Lima, L. B., Moreira, I. C., & Massarani, L. (2013). As opiniões dos brasileiros sobre ciência e tecnologia: o 'paradoxo' da relação entre informação e atitudes. *História, Ciências, Saúde – Manguinhos*, *20*(1), 1163-1183. https://dx.doi.org/10.1590/S0104- 59702013000400005

Cavas, B., Cavas, P., Tekkaya, C., Cakiroglu, J., & Kesercioglu, T. (2009). Turkish Students' Views on Environmental Challenges with respect to Gender: An Analysis of ROSE Data. *Science Education International*, *20*(1-2), 69-78. Retrieved from http://www.icaseonline.net/sei/files/p6.pdf

CGEE - Centro de Gestão e Estudos Estratégicos. (2019). *A ciência e a tecnologia no olhar dos brasileiros*. Percepção pública da C&T no Brasil. Brasília, DF: MCTIC. Retrieved from https://www.cgee.org.br/documents/10182/734063/percepcao_web.pdf

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPQ); GALLUP. (1987). *O que o brasileiro pensa da ciência e da tecnologia?* Rio de Janeiro, RJ: CNPq/GALLUP.

Cronbach L. (1951). Coefficient alpha and the internal structure of tests. *Psychomerika*,*16*, 297-334. https://dx.doi.org/10.1007/BF02310555

Cunha, M. B. da. (2009). A percepção de Ciência e Tecnologia dos estudantes de ensino médio e a divulgação científica. (Doctoral Dissertation). Graduate Program in Education, University of São Paulo, São Paulo, SP. https://dx.doi.org/ 10.11606/T.48.2010.tde-02032010-091909

Cunha, M. B. da & Giordan, M. (2012). As percepções na teoria sociocultural de Vigotski: uma análise na escola. *Alexandria: Revista de Educação em Ciência e Tecnologia*, *5*(1), 113-125. Retrieved from https://periodicos.ufsc.br/index.php/alexandria/article/view/37700

European Commission (2008). *35 years of Eurobarometer European Integration as Seen by Public Opinion in the Member States of the European Union: 1973–2008.* European Commission, Brussels, Belgium. Retrieved from https://europa.eu/eurobarometer/screen/home

European Commission (2011). *Special Eurobarometer 340: science and technology*. European Commission, Brussels, Belgium. Retrieved from https://europa.eu/eurobarometer/screen/home

Field, A. (2020). Análise de fatores exploratória. In A. Field (Ed.), *Descobrindo a estatística usando o SPSS* (pp. 553-605). Porto Alegre, RS: Penso.

Fonseca-Janes, C. X., & Lima, E. A. (2013). O processo de formação de conceitos na perspectiva vigotskiana. *Revista Da FAEEBA* - Educação E Contemporaneidade, *22*(39). https://dx.doi.org/10.21879/faeeba2358-0194.2013.v22.n39.p%p

Hair, J. F., Anderson, R., & Babin, B. (2009). Análise Fatorial. In Hair, J.F. (Ed.), *Multivariate Data Analysis*. Porto Alegre, RS: Bookman.

Hargittai, E. (2008). An Update on Survey Measures of Web-Oriented Digital Literacy. *Social Science Computer Review*, *27*(1), 130-137. https://dx.doi.org/10.1177/0894439308318213

Hargittai, E. & Hsieh, Y. P. (2012). Succinct Survey Measures of Web-Use Skills. *Social Science Computer Review*, *30* (1), 371–379. https://dx.doi.org/10.1177/0894439310397146

Hayes, A. F. (2017). Moderation analysis. In T. D. Little (Ed.), *Introduction to mediation, moderation, and conditional process analysis, second edition: a regression-based approach* (pp.219-266). The Guilford Press, New York, United States of America.

Jidesjö, A., Oscarsson, M., Karlsson, K., & Strömdahl, H. (2009). Science for all or science for some: What Swedish students want to learn about in secondary science and technology and their opinions on science lessons. *Nordic Studies in Science Education – NorDiNa*, *5*(2), 213-229. https://dx.doi.org/10.5617/nordina.352

Jolliffe, I. T. (2010). Properties of Sample Principal Components. In Jolliffe, I.T. (Ed.) *Principal component analysis* (pp. 29-62). Springer, New York, United States of America.

