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BLINDNESS AND SCIENCE CONCEPTUALIZATION: THE PERCEPTION OF BASIC EDUCATION TEACHERS AND STUDENTS

CEGUEIRA E CONCEITUALIZAÇÃO EM CIÊNCIAS: A PERCEPÇÃO DE PROFESSORES E ALUNOS DA EDUCAÇÃO BÁSICA

CEGUERA Y CONCEPTUALIZACIÓN EN CIENCIAS: LA PERCEPCIÓN DE PROFESORES Y ALUMNOS DE LA EDUCACIÓN BÁSICA

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ABSTRACT

This paper presents the results of a research with the objective of understanding how the process of science conceptualizing occurs from the perspective of congenitally blind students and teachers or specialists in visual impairment. It is a qualitative research in which the information was collected in real scenarios to understand the meaning of physical phenomena to the surveyed subjects. The survey was elaborated considering that although concepts and sensitive phenomena are interrelated by their meanings, they are parts of different categories of consciousness. To facilitate the analysis, the answers were grouped into three topics: "congenital blindness and scientific work," "congenial blindness and the nature of light," and "congenital blindness, concepts and scientific phenomena." The results demonstrate that in a world dominated by sight, it's natural to establish associations of dependence between sight and thinking capacity, knowledge, study and work—in such a way that those who are visually impaired are considered incapable of performing these functions.

KEYWORDS: visual impairment; special education; physical phenomena; inclusive education.

RESUMO

Este texto apresenta os resultados de uma pesquisa realizada com o objetivo de compreender o processo de conceituação em ciências na perspectiva de estudantes cegos congênitos e videntes e seus professores ou especialistas em deficiência visual. Trata-se de uma pesquisa qualitativa cujas informações foram constituídas em cenários reais com o intuito de entender os fenômenos físicos em termos dos significados atribuídos por seus participantes. As questões do instrumento de pesquisa foram elaboradas considerando-se que, embora os conceitos e fenômenos sensíveis estejam interrelacionados por seus significados, psicologicamente, são categorias diferentes de consciência. Para efeito de análise, as respostas foram agrupadas em três tópicos: cegueira congênita e trabalho científico, cegueira congênita e natureza da luz e cegueira congênita, conceitos e fenômenos científicos. Os resultados apontam que ainda prevalece a concepção de que em uma cultura de videntes, é natural o estabelecimento de associações de dependência entre pensamento e visão, conhecimento

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e visão, realidade e visão, estudo e visão, trabalho e visão, de tal forma que os visualmente impossibilitados são considerados incapazes de exercerem as funções indicadas, como, por exemplo, tornar-se um cientista.

PALAVRAS-CHAVE: deficiência visual; educação especial; fenômenos físicos; educação inclusiva.

RESUMEN

Este texto presenta los resultados de una investigación realizada con el objetivo de comprender el proceso de conceptualización en ciencias en la perspectiva de estudiantes ciegos congénitos y videntes y sus profesores o especialistas en deficiencia visual. Es una investigación cualitativa cuyas informaciones se constituyeron en escenarios reales con el fin de entender los fenómenos físicos en términos de los significados atribuidos por sus participantes. Las cuestiones del instrumento de investigación se elaboraron considerando que, aunque los conceptos y fenómenos sensibles están interrelacionados por sus significados, se constituyen como categorías diferentes de conciencia. Para efectos de análisis, las respuestas fueron agrupadas en tres tópicos: ceguera congénita y trabajo científico, ceguera congénita y naturaleza de la luz y ceguera congénita, conceptos y fenómenos científicos. Los resultados apuntan que aún prevalece la concepción de que, en una cultura de videntes, es natural el establecimiento de asociaciones de dependencia entre pensamiento y visión, conocimiento y visión, realidad y visión, estudio y visión, trabajo y visión, de tal forma que los visualmente imposibilitados son considerados incapaces de ejercer las funciones indicadas, como, por ejemplo, convertirse en un científico.

PALABRAS CLAVE: deficiencia visual; educación especial; fenómenos físicos; educación inclusiva.

1 INTRODUCTION

In recent decades, Brazilian educational policies have been guided by the neoliberal model as a reflection of the strong advancement of capital on the organization of workers. From then on, the speech proclaimed by the Governments was the guarantee of access and permanence of students in schools, but this guarantee isn't always accompanied by due concern with the qualitative aspects.

In Gentilli's analysis (1996), this policy represented a profound crisis of efficiency, effectiveness and productivity, as it sought to overcome a possible crisis of quantity, universalization and extent. For this author, this crisis reflects the disorderly expansion the educational system has been through in recent years, which foundations are in the disorders generated by the absence of quality due to the unproductivity evidenced by pedagogical practices and administrative management of most school establishments (GENTILLI, 1996).

On the other hand, although these authors agree with Gentilli (1996) regarding the qualitative dimension of education, they understand that quantitative data refers to the analysis of the inclusion of students with Special Educational Needs (NEE) in Brazilian schools because they reflect to some extent the government's concern with a significant portion of the population—which, until recently, did not receive adequate attention from educational policies.

To illustrate the above, they use the School Census of Basic Education of 2015 and state that, from 1998 to 2015, NEE students' enrollment in common classes, among which are included the congenitally blind, jumped from 43,923 to 750,893, representing a growth bigger than 1,400% in the mentioned period (BRASIL, 2016).

