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Adequate and Inadequate Communicational Contexts for the Inclusion of Visually Impaired Students in Electromagnetism Classes

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Abstract

The physics teaching often uses analogies, metaphors, didactic transpositions and other resources that make use of a semiotic language based on models and audio-visual strategies. The effectiveness of learning using strictly this approach has been questioned by several authors, considering both sighted students as visually impaired students. The research analyzed students with disabilities in electromagnetism classes, evaluating the relationship between the languages used and the communicative contexts. As a result, we find be necessary for physics teaching to use other language categories with varying combinations of sensory-perceptual modalities. We demonstrated that didactic strategies such as " tactile-auditory" favor conceptual learning in comparison with activities such as "audio-visual", leading to segregational and authoritory contexts. Moreover, the study concluded that those same strategies should be used simultaneously for seeing students. Thus, the visually impaired students would not be treated in a manner segregated

Keywords: electromagnetism teaching; visual impairment; communicational context; special education needs.

INTRODUCTION

In Brazil, the educational integration of persons with disabilities (visual, auditory, physical and intellectual) has increased, hence mobilizing the physical bases as well as the attitudes. However, this insertion alone does not guarantee the inclusion of these students, which produces discontent and crises. Notwithstanding, this situation has a positive side, for it seeks alternatives to the social adequacy of the new school reality. On the other hand, the crisis that sets in should not be analyzed unilaterally, that is, investments are needed in the research areas, in teacher training and in accessibility. Characterizing school as a social space, guided by respect and the right to expression by multiple differences, is no more than acknowledging human ontology, hence its structuring on this. Inclusion is positioned in a manner contrary to the movements of homogenization and standardization. It defends the right to difference and diversity. It is put into effect through three general principles: the presence of disabled students in regular schools, the adaptation of that school to the needs of all its participants, and adaptation, by providing conditions for students with disabilities in the classroom context. It involves a bilateral adequacy relationship between the educational environment and students with disabilities, in which the first generates, mobilizes and directs the conditions for the effective participation of the latter. In the logic of inclusion, individual differences are acknowledged and accepted and are the basis for building an innovative pedagogical approach. In this new approach there is no room for exclusion or segregation and all students, with and without disabilities, participate fully.

Effective participation is understood as the formation of a particular school activity that gives students with disabilities all-inclusive conditions. Therefore, this can, in addition to clarifying the real educational needs of students with disabilities, serve as a baseline on the occurrence or not of inclusion.

The understanding of inclusion, for effective participation, makes it objective, shows the real difficulties and viabilities found by teachers and students, and explains specific variables related to the educational phenomenon and the characteristics of disability. One of these variables relates to communication in Physics classes that includes the presence of visually impaired students, given that a science classroom can and should be considered as an environment to discuss/share meanings. According to Geraldi (1998), it is the importance of communication processes among the participants in a teaching/learning episode that produces more efficient students, that is, they learned the studied contents more significantly. Following this line of thought, we conclude that the construction of scientific meanings receives the influence of communication structure and context in which a particular language is used. This implies that the communication relationship between teachers and students developed in the classroom are crucial for the emergence and consolidation of teaching/learning processes that would otherwise not occur.

We prepared the research in the physics/science teaching area for blind or low vision students, summarizing the following theoretical approaches. Probably, the first studies on science teaching for visually impaired students were published by the AAIB *(American Association of Instructors of the Blind)*, especially in its 1871 annals.

There is a North American publication on the state of the art in the Science Education area for students with disabilities (Davies, 1994) with more than 1,000 references from the 1920s. Among these are investigations such as the one by Henderson, (1965), who addressed the physics laboratory for blind students, Beck-Winchatz, Ostro (2003), Grady *et al*. (2003), and Gardner (1996) which emphasized the use of resources and specific or adapted teaching materials, as well as different strategies for teaching science and mathematics to visually impaired students, Schleppenbach (1996), Kucera (1996), Kumar *et al*., *(*2001), which address guidelines using information technology, computers, calculators and the Braille system for the students in question.

In The Physics Teacher, we find articles related to Physics Teaching for visually impaired students (Baughman, Zollman, 1977; Rossing, 1977; Weems, 1977; Parry, et al., 1997; Windelborn, 1999). Some of these bibliographies are part of a dossier entitled *Resource Letter EPGA-1: The education of physics graduate assistants*, published by the American Association of Physics Teachers, whose goal is to offer guidance for physics teachers who teach visually impaired students (Jossem, 2000).
A literature review in five major journals in this specific area of Science Education (*International Journal of Science Education, Studies in Science Education, Science and Education, Physics Education e Enseñanza de las Ciencias*) conducted between 2000 and 2010, showed a total of four articles on the subject discussed herein (Rule *et al*., 2010; Ramadas, 2009; Padilla, 2009; Camargo *et al*., 2007). This demonstrates that the recent research focus on science teaching is focused on other areas of interest, as necessary as teaching physics to blind and low vision students.