Lavonen, J., Byman, R., Uitto, A., Juuti, K., & Meisalo, V. (2008). Students' interest and experiences in physics and chemistry related themes: Reflections based on a ROSE-survey in Finland. *Themes in Science and Technology Education*, *1*(1), 7-36. Retrieved from https://files.eric.ed.gov/fulltext/EJ1131483.pdf

Lima, G. S. (2016). O professor e a divulgação científica: apropriação e uso em situações formais de ensino. (Doctoral Dissertation). Graduate Program in Education, University of São Paulo, São Paulo, SP. https://dx.doi.org/10.11606/T.48.2016.tde-16082016-093959

Lima, G. S.,& Giordan, M. (2018). O Movimento Docente para o Uso da Divulgação Científica em Sala de Aula: Um Modelo a partir da Teoria da Atividade. *Revista Brasileira de Pesquisa em Educação em Ciências*, *18* (2), 493-520. https://dx.doi.org/10.28976/1984-2686rbpec2018182493

Maroco, J. & Garcia-Marques, T. (2006). Qual a Fiabilidade do Alfa de Cronbach? Questões Antigas e Soluções Modernas? *Laboratório de Psicologia*, *4*(1), 65-90. https://dx.doi.org/10.14417/lp.763

National Science Board (NSB). (2018). *Science and Engineering Indicators 2018.* NSB 20181. National Science Foundation, Arlington, United States of America. Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/assets/404/science-and-technology-public-attitudes-and-understanding.pdf

NORC, National Opinion Research Center. (1973). *General Social Survey.* Inter-university Consortium for Political and Social Research, Ann Arbor, United States of America. Retrieved from https://www.norc.org/Research/Projects/Pages/general-social-survey.aspx

OCDE. (2016). *Brasil no PISA 2015: análises* e reflexões sobre o desempenho dos estudantes brasileiros. São Paulo, SP: Fundação Santillana. Retrieved from https://download.inep.gov.br/acoes_internacionais/pisa/documentos/2016/pisa_brasil_2015_sumario_executivo.pdf

OCDE (2016). *PISA 2015 Assessment and Analytical Framework:* Science, Reading, Mathematic and Financial Literacy. OECD Publishing, Paris, France. Retrieved from https://www.oecd.org/education/pisa- 2015-assessment-and-analytical-framework-9789264281820-en.htm

OCDE. (2019). *Pisa 2018 assessment and analytical framework.* OECD Publishing, Paris, France. Retrieved from https://www.oecd-ilibrary.org/education/pisa-2018-assessment-and-analytical- framework_b25efab 8-en

Pagliarini, C. R. & Almeida, M. J. P. M. (2015). Física Quântica numa leitura de Divulgação Científica no início do Ensino Médio: manifestações dos estudantes In M. Giordan, M.B Cunha da (Orgs). *Divulgação Científica na Sala de Aula: Perspectivas e Possibilidades* (pp. 249-284). Ijuí, RS: Unijuí.

Paulo, W. O. (2016). Modelo metodológico de construção de indicadores de uso de TIC para gestão da produção de planos de ensino. (Doctoral Dissertation). Graduate Program in Science Teaching (Physics, Chemistry and Biology), University of São Paulo, São Paulo, SP, Brazil. https://dx.doi.org/10.11606/T.81.2016.tde-08122016-154833

Polino, C., & Castelfranchi, Y. (2017): Consumo informativo sobre ciencia y tecnología. Validez y relevancia del índice ICIC para la medición de la percepción pública. In R. Barrere (Org.). *El estado de la ciencia 2017: principales indicadores de ciencia y tecnología Iberoamericanos / Interamericanos*, RICYT-OEI, Buenos Aires, Argentina. Retrieved from http://www.ricyt.org/wp-content/uploads/2017/10/files_Estado- de-la-Ciencia-2017_E_2017_2_4_Consumo_Informativo_sobre_Ciencia_y_Tecnologia.pdf