Roughly, it can be said that this new scenario reflects the effects of regulatory

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educational policies for special education in Brazil, as well as the guidelines of the international organizational movements of the area. In these terms, although it is known that the presence of students with these characteristics in the regular school system does not guarantee an effective inclusion, it is assumed that without it, the relationships of a more excluding society are intensified. (CAMARGO et. al., 2013).

However, it is known that, in proportion that the attendance number of students with different NEEs increases, the challenges for teachers and managers are widened as a result of two factors: a) if, on one hand, inclusive educational proposals have been developed efficiently, b) on the other hand, the Brazilian educational system still lacks profound changes, both concerning adequate infrastructure and the attitudinal aspects of teachers and managers who need to learn how to deal with inclusive environments, as show studies on the conceptualization process for science congenitally blind individuals (VERASZTO, CAMARGO, CAMARGO, 2016a, 2016b, 2016c, VERASZTO; CAMARGO, 2015; VERASZTO et. al., 2014).

Although these studies have contributed significantly to understanding the inclusion of congenitally blind students in the school environment, it is understood that the search for other viewpoints on the same thematic is necessary to subsidize the teaching work with people with this kind of disability. It is noteworthy that the conception of blindness emphasizes its limitations and not its possibilities (NUNES; LOMONÂCO, 2010), therefore justifying the need to listen to other actors, among them, blind students and teachers.

In these terms, the main objective of this study is to broaden the understanding of the conceptualization process in sciences by congenitally blind individuals from the perspective of:

i. students with visual impairment (VI), being either born blind or with low vision, about natural phenomena and the process of conceptualization in sciences.

ii. sighted students, classmates of congenitally blind students, concerning natural phenomena and the process of conceptualization in science;

iii. teachers of VI students, about natural phenomena and the conceptualization in science;

iv. teachers from the area of natural sciences, who teach VI students, about natural phenomena and the process of conceptualization in science.

v. In this sense, the research seeks to answer the following question: how the process of conceptualization in science is understood by congenitally blind students, sighted students, blind teachers or experts in visual impairment?

1.2 Theoretical basis

Among the various challenges in the promotion of inclusive education, one of the greatest is to teach scientific concepts and phenomena for students with and without visual impairment. This fact is based on the social construction that non-visual phenomena are less

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valued when compared to visual ones. This consideration is sustained in studies that discuss this thematic (CAMARGO, 2016, 2012a, 2012b, 2011a, 2011b, 2010, 2008; CAMARGO; NARDI, 2010, 2008; CAMARGO; NARDI; CORREIA, 2010; CAMARGO; NARDI; VERASZTO, 2009; CAMARGO et. al., 2013, 2009).

Nevertheless, the option for this point of view does not lessen the value of seeing and not seeing. On the contrary, it highlights the importance of a more holistic perceive of what the human being can see, hear, touch, sniff and taste—and also highlights the importance of what blind people are capable of listening, touching, sniffing and tasting, since "blind people perceive the world using every other sense aside from the vision (tact, smell, palate, hearing)" (NUNES; LOMONÂCO, 2010, p.57).

1.3 Concept of blindness

Blindness is a visual deficiency that concerns the limitation of understanding the world through sight. Given the nature or depth of the visual deficiency, it can be described as blindness or low vision.

It is noteworthy that the definition of these terms isn't this simple, because the boundary between these dimensions resides in the medical area. Therefore, to clarify the differences between these dimensions, legal devices that define the parameters of blindness and low vision are employed.

According to Decree Law Noº 5.296/2004, blindness is identified when a person has visual acuity equal or less than 0.05 in their best eye with the best optical correction possible; low vision is identified when someone's visual acuity is between 0.3 and 0.05 in their best eye with the best optical correction possible. Moreover, other characteristics of visual deficiency are in cases where the sum of the measurement of the visual field in both eyes is equal to or less than 60º or the simultaneous occurrence of any of the previous conditions (BRASIL, 2004).

It is therefore noted that there are differences between these terms. However, in common sense, this isn't always regarded. People are often concerned about the use of the politically correct term "visual disability" in detriment of the term "blind," as the latter is assumed pejorative and therefore prejudiced.

This is mainly due to the many discussions on disability and the stigmas that have marked the last decades. Moreover, given the above, it is clear that these terms are not equivalent because the concept of "visual impairment" is more inclusive by encompassing both blindness and low vision cases (NUNES; LOMONÂCO, 2010).

Nevertheless, it is known that in general, visual impairment is associated with deformed eyes and dark glasses, which in fact does not always occur. Between low vision and total blindness there is a great way, and it is fundamental for the teacher to know the characteristics of the visual deficiency of his student (CAMARGO, 2016a).

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But this stereotypical vision needs to be overcome, since people with visual impairment do not want to deny or disguise the fact that they do not see it. However, they want to know more about their deficiency, their limitations and potentialities. They want access to cultural and material heritage. They want to be respected and not underestimated. They want to occupy a space in social life, to be treated with dignity, to correct, to err, to invest, to change, in the end, to exercise rights and duties common to any individual (CAMARGO, 2016a).

It must be clear that visual impairment is more than an organic and sensory phenomenon. It is a social phenomenon, manifested in an objective way, considering that society, in its contexts, spaces and attitudes structured itself based on the ideal of normalcy for sighted people. According to Camargo (2016a), this suggests that the dominant way of being, perceiving, thinking, acting and living are graded in a visual society.