In Brazil, studies on physics education for visually impaired students have been conducted over the last ten years (These studies focused on the issue of alternative conceptions of blind people from birth and the preparation and coordination of activities for the visually impaired students. The results indicated the non-visual perception potential for the construction of knowledge in physics, as well as a model for the teacher's performance with visually impaired students.

Besides the theoretical framework presented, institutional and non-governmental initiatives have been adopted in several countries, trying to reach a very diverse spectrum of people with all types of disabilities. This includes guidance and specific works on university and pre-university education carried out in nearly every country in the world, and by UNESCO and the World Health Organization. There is, for example, the Scottish institutional program subsidized by the *Scottish Funding Council*, which conveys a national accessibility project through the University of Strathclyde, called '*Teachability Project*'.

A significant part of the aforementioned studies and initiatives implicitly address the inclusion of blind and low vision students in physics classes. They emphasize the creation of methodologies and materials for these students' education. Therefore, since 2005, we have performed in Brazil an investigation that seeks to understand which are the inclusion barriers visually impaired students face in physics classes. The thematic reported here is particularly important in Brazil, which has, through legislation, guidelines and directives, followed the international trend of educational services for students with disabilities through the inclusion process (UNESCO, 1994). It can also assist to understand this process by presenting results related to the particular characteristics of the Brazilian reality, the type of disability (visual) and areas of scientific knowledge (physics).

Thus, we aimed to answer the following question: ***what communicative contexts and language profiles favor and what hinder the communication of the topic electromagnetism for students with visual impairments?***

The Activities of Electromagnetism

This article is part of a long-term study conducted between 2005 and 2010. The purpose of this study is to understand the process of inclusion of visually impaired students in physics classes. The first part of the investigation, which began in 2005, focused on the analysis of lesson plans developed by undergraduate physics students. The second part, begun in 2006, analyzed the implementation of activities in the physics learning environment that included the presence of students with and without visual impairment.

The research procedures followed these steps: (a) monitoring and recording the entire planning process and the implementation of activities in physics teaching in an educational environment that included the presence of students with and without visual impairment (2005). This process will be detailed to follow; (b) transcription of activities – 80 hours of recordings – (2006); (c) development of analysis categories for understanding the educational process in question (2006); (d) analysis of teaching modules (2007 to 2010).

Moreover, the data analyzed here were organized in a course called "The Other Side of physics" offered in 2005 by undergraduate students of São Paulo State University – UNESP – Bauru campus, a Brazilian city in the state of São Paulo. This course was part of the undergraduate students' course and was composed of modules that addressed the following topics: optics, electromagnetism, mechanics, thermology and modern physics. The modules comprised 4 individual activities of 4 hours. The organization to implement the activities occurred in two stages, the preparation time and the defining moment of the educational environment.

The preparation time was characterized by two basic activities performed in the first half of 2005: modules planning and teaching materials, and reflective discussion pertaining to issues related to teaching physics and visual impairment.

At the beginning of the first semester, in the undergraduate course "Physics teaching practices", the undergraduates were randomly divided into five groups according to the physics themes mentioned earlier (modules planning and teaching materials). Once the groups were defined, they received the following educational problem:

"You should prepare a short 16-hour course on the theme chosen by your group, and the physics teaching activities of the mini-course should be suited to the education of students with and without visual impairments".

In the following meetings (reflective discussion), topics related to physics teaching and visual impairment were discussed (Camargo, 2000, 2005). There were two discussion coordinators: (a) a teacher responsible for undergraduate teaching (second author of this paper) and (b) a researcher (first author of this paper). It should be noted that the coordinator (b) has experience with the topic of teaching physics to the visually impaired for the following reasons: (1) he is blind and is a physics teacher. This bestows him practical experience as a visually impaired student and as a visually impaired physics teacher; (2) his master's and doctorate research focused on the subject focused herein.

The undergraduate students determined that the activities would be an extension course to be offered by UNESP for a public high school in Bauru (school 1). The choice of school 1 was due to four factors: (a) This school is associated to UNESP; (b) A good relationship between the school and UNESP; (c) Similar courses have already been successfully applied in this institution; (d) Proximity between school and UNESP. This proximity facilitated the students' journey. Once the agreement was signed with this school, the second stage began.

At the beginning of the second semester of 2005, the undergraduate students began a dissemination stage for the students of school 1. The number of vacancies for student participation was thirty-five, and the number of those who registered was of approximately seventy students. The thirty-five students of school 1 were randomly chosen.

Parallel to the dissemination process described, we contacted another public school in Bauru to invite students with visual impairments to participate in the aforementioned course (school 2). This new school was contacted because at the school there were no visually impaired students enrolled. School 2 has a teaching room that meets the educational needs of visually impaired students in the region of Bauru (e.g., teaching of Braille, transcribing texts or exams into Braille). Two visually impaired students were interested in participating in the course. One student was born blind and the other one lost his vision over time. We clarify that these students were studying in different schools. School 2 offered them a support educational service, not a substitute for regular education.