Polino, C., & Rodriguez, G. (2015). Percepción pública de la ciencia y la tecnología en Iberoamérica: evolución de las encuestas y comparaciones internacionales. In R. Barrere (Org.). *El estado de la ciencia 2015: principales indicadores de ciencia y tecnología Iberoamericanos / Interamericanos*, RICYT-OEI, Buenos Aires, Argentina. Retrieved from http://www.ricyt.org/wp- content/uploads/2015/12/files_MAntigua.pdf

Santos, W. L. P., & Mortimer, E. F. (2000). Uma análise de pressupostos teóricos da abordagem CTS (Ciência-Tecnologia-Sociedade) no contexto da educação brasileira. *Ensaio Pesquisa em educação em ciências*, *2*(2), 1-23. https://dx.doi.org/10.1590/1983-21172000020202

Sarjou, A. A., Soltani, A., Afsaneh, K., & Mahmoudi, S. A. (2012). Study of Iranian Students' Attitude towards Science and Technology, School Science and Environment, Based on the ROSE Project. *Journal of Studies in Education*, *2*(1), 90-103. http://dx.doi.org/10.5296/jse.v2i1.961

Schreiner, C., & Sjøberg, S. (2004). *ROSE the relevance of science education: sowing the seeds of ROSE.* Department of Teacher Education and School Development, University of Oslo, Oslo, Norway. Retrieved from https://roseproject.no/key-documents/key-docs/ad0404-sowing-rose.pdf

Tolentino-Neto, L. C. B. de. (2008). Os interesses e posturas dos alunos frente às ciências: resultados do Projeto ROSE aplicado no Brasil. (Doctoral Dissertation). Graduate Program in Education, University of São Paulo, São Paulo, SP. https://dx.doi.org/10.11606/T.48.2008.tde-16062008-155323

Vázquez, Á., & Manassero, M. A. (2008). El declive de las actitudes hacia la ciencia de los estudiantes: un indicador inquietante para la educación científica. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, *5* (3), 274-292. http://dx.doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2008.v5.i3.03

Vigotski, L. S. (2001). *A construção do pensamento e da linguagem.* (Translation: Paulo Bezerra). São Paulo, SP: Martins Fontes.

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Appendix A

Survey on S&T Conceptualization and Digital Literacy

Dear Student,

This questionnaire contains questions about you, your experiences and interests in Science and Technology and about your knowledge of digital technologies. There are no right or wrong answers. We only need your opinion, whatever it may be. Think carefully and answer truthfully. In questions 3 through 27, mark with an "X" each question that best represents your opinion.

1 - Full name: ______________________________

Email: ______________________________

2 - How old are you? ______ ______________________________

3 - Gender: ☐ 1. Female ☐ 2. Male

4 - Which undergraduate course are you a student of?

☐ 1 Environmental Sciences ☐ 2 Biological Sciences

☐ 3 Sciences ☐ 4 Chemical Engineering

☐ 5 Pharmacy ☐ 6 Chemistry

☐ 7 Industrial Chemistry

5 - To what extent do you agree with the following statements? Rate your answer on an agreement scale of 1 to 10, with 1 for strongly disagree (DT) and 10 for strongly agree (Ct).

	DT					...					NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Science and technology are of great importance to society												
2. Science and technology will find cures for diseases like AIDS, cancer, etc.												
3. Due to science and technology, there will be better opportunities for future generations												
4. Science and technology make our lives healthier, easier, and more comfortable												
5. New technologies will make work more Interesting												
6. The benefits of science outweigh the negative effects it may have												
7. Science and technology will help eradicate poverty and hunger in the world												
8. Science and technology can solve almost any problem												
9. Science and technology help the poor												
10. Science and technology are the causes of environmental problems												
11. A country needs science and technology to develop												
12. Science and technology mainly benefit developed countries												
13. Scientists follow the scientific method that always leads them to the correct answers												
14. We can always trust what the scientists say												
15. Scientists are always neutral and objective												
16. Scientific theories are constantly developing and changing												

6 - How much do you think the following factors determine the directions of Science in the world? Consider the scale of 1 to 10, with 1 being for do not determine (ND) and 10 for determine completely (DC).