According to Vygotsky (1997), blindness is not only considered the lack of vision or the failure of a particular organ, but also a characteristic that causes profound restructuring of the body and personality of an individual. Blindness, when configuring a personality, modifies certain functions of the organism, restructures and forms every psychological characteristic a man possesses in a creative and organic manner.

On the other hand, it is known that different types of deficiencies have been identified in the medical field through diagnoses that signal the presence of some pathogenic element in the organism (OMOTE, 1989). In this approach, the origin of visual impairment is in the person themselves. However, this same author points out that disability is a much more complex phenomenon and cannot be attributed to someone's inherent characteristic or a unique attribute.

It is therefore assumed that conditions of disadvantage and limitations visually impaired people face in social contexts—such as educational context—should not be understood as being exclusively theirs. These conditions are only disadvantageous the moment the impaired attributes become important to people's suitability in their social environment (CAMARGO, 2016; OMOTE, 1989).

For believing that there are two epistemological approaches (those who are sighted and those who are blind) and that the proximity of each of them with reality is a matter of point of view, this research is based on the conception that inclusion is the most acceptable path for the differences to complement each other in the teaching and learning process.

1.4 Compensating blindness through other senses

The idea that other senses are more enhanced in blind individuals—such as smell, hearing and tact—is part of common sense. However, it's an erroneous and distorted interpretation of the compensation, since it occurs through social channels. Vigotski (1997 apud CAMARGO, 2016a) points out that there is no supernormal development of functions

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such as tact and hearing. Tactile sharpness in blind people does not arise as direct physiological compensation of the visual deficiency, but by indirect and complex pathways. This is the general socio-psychological compensation. Blind people tend to concentrate their voluntary attention (VIGOTSKI, 2001) in the non-visual information that is made available to anyone. This fact, therefore, doesn't imply that blind people, for example, have ears, in biological terms, more developed than those of a sighted person. It implies that psychologically their hearing finds information that for most sighted people are usually "transparent." In short, tact or hearing won't teach a blind person how to see.

Concepts and physical phenomena

Assuming that "concept" and "phenomena" are central terms in this project—correlated but still distinct—a brief delimitation of the terminology should be made.

It is necessary to define that the term "concept"—here related to science—is employed in what constitutes a broader, universal, abstract and systematized formulation of the knowledge that the scientific community has figured so far. From this scientific-cultural standpoint, it is still necessary to consider that scientific concepts are not assimilated into their readied form, but through a development process related to their overall ability to form concepts in students' minds (GASPARIN, 2013; SCHROEDER, 2007). Thus, the construction of the scientific concept originates in the teaching processes, through its structured activities, with the participation of the teachers, assigning to the student more formal abstractions and more definite concepts than those constructed spontaneously, as a result of cultural agreements (SCHROEDER, 2007).

Concept formation is a specific and unique way of thinking and the immediate factor that determines the development of this new way of thinking is not the association, the attention, the judgment or the decisive trend. All of these moments (and processes) participate in the formation of concepts, but none of them is the decisive and essential moment that can explain the emergence of a new form of thought that is qualitatively original and irreducible. The process of formation of concepts is not limited to associations, representations, judgments or determinant trends—although all of these functions are mandatory participants of the complex synthesis that is the process of forming concepts. All of the elementary psychological functions participate in the process of formation of concepts in a diverse way leading to a new combination, a new synthesis, a single moment in which each participant process finds its true functional sense (VIGOTSKI, 2001).

To clarify the understanding of the term "phenomenon," the viewpoint of the philosopher Immanuel Kant is used. To Kant, phenomena constitute the world as we experience it. Thus, according to Kant (2009), human beings cannot understand the essence of things themselves, but understand things only according to our mental schemes. These considerations have given rise to the philosophical tradition known as "phenomenology." And in this line of thought, the phenomenological reduction is the process whereby all that is

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informed by the senses is changed in an experience of consciousness, in a phenomenon that consists of being conscious of something.

According to Galeffi (2000), the word “phenomena” comes from the Greek phainómenon and means “what appears.” The word derives from the Greek verb phainomenai: “I appear.” Therefore, what appears is what is shown in the light, the bright (phaino).

Although the term “phenomena” designates “what appears,” it is also used to designate appearance itself. Thus, with ambiguous its use, the word “phenomena” favors misunderstandings, as the appearance itself becomes an object of investigation. This means that the subject of knowledge is investigated in its structure of behavior, due to the essential correlation between its “appearance” and “what appears.” It is an interdependent relationship between “appearance” and “what appears,” between the subject of knowledge and the known world, between the consciousness and the world/object that appears or is shown knowable.

In this sense, the word “phenomena” is, for the phenomenology, something that understands, simultaneously, both “appearance” and “what appears”: the inseparable relationship between the subject and the world, consciousness and its objects (GALEFFI, 2000).

On the other hand, Lopes (1994) states that since the 20th century, scientific advances have been made without researchers having direct contact with the phenomena. Thus, the relationship of the observer mediated by the instrument ceased to exist. In this perspective, Bachelard (2000), one of the main names in the reconstruction of the term “phenomena” in contemporary science, emphasizes that the phenomena should be considered a tissue of relationships, since it’s constructed from multiple methods and since instrumented science is transcendent to the science of natural observation (the one that considers the senses as intermediates of knowledge.)

Thus, the scientific phenomenon is an instrumental and theoretical construction. Masini (1994) points out that phenomena are not things, but they happen in the field where the subject located. Then subject and phenomena are, together, a system.

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2 METHODS

2.1 Research instrument

The questions of the survey instrument were elaborated based on the theoretical benchmark of Leontiev (1988), who believes that, although the concepts and sensitive phenomena are interrelated by their meanings, psychologically, they are part of different categories of consciousness. This idea is grounded on the concept of the psychophysiological functions of the organism. The group includes the sensory, mnemonic devices and tonic functions. No psychic activity can be executed without the development of these functions—this form the basis of the corresponding subjective phenomena of consciousness. Considering this, "a blind person could become a scientist and create a new and more perfect theory on the nature of light, although their sensible experience of light is as small as the experience a sighted person has of the speed of light" (LEONTIEV, 1988, p.13).

These considerations have motivated the elaboration of the questions constituting the survey, as follows:

i. Question 1 (Q.1) Concerning a congenitally blind person, answer the following: (Q1.1) Is it possible for them to become a scientist? Explain. (Q1.2) Is it possible for them to understand the nature of light? Explain.

ii. Question 2 (Q2) Sight isn't required to know and understand physical phenomena. Do you agree with this statement? Explain.

iii. Question 3 (Q3) The sensible experience a congenitally blind person has of the light is as small as the experience a sighted person has of the speed of light. Do you agree with this statement? Explain.

2.2 Characterization of the target audience

The subjects of this survey are visually impaired students, sighted students and teachers from a state school of the municipality of Piracicaba. Consulted on the possibility of granting interviews on the thematic previously described, only 1 person refused to participate. Among those who agreed to answer the questions are: 1 student with low vision, 2 congenitally blind students, 1 congenitally blind teacher from the resource room. In addition to these individuals, two more teachers were interviewed, 1 teacher from the resource room, 1 Nature Sciences teacher and 1 Physics teacher, 11 sighted students from the 3rd year of High School, 6 sighted students from the 6th grade and 3 sighted students from the 8th grade. The synthesis of responses is in Frame 1.

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FRAME 1 - Characterization of the subjects of this survey.

SUBJECT	AGE OR TEACHING TIME	EDUCATION	CHARACTERISTICS
A1: Student 1	16 years	3rd year of High School	Low vision and total deafness. The school record characterized this as "deaf-blindness." However, he could not specify the level of his low vision.
A2: Student 2	16 years	9th Grade	Congenitally blind.
A3: Student 3	12 years	7th Grade	Congenitally blind and with low intellectual disability.
PSR1: Resource Room Teacher 1	Did not inform	Doctorate (Special Education)	Congenitally blind.
PSR2: Resource Room Teacher 2	20 years of teaching	Higher Education (Special Education)	Works in 3 classes and serves 4 blind students and 8 students with low vision.
PCN1: Natural Sciences Teacher 1	8 years of teaching	Superior	Works in Elementary and Middle School.
PCN2: Natural Sciences Teacher 2	10 years of teaching	Superior	Works in High School and Education of Children and Adults.
A4-A14	Average of 17 years	3rd year of High School	11 sighted students.
A15-A20	Average of 14 years	9th Grade	6 sighted students.
A21-A23	Average of 13 years	8th Grade	3 sighted students.

Source: Prepared by the Authors.

Methods and analysis techniques

A thorough reading and categorization of the responses of the previously presented survey was done based on the reference of the theoretical justification.

Thus, using both the theoretical and referential responses, all gathered material went through a process of content analysis and classification of data until the variables found could be compared to the results of previous researches (VERASZTO, CAMARGO, CAMARGO, 2016a, 2016b, 2016c, 2015; VERASZTO, CAMARGO, 2015; VERASZTO et. al., 2014) discussing the subject (Frame 2.)

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FRAME 2 – Categories for analysis of the conceptualization process in sciences by congenitally blind individuals.

CATEGORIES	DEFINITIONS ACCORDING TO THE ANALYZED RESPONSES
Learning	Research has shown that the term "learning" appeared significantly in responses related to teaching science to blind people. Mostly, the term appeared related to some theory of learning.
Capacity	A sensory deficiency would not be a hindrance for the congenitally blind to become a scientist.
Cognition and Perception	This category indicates that research has found that many individuals consider sensory perception to be fundamental to cognitive development.
Compensation through other senses	Blind or visually impaired individuals are often "compensated" through their other senses, according to the opinion of the surveyed individuals in the mentioned studies.
Creativity and abstraction	Creativity was another element mentioned by the subjects of this research. Often, respondents have used the term "imagination" to explain processes of abstraction of scientific concepts.
"It depends"	Many individuals did not know how to position themselves on processes of conceptualization of sciences to blind individuals.
Unfamiliarity with the concept of light	Many of the surveyed individuals are unaware of the nature of light. Others gave wrong explanations regarding the scientific framework. Thus, the category groups answers that did not present sufficient scientific knowledge in relation to the subject matter.
Difficulties for inclusion	Inclusion is possible, but still difficult to achieve because higher education institutions are not prepared to receive blind students.
Empowerment	The process by which a person uses their willpower (inherent in their condition) to make choices and make decisions, taking control of their life, is critical.
Impossibility	This category arose from the unbelief that a blind individual could become a scientist.
Modifications and adaptations of the environment	It points out the importance for adaptation and modification of the environment to provide adequate conditions for the inclusion of a blind individual.
Role of society (or social mediation)	It signals that the success of a blind individual is directly related to a teacher, classmates, family or society as a whole.
Support resources	It deals with resources to support Physical Education/Gym for students with visual impairment, such as the use of tactile and auditory resources, technological and assistive resources, etc.