	ND					...					NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Economic market demand												
2. Large multinational companies												
3. The choices of scientists												
4. The governments of rich countries												
5. International institutions or organizations												
6. The challenges of science itself												

7 - To what extent do you agree with the following statements? Rate your answer on an agreement scale of 1 to 10, with 1 for strongly disagree (DT) and 10 for strongly agree (Ct).

	DT					...					NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Computer use and industrial automation are causing job losses												
2. Our society depends WAY too much on science, and WAY too little on religious faith												
3. Rulers must follow scientists' directions												
4. Because of their knowledge, scientists have powers that make them dangerous												
5. Most people are able to understand scientific knowledge if it is well explained												
6. Scientific research is not essential for industry development												
7. Scientists must publicly expose the risks arising from scientific and technological developments												
8. If a new technology offers benefits, it should be used even if its consequences are not well known												
9. The population must be heard in the major decisions about the directions of science and technology												
10. Scientists are responsible for other people's misuse of their discoveries												
11. Authorities must legally compel scientists to follow ethical standards												
12. Scientists must have broad freedom to do the research they want												
13. Horoscopes predict the future												
14. Depending on the case, scientific tests on animals should be allowed												
15. Scientific and technological development will lead to a decrease in the country's social inequalities												
16. In everyday life, it is not important for me to know science and technology												

8 - To what extent do you agree with the following statements about the science you learned in school? Answer according to the subject you have chosen for your degree, which is related to the area of science (Biology, Physics or Chemistry) most meaningful to you during high school. Rate your answer on an agreement scale of 1 to 10, with 1 for strongly disagree (DT) and 10 for strongly agree (Ct).

	DT					...					NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. The science subject covers difficult content												
2. The science subject is interesting												
3. Science, for me, is very easy to learn												
4. Science opened my eyes to new and exciting jobs												
5. I like science more than other subjects												
6. I think everyone should learn science												
7. The knowledge I gained in science will be useful in my daily life												
8. I think that the sciences I learned in school will improve my career opportunities												
9. Science has made me more critical and skeptical												
10. Science stimulated my curiosity about the things we still can't explain												
11. Science increased my appreciation for nature												
12. Science showed me how important it is to the way we live												
13. The science I learned in school teaches me to take better care of my health												
14. I would like to be a scientist												
15. I wish I had learned as much science as												

possible in school												
16. I would like to have a job that deals with advanced technology												

9 - About these subjects, how interested are you in each of them? Rate your answer on a scale of 1 to 10, with 1 being not at all interested and 10 being very interested.

	Not at all Very interested interested										I don't know	No answer
	1	2	3	4	5	6	7	8	9	10		
1. Politics												
2. Medicine and Health												
3. Art and Culture												
4. Environment												
5. Science & Technology												
6. Sports												
7. Fashion												
8. Economics												
9. Religion												

10 - How informed are you about the following topics? Rate your answer on a scale of 1 to 10, with 1 being not at all informed and 10 being extremely informed.

	Not at all Extremely informed informed										I don't know	No answer
	1	2	3	4	5	6	7	8	9	10		
1. Politics												
2. Medicine and Health												
3. Environment												
4. Science & Technology												
5. Religion												

11 - How easily do you think you could perform the following tasks by yourself? Rate your answer on a scale of 1 to 10, with 1 for extremely difficult (ED) and 10 for extremely easy (EF).

	ED ...										NS	NR
	1	2	3	4	5	5	7	8	9	10		
1. Recognize what science issues are involved in a news report about a health problem												
2. Explain why earthquakes occur more frequently in some areas and not in others.												
3. Describe the role of antibiotics in the treatment of disease												
4. Identify science issues associated with waste dispersion												
5. Predicting how changes in an environment will affect certain species												
6. Interpret the scientific information provided on food labels												
7. Discuss how new evidence may lead you to change your understanding about the possibility of life on Mars												
8. Identify the best of two explanations for the formation of acid rain.												