Source: Prepared by the authors based on the studies of VERASZTO, CAMARGO, CAMARGO, 2016a, 2016b, 2016c, 2015; VERASZTO, CAMARGO, 2015; VERASZTO et. al., 2014 (2017.)

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After analysing the responses, the work was organized in three distinct poles according to Bardin's theory (2004).

First, to categorize the data, the composed material was organized for a brief reading. The second stage of the analysis consisted of the exploration of the material, trying to manage the decisions taken for the categorization process. Finally, the third stage interpreted the material, seeking to combine reflection, intuition and the foundation in theory to establish relationships. Thus, the data was encoded so that the categories could dialogue with the theoretical research reference, which established the criteria for categorization, assuming that the responses could be sorted according to the surveys that used the same theoretical benchmark and the same research instrument (BARDIN, 2004).

3 RESULTS

In the transcript of the results, were transcribed in full the responses of the visually impaired students (VIS,) the Resource Room teachers (PSR) and the Nature Sciences teachers (PCN.) Because of a matter of space, only excerpts of the responses of sighted students were included. It is noteworthy to mention that the letter "E" refers to the interviewer.

For didactic purposes, the presentation is divided into three distinct topics: the 1st addresses the question 1.1; the 2nd the question 1.2; and 3rd addresses the questions 2 and 3 because both deal with similar themes.

Congenital blindness and scientific work

This category covers the responses (Frame 3) of VI students and their Nature Sciences and Resource Room teachers that are related to the categories in Frame 2.

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FRAME 3 – Transcription and categorization of what was said by VI students and their teachers to Q1.1.

EXCERPTS FROM THE TRANSCRIPTS	CATEGORIES FOUND
A1: If you have a lot of willpower and capacity, it's possible.	*Empowerment*
A2. No. [After E explains what scientist is.] VIS2: Yes. (But the student couldn't explain why and chose to move on to another question.)	Do not know
A3: What is a scientist? E explains and repeats the question. A3: Yes. Because she's smart. She studied a lot.	Capacity
PSR1: I don't think so. Think not. Because there's no way a blind person can do the experiments. They need to see what they're doing. That mouse thing, for example. When I was in school, they never made me participate in experiments in Science classes. Chemistry, I participated once—but it was a minor role. I think there's no way a blind person can become a scientist—and I'm blind myself. But it's alright.	Impossibility
PSR2: Yes, provided that the blind person is stimulated since an early age, starting with early stimulation and continuing throughout their academic life. Today we have advanced technological resources that can allow a blind person to become a scientist.	Capacity Supporting resources
PCN1: Yes. If they learn Braille and the laboratory has the necessary, it's possible. But for visual phenomena a helper is required.	Supporting resources Modifications and adaptations of the environment Role of society (or social mediation)
PCN2: Yes, because being a scientist is not conditioned to having sight or not. But if society and the environment in which the blind individual lives isn't accessible or facilitate their access, this individual will certainly have some difficulties. But to be a scientist as in "making science," investigating problems and such, it's always independent of blindness.	Capacity Difficulties for inclusion Supporting resources Modifications and adaptations of the environment Role of society (or social mediation)

Source: Prepared by the authors.

Since there were subjects that didn't know how to position themselves according to the questions, the category "do not know" was created and is present in Frame 3.

Considering this same issue, some sighted subjects (Frame 4) manifested themselves that they believe a congenitally blind individual can be a scientist.

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FRAME 4 – Transcription and categorization of what was said by sighted students to Q1.1.

Excerpts from the transcripts	Categories found
A7: Yes, it's possible, because a person doesn't need to see to do something scientific or to research.	Capacity
A14: Yes, sight doesn't stop someone from getting knowledge.	Capacity Cognition and perception
A4: Yes. Their difference doesn't stop them from becoming whatever they want, they just need to study some more to achieve their goals. Even when someone has a visual deficiency, their other senses are more developed, such as smell, hearing and touch.	Capacity Compensation through other senses
A13: In my opinion, yes, because if the person learned how to read Braille from a young age and the materials used are written this way, the student has the right to choose this profession.	Capacity Supporting Resources
A12: Well, it depends. In theory, yes. But when the person needs to use the microscope and be part of the experiments, I think it's not possible anymore.	Cognition and perception Difficulties for inclusion
A11: It depends. If the person only uses easier equipment, I guess it's possible [...].	Difficulties for inclusion
A8: Like, it's possible. It'll be considerably more difficult—but with dedication the person could do it. A15: Yes, it's possible to become a scientist if they really want to do it. A16: If they find enough willpower to achieve their goals, it's possible. A20: Yes, I don't doubt anything. I think everyone can do whatever they want if they have willpower. A22: Yes, they just need to be really driven and have lots of willpower.	*Empowerment*
A9: No, because the blind person won't manage to identify chemical elements or analyze something with a microscope. A23: No, because they can't see what they're doing. When you're a scientist, you need to see things.	Impossibility
A10: I think so, but only if they have the right equipment and the necessary help.	Role of society (or social mediation) Supporting Resources

Source: Prepared by the authors.

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3.1 Congenital blindness and the nature of light

The excerpts presented in Frame 5 refer to the conceptions of blind students regarding the nature of the light.

FRAME 5 – Transcription and categorization of what was said by VI students and their teachers to Q1.2.

Excerpts from the transcripts	Categories found
A1: They can get a sense of what it is, but they can't see/understand it.	Impossibility
A2: Yes. There are light bulbs.	Unfamiliarity with the concept of light
A3: No, because they can't see.	Impossibility
PSR1: Maybe, if they have some perception of light. E: And what about a congenitally blind individual? PSR1: Who knows nothing about light? One that never saw light? Someone who only sees the dark, all the time? Someone who doesn't has any idea of what light is? I think they could form a concept in their mind of what is "dark" and what is "light." With the help of teachers and other people, it can be done. Right?	Creativity and abstraction Role of society (or social mediation)
PSR2: Yes, when I go out with my blind students in the courtyard they feel the sunshine. They say "the sun is hot, I'm feeling it on my face!"	Unfamiliarity with the concept of light
PCN1: Theoretically, yes. In practice, a congenitally blind person couldn't understand the light at all.	It depends
PCN2: If by nature we're talking about origins, what actually is the light, I think so. But it'll be an abstract concept to this individual, something more theoretical. It'd probably work the same way we understand the space-time concept and spaces with more than three dimensions. We can make analogies to explain, but we have no practical experience of it.	Capacity Creativity and abstraction

Source: Prepared by the authors.

The replies presented below (Frame 6) refer to the conceptions of sighted students regarding blindness and nature of the light.

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FRAME 6 – Transcription and categorization of what was said by VI students and their teachers to Q1.2.

Excerpts from the transcripts	Categories found
A6: Yes, because you don't need to have eyes to see things. You can imagine them. A7: Yes, they can understand the light, but they can't experience it.	Capacity
A19: Yes, and they could feel even more things surrounding them. A22: No, but they could feel the light.	Compensation through other senses
A9: No, because their vision is either something too bright or something too dark. A18: Yes, they can feel things and see shades of light.	Partial knowledge of the concept of blindness
A4: I think it is possible, because even sunlight has its heat. I don't know if it's the same with artificial light or if goes unnoticed usually. A5: I believe so, because, using the sun as an example, we feel it with our bodies, we feel its intensity, its heat. A14: Yes, partly. They can feel sunlight and can study to understand the light.	Unfamiliarity with the concept of light
A10: I think it's not possible because they don't know what light is. But, maybe if someone explained to them, they could understand it.	Difficulties for inclusion Role of society (or social mediation)
A11: No, because for them everything is completely dark.	Impossibility
A13: Yes. If someone explains what light is to them, they can imagine and understand it even without their sight.	Cognition and perception Creativity and abstraction Role of society (or social mediation)
A15: I don't know.	Do not know
A16: It's possible with a good professional helper. A23: Yes, with explanations people can understand it. Someone can tell them it's the opposite of all that darkness.	Role of society (or social mediation)

Source: Prepared by the authors.

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3.2 Congenital blindness, scientific concepts and phenomena

In this topic are presented responses inherent to the conceptions of congenital blindness, scientific concepts and phenomena (Frame 7) relating to Question 2—which asked the subjects about the possibility of the absence of vision contributing or not to the knowledge of different physical phenomena.

FRAME 7 – Transcription and categorization of what was said by VI students and their teachers to Q2.

Excerpts from the transcripts	Categories found
A1: It doesn't interfere, because I know a blind person who goes everywhere and plays football.	Capacity
A2: No.	Impossibility
A3: Oh, like an earthquake! [...] Oh, I know what you're talking about. Rain, earthquake, tsunami. [...] They can feel it and/or hear the television talking about it.	Capacity
PSR1: They can have knowledge of some or many physical phenomena. Earthquake, they'll know if an earthquake is happening if they feel the ground shaking! The sinking of the Titanic, they'll only know when it's actually happening. But rain, they don't need to see the rain to feel it. Hail rain, they can hear the sound the hail makes, or someone can put a hail in their hands. They can indeed know about many physical phenomena. One thing I can't ever see but wanted to know is the moon. The full moon, they say it's a big, beautiful thing. Some time ago, when I was leaving UNIMEP, I got in the car with a friend and she said, "I'm sorry you're blind. The moon is so beautiful today." Then I answered, "But hey, if the moon is so beautiful, you can describe it to me. How is it beautiful?" And she couldn't explain, she just said the moon was very beautiful.	Do not know or Unfamiliarity with the concept of light
PSR2: Sight isn't required to understand physical phenomena, but through some sensorial adjustment we can pass this knowledge to our blind student.	Compensation through other senses
PCN1: Yes. Tactile, auditory and olfactory phenomena can be observed by those who are visually impaired.	Compensation through other senses
PCN2: I agree. Many concepts are abstract and theoretical (intangible) to everyone, it doesn't make a difference if they can see it or not.	Creativity and abstraction

Source: Prepared by the authors.

ARTIGO

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As occurred in another topic, it was also identified here the idea of compensation of blindness through other senses. This view, inherent in common sense, was found in seven answers coming from sighted students (Frame 8.)

FRAME 8 – Transcription and categorization of what was said by sighted students to Q.2.