12 - On a scale of 1 to 10, where 1 means not at all concerned, and 10 means extremely concerned, how concerned would you say you are about the following issues.

	Not at all Extremely concerned ... concerned										I don't know	NR
	1	2	3	4	5	6	7	8	9	10		
1. Transgenic plants or food with transgenic ingredients as possible causes of disease												
2. Use of nuclear energy												
3. Pesticide use in agriculture												
4. Effects of climate change and global warming												
5. Deforestation in the Amazon												

13 - To what extent do you agree with the following statements about the problems of the environment (air and water pollution, natural resource abuse, global climate change, etc.)? Rate your answer on a scale of agreement of 1 to 10, with 1 being for strongly disagree and 10 for strongly agree.

	Strongly Strongly disagree ... agree										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Threats to the environment are none of my business												
2. Environmental problems give the future of the world a bleak and hopeless look												
3. Environmental problems are exaggerated												
4. Science and technology can solve all environmental problems												
5. I want to see environmental problems solved even if it means sacrificing consumer products												
6. I myself can have an influence on what happens in the environment												
7. We can still find solutions to environmental problems												
8. People worry too much about environmental problems												
9. Environmental problems can be solved without major changes in our lifestyle												
10. People should take more interest in protecting the environment												
11. It is the responsibility of rich countries to solve the world's environmental problems												
12. I think that each of us can make a significant contribution to protecting the environment												
13. Environmental problems should be left to the experts												
14. I am optimistic about the future												
15. Animals should have the same right to life as people												
16. It is right to use animals for medical experiments if it is for the benefit of man												
17. All human activity harms the environment												
18. The natural world is sacred and we must leave it alone												

14 - For each of the statements, please indicate the option that represents how often you perform such activities. Rate your answer on a scale of agreement of 1 to 10, with 1 for not very often and 10 for very often.

	Not very Very often ... often										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Watch TV programs that deal with Science and Technology												
2. Read about Science and Technology on the Internet												
3. Listen to radio programs that deal with Science and Technology												
4. Talk with friends about Science and Technology topics												
5. Read about Science and Technology in newspapers and magazines												
6. Sign manifestos or participate in demonstrations or protests on Science and Technology issues												

15 - How trustworthy are the following media when you look for information about science and technology? Rate your answer on a confidence scale with 1 for not at all trustworthy and 10 for completely trustworthy.

	Not at all Completely trustworthy ... trustworthy										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Scientific or technical programs on TV and radio												
2. Scientific magazines (Ciência Hoje, Galileu etc.)												
3. Television news												
4. Radio news												
5. Specialized books												
6. Newspapers												
7. Weekly general information magazines (Isto É, Veja, etc.)												
8. Internet (science blogs, video channels, social networks)												
9. Visits to Science and Technology Museums												
10. Science fairs and exhibitions												

16 - When you want to have information about something important to you and to society, how much do you trust the following professionals as a source of information? Rate your answer on a confidence scale with 1 for not at all trustworthy and 10 for completely trustworthy.

	Not at all Completely trustworthy ... trustworthy										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Scientists												

2. Writers												
3. Journalists												
4. Physicians												
5. Military												
6. Politicians												
7. Teachers												
8. Religious People												
9. Representatives of Non-Governmental Organizations (NGOs)												

17 - For each of the statements, please indicate the option that best represents how often you perform such activities. Rate your answer on a frequency scale with 1 for no frequency and 10 for maximum frequency.

	No Maximum frequency ... frequency										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. Read medicine package inserts												
2. Follow medical advice when undergoing treatment/diet												
3. Read information on food packaging												
4. Stay informed during an epidemic												
5. Check technical specifications/manuals												

18 - Evaluate your familiarity with the following Internet and Web terms and concepts. Rate your familiarity on a scale of 1 to 10, with 1 for no familiarity and 10 for full knowledge.