Excerpts from the transcripts	Categories found
A9: I agree, because we don't need to see something to identify it — especially if it's something ordinary.	Capacity
A4: Sight is very important to humans and animals, but that doesn't mean it's fundamental for life and to identify the physical phenomena. Other senses are sometimes way more important than sight. A15: No, because they can hear and feel things. A17: I don't agree, because they can also feel things. A21: No, because those who are disabled can still hear and feel. A22: Yes. They can feel, they can hear. A23: No. Just because they don't see something doesn't mean they can't feel it.	Compensation through other senses
A8: I agree. Even if you have your sight to make things easier and more interesting, things like distant stars and microscopic beings are invisible to everyone—so there's an equality.	Capacity Cognition and perception
A5: I agree, sight is really important to understand things. But since we have our minds and our creativity, we can imagine anything.	Cognition and perception Creativity and abstraction
A7: Yes, for many physical phenomena sight isn't a requirement. But it can be required to understand some psychological phenomena.	Creativity and abstraction
A13: Yes, I agree [...] It's only necessary that the individual is taught and is willing to learn.	*Empowerment* Role of society (or social mediation)
A10: I agree. Just because this person can't see something doesn't mean they can't learn about it. For example, to read, they can pick a book written in Braille and can feel the dots. This is a valid way of reading.	Supporting Resources

Source: Prepared by the authors.

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The answers regarding Question 3 ("The sensible experience a congenitally blind person has of the light is as small as the experience a sighted person has of the speed of light") are transcribed in Frame 9.

FRAME 9 – Transcription and categorization of what was said by VI students and their teachers to Q3.

Excerpts from the transcripts	Categories found
A1: There's a possibility, yes.	Capacity
A2: Yes.	Capacity
A3: I don't know.	Do not know
PSR1: You have light in the heads, right? Tell me again about the light, let's see if I'll agree or not. The sensory experience? [The question was repeated.] PSR1: No, blind people can learn more about the light. The experience isn't so small, not really. [...] I think there's a way to work around this. Especially if the blind person has some perception of light.	Creativity and abstraction Unfamiliarity with the concept of blindness
PSR2: I partly agree, depending on who the blind person is (there are some who were more stimulated,) they can have some perception of light. Others can't understand the light at all, because it's much too abstract for them.	Impossibility
PCN1: No. Total blindness and the speed of light ($3x10^8$ km/s) are two imperceptible events.	Do not know
PCN2: Yes, because we have no ability to see and perceive many great speeds such as the speed of the light. We can only make comparisons with what we know, we can understand the concept, but we don't see it.	Cognition and perception Creativity and abstraction

Source: Prepared by the authors.

Following are presented the answers of the sighted students regarding Question 3.

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FRAME 10 – Transcription and categorization of what was said by sighted students to Q.3.

Excerpts from the transcripts	Categories found
A13: Even if a congenitally blind person has no experience with light, they can imagine it and know that it's very important.	Creativity and abstraction
A4: I disagree, because when a blind person is born, they can identify something, and I believe their light sensitivity shifts.	Ignorance of the concept of blindness
A7: Well, I think so, because no one can see the light. Anyone who feels heat can close their eyes and learn the answer to this question. A14: Yes, sighted people have as little knowledge of the speed of light as a congenitally blind has about light.	Unfamiliarity with the concept of light
A20: Yes, because they'll never have an experience with the light. They can't ever see the light, but they can understand it through others.	Role of society (or social mediation)
A17: Yes, because a blind person can't understand what light is. A18: No, because they can't see things like I can. A19: No, because they can't see things. A22: No, because they can't see things.	Impossibility

Source: Prepared by the authors.

4 DISCUSSION

To further understand the conceptions of the subjects participating in this survey, some comments regarding the results presented in the previous section are needed.

First, it's important to point out that, when analyzing the responses of VI students and their teachers concerning congenital blindness and scientific work, it was noted that some categories such as **Capacity**, **Empowerment** and **Impossibility** appeared isolated in some answers. Other times, these categories appeared mixed with different categories. However, since the survey was about keeping full transcriptions, it was decided to keep some categories mixed—as it can be seen when **Capacity** is associated with **Support Resources**. It was understood that some responses represented inseparable ideas that should therefore be kept together.

Among the transcribed responses (Frame 3), it is seen that one of the resource room teachers (PSR1), a congenitally blind woman with a PhD, affirms that a blind individual can't perform any scientific work. It is understood that this statement opens some doors to discussions about understanding the nature of science, which can be empirical and inductive. In addition, the surveyed teacher could not have considered her own reality as a blind individual, a PhD student, and a researcher in the area of education.

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On the other hand, some transcripts of sighted students (Frame 4) indicate the possibility of a congenitally blind individual becoming a scientist. This answer appeared in a simple and isolated form, but also associated with other categories such as **Compensation Through Other Senses**.

That answer might have come from the common belief that the absence of sight can be compensated by other senses. Nevertheless, as already mentioned, there is no basis to prove this view.

Regarding what blind individuals answered about congenital blindness and the nature of light, it's observed that there is no common opinion. For example, in Frame 5, blind students emphasized that both of them believe blind individuals can't understand the nature of light. The only one who responded positively was unaware of the nature of light, considering he associated it only to the lamp. Resource room teacher, on the other hand, showed different responses. Two of them (PSR1 and PCN2) state that a blind individual knows the nature of light because, to do so, having creativity is enough. It is noteworthy that PSR1 also points out that the role of society is fundamental in this process. PSR2, however, is unfamiliar with the concept of light. When she states that "the sun is hot, I'm feeling it on my face," she's mixing light and heat.