	No Full familiarity ... knowledge										NS	NR
	1	2	3	4	5	6	7	8	9	10		
1. JPEG												
2. Preferences												
3. Email list												
4. PDF												
5. Refresh page												
6. Advanced Search												
7. Proxypod												
8. Blog												
9. Anonymous Window												
10. Favorite												
11. Spyware												
12. Cco (email)												
13. Bluetooth												
14. Keywords												
15. Browser Tabs												
16. SD Card												
17. Wiki												
18. Virus												
19. Podcast												
20. Phishing												
21. Web Feeds												
22. Firewall												
23. Filtibly												
24. Apps												
25. Cache												

19 - How often do you access the Internet?

☐ 1. Never ☐ 2. Rarely

☐ 3. Sometimes ☐ 4. Often

☐ 5. Always

20 - When traveling between home and work/college, how do you use mobile technologies, such as cell phone or tablet? Rate your familiarity on a scale of 1 to 10, with 1 being never and 10 being often.

	Never ... Often										**NS**	**NR**
	1	2	3	4	5	6	7	8	9	10		
1. Listen to music												
2. Listen to the radio												
3. Listen to Podcast												
4. Read to study												
5. Read for leisure												
6. Watch video to study												
7. Watch video for leisure												
8. Chat using WhatsApp or similar												
9. Social network using Facebook or similar												

21 - After work/college, at night, in which way do you use the computer and the internet at home? Rate your familiarity on a scale of 1 to 10, with 1 being never and 10 being often.

	Never ... Often										**NS**	**NR**
	1	2	3	4	5	6	7	8	9	10		
1. Listen to music												
2. Reading and research for study												
3. Reading for leisure												
4. Social network using Facebook or similar												
5. Watch video using Youtube, Netflix or similar for leisure												
6. Watch video for study												
7. Write documents for work/college												

22 - Below are some comfort items. How many are there in your family residence? Also consider those that are stored. If they are not working, check only if you intend to repair or replace them in the next six months.

	Don't have	1	2	3	4 or more
1. Number of passenger cars exclusively for private use					
2. Number of monthly employees, considering only those who work at least five days a week					
3. Number of washing machines, excluding wash tubs					
4. Number of bathrooms					
5. DVD, including any device that reads DVD except for automobile DVD					
6. Number of refrigerators					
7. Number of independent freezers or part of the duplex refrigerator					
8. Number of microcomputers, considering desktop computers, laptops, notebooks and netbooks, except for tablets, palmtops or smartphones					
9. Number of of dishwashers					
10. Number of microwave ovens					
11. Number of motorcycles, excluding those used exclusively for professional use					
12. Number of clothes dryers, considering washer and dryer					

23 - What is the educational level of the head of the household? Consider as head of the household the person who contributes most of the household income.

☐ 1. Illiterate / Incomplete elementary school I

☐ 2. Complete elementary school I / Incomplete elementary school II

☐ 3. Complete elementary school/ Incomplete high school

☐ 4. Complete high school/Incomplete higher education

☐ 5. Complete higher education

24 - Your family residence has the following public services:
Piped water ☐ 1. Yes ☐ 2. No

Paved road ☐ 1. Yes ☐ 2. No

25 - What is your family income? Value of the minimum wage in effect: R$1,039.00

☐ 1. Up to 2 minimum wages

☐ 2. More than 2 to 5 minimum wages

☐ 3. More than 5 to 10 minimum wages

☐ 4. More than 10 to 20 minimum wages

☐ 5. More than 20 minimum wages

26 - Among the following public venues or events, how often have you visited or attended them in the past 12 months?

	At least once a month	At least once every two months	A couple of times a year	Once in the past	I did not visit	I don't know	No answer
1. Library							
2. Zoological Garden							
3. Museum or Science and Technology Center							
4. Science or math fair/olympiad							
5. Art Museum							
6. National Science and Technology Week activity							
7. Botanical Garden or Environmental Park							

27 - Please indicate the approximate number of hours spent taking extracurricular courses in the last 12 months.

	More than 60 hours	Up to 60 hours	Up to 40 hours	Up to 20 hours	None	I don't know	**No answer**
1. Sports							
2. Languages							
3. Computer Science							
4. Music Education							
5. Drawing/Painting							
6. Theater/Dance							
7. Art/Crafts							
8. Photography							
9. Other							

28 - In this space, you can suggest points to be improved in the questionnaire.