In turn, analyzing the responses of sighted students on the same subject, it's noted that when considering their lack of knowledge on the concept of light, three of them came up with unexpected answers. As a result, a new category has been identified and referred to as **Partial Knowledge of the Concept of Blindness**.

When stating that "blind individuals can perceive the light," it's considered that this is true to some extent. According to Decree Law Noº 5.296/2004, it is considered blind an individual with a visual acuity (in their best eye and with the best optical correction) smaller than 20/400 (0,05).

Moreover, individuals with visual acuity smaller than the aforementioned are considered blind. In other words, a person doesn't need to be blind to completely lose sight. They can still perceive light while blind, or perceive light and darkness—this is a very common situation to most blind individuals. Thus, blind individuals who don't have any visual acuity are considered a minority. Even then, there are still among them that can distinguish light and darkness without any visual acuity.

Considering the above, there is only one type of blindness: the one in which the eye of the individual does not perceive the light at all. Still, as also mentioned above, a blind individual with zero visual acuity can still perceive the differences between light and dark in some cases.

When analyzing the opinions of the surveyed blind individuals concerning the possibility of absence of sight contributing to their understanding of different physical phenomena, there were noted some misunderstandings from a scientific point of view.

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Usually, they confuse physical phenomena that "don't exist by themselves, but only exist in experience"—such as "colors, sounds, tastes, smells, sensations, etc (Brentano, 1874/1995)" (LEONARDI, 2011, p.8)—with natural phenomena that occur independently of human action.

It's worth mentioning that when addressing the idea of physical phenomena, the surveyed subjects may have thought of natural phenomena in their daily routine or commonly approached by the media. This statement is based on the fact that a mentioned natural phenomenon was the earthquake (Frame 7) as if it were a physical phenomenon.

The responses from the sighted students are not only dissociated from the scientific sense of the physical phenomena, but are also centered on common sense—they often mention that blindness can be compensated through other senses. For example, there is no such a thing as super development of hearing in blind individuals (VIGOTSKY,1997), apud CAMARGO (2016a.) Therefore, there is no way to affirm that the absence of sight is compensated through other senses—though that doesn't mean other senses aren't important, since "the acquisition of information by blind individuals occurs through the combination of tactile, kinesthetic and auditory sensations along with past mental experiences built by this person" (NUNES; LOMONACO, 2010, p.58).

Analyzing the responses given by the visually impaired students regarding the concept of light and its speed, it was found that two of these answers fall into the category **Capacity** (A1 and A2,) though both responses were only one word, without further explanations. The responses coming from the resource room teacher (PSR1) and the natural sciences teacher (PCN2) are related to the category **Creativity and Abstraction** (Frame 9).

Finally, most sighted students consider that a blind individual can't understand the nature of light at all (Frame 10,) which isn't correct because "when observing something we only look at it and forget about every other sensory channels, through which information can still be captured" (ANDRADE, 2011, p.2).

5 CONCLUSIONS

To understand the process of conceptualization in science from the perspective of congenitally blind and sighted students, as well as visually impaired or blind teachers, it was found through this research that the opinion of the surveyed subjects are sometimes centered in common sense (sighted students) or scientifically wrong (congenitally blind or visually impaired students) when concerning physical phenomena.

Analyzing the answers presented and discussed in the previous sections, it is understood that, to some extent, they corroborate the view that "the difficulty in the teaching-learning process lies in the fact that the teachers themselves believe there is no possibility of perception of physical phenomena by those who are visually impaired" (ANDRADE, 2011, p.2.) However, it is known that this is a misconception arising from the habit of associating physical phenomena only with sight (SOLER, 1999 apud ANDRADE, 2011).

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To illustrate the issue, a response from one of the resource room teachers can be cited. When asked about the possibility of a blind individual becoming a scientist, her answer was: *"I don't think so. think not. Because there's no way a blind person can do the experiments. They need to see what they're doing. That mouse thing, for example. When I was in school, they never made me participate in experiments in Science classes. Chemistry, I participated once—but it was a minor role. I think there's no way a blind person can become a scientist—and I'm blind myself. But it's alright."*

It's noted that this teacher forgets there are other sensory channels through which information can be captured. Touch, hearing, sight, taste and smell, for example, can give provide essential information as well (ANDRADE, 2011.) Although the information is received through different sensory channels, they have the same destination: the brain. That's where the information interrelate to produce a more meaningful learning (SOLER, 1999 apud ANDRADE, 2011.)

Although these researchers understand that "sight isn't the *sinequanon* condition to 'know'" (CAMARGO, 2016a, p.40,) they believe that "by definition, sight prevents the complete knowledge of some phenomena and physical concepts." However, the answers provided by this research doesn't meet this view.

Given the above, it is assumed that the subjects of this research—despite their condition of being visually impaired or not—still consider that in a culture of seers, it is natural to establish associations of dependence between thought and vision, knowledge and vision, reality and vision, study and vision, work and vision, in such a way that the visually impaired are considered incapable of performing the indicated functions . Seer culture, by influencing accessibility criteria, makes it difficult for the blind or low vision to perform simple, everyday tasks such as taking a bus, choosing what to eat in a restaurant, counting money, accessing information, crossing a participate in school activities, etc. (CAMARGO, 2008, p. 19).

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