The electromagnetism group was composed of four undergraduate students who alternated between the roles of coordination and support activities. With the procedures described, a learning environment similar to a regular room was set up. In this environment, the undergraduate students performed their course program addressing the theme of inclusion.

ANALYSIS METHODOLOGY

The audio-visual recording and the full transcript of the activities comprised the analysis *corpus* with the following procedures: exploring the material; processing and interpretation of results to conduct a thematic analysis - content analysis technique (Bardin, 1977) which enabled us to identify the feasibility and difficulties of communication between the teachers and the visually impaired students. The evaluation of communication feasibility or difficulty was guided by the visually impaired students' access to the information conveyed in the classroom. The accessibility, in turn, took into account the language characteristics of the student's "visual history", in other words, if he was born blind or lost his vision over time.

In the process of exploring the material, we performed the fragmentation of *corpus* analysis (Bardin). For fragmentation, we enclosed passages containing the undergraduate and students with and without visual impairment speech characterized by the same language and the same communicative context. After fragmentation, we organized two types of groups: (a) of the passages that contained similar language, and (b) passages characterized by the same communicative context. With the grouping (a), it was possible to identify the language that generated communication feasibilities and difficulties, and with group (b), the identification of communicative contexts. Once the languages and contexts were explained, we established relationships between these variables in order to understand the contextual frequency of a given communication feasibility or difficulty. These will be presented in the data analysis.

Because the maximum dimensions allowed for submission of articles in this journal, the results emphasize the communication feasibilities and difficulties experienced only by the student who was born blind (identified in the text as a student "B"). The results of the analysis of the student "A" will be addressed elsewhere.

Criteria to Characterize the Linguistic Profile

Identifying the characteristics of a given language was based on two structures: empirical and semantic-sensorial. The empirical structure refers to the way in which specific information is materialized, stored, transmitted and perceived. It is organized according to basic sensorial and mixed codes, where the first ones represent unitary or independent codes (visual, auditory, tactile, etc.), and second ones, interdependent codes (audio-visual, tactile-auditory, etc.).

The sensory-semantic structure refers to the effects produced by the sensory perceptions in the meaning of phenomena, concepts, objects, situations and contexts. These effects are understood by four associative references between meaning and sensory perception: inseparable, association, unrelated and secondary related. Inseparable meanings are those whose mental representation is dependent on a specific sensory perception. These meanings can never be represented internally by different sensory perceptions from those that constitute them.

Associated meanings are those whose mental representation is not exclusively dependent on the sensory perceptions used to register or describe them. They will always be represented through different sensory perceptions than the first ones.

Unrelated sensory meanings (or without sensory relationship) have no connection or association with any sensory perception. While the learner may construct sensory mental representations about ideas with the characteristic, they never actually correspond to the phenomena/concepts intended to be communicated. The mental representations with the semantic-sensory feature discussed here will always be in the analog, metaphorical and artificial level. These are abstract meanings referring to the hypothetical constructs prepared to explain the phenomena, effects, properties, etc.

Secondary related sensory meanings (or secondary sensory relationship) are those whose understanding establishes a non-priority relationship with the sensory element. In other words, although there are mental representations of sensory constructions by the learner, they do not represent a prerequisite to understanding the phenomenon/concept that is addressed.

Thus, the characterization of languages obeys the relationship: **Language = (empirical structure) + (semantic-sensory structure).**

The evaluation of a feasibility or communication difficulty took into account the fact that a given language made available, or not, the meanings it transmitted to student (B). In other words, accessibility was evaluated due to the communicative potential of the language's empirical and semantic-sensory structures, compared with the visual characteristic of the student (blind at birth). Next, we elucidate, respectively, the languages that generate difficulty and communication feasibility.

Profile of Languages Generating Communication Difficulty and Feasibility

Languages generating difficulties

We identified 92 communication difficulties among the undergraduate students and student (B), which were grouped in four different linguistic profiles. These profiles comprised the following empirical structures: (a) basic structure: independent auditory and visual; and (b) mixed structures: interdependent

audio-visual and interdependent tactile-auditory. The characteristics of such structures are described next.

Independent auditory and visual. Is characterized by the independence between the auditory and visual codes that serve as support material. This takes place, for example, when the same information is projected and spoken. Therefore, the level of oral detail determines quality standards of accessibility to the information transmitted.

Interdependent audio-visual. Is characterized by mutual dependency between the auditory and visual codes that provide material support to the information transmitted. From an empirical point of view, access to languages with this feature can only be achieved through the simultaneous observation of the codes mentioned, since the partial observation of one of the codes does not undo the interdependence of its material support.

Interdependent tactile-auditory. Is characterized by mutual dependency between the tactile and auditory codes that provide material support to the transmission of information. From the empirical point of view, access to languages with this feature can only be achieved through the simultaneous observation of the codes mentioned, since the partial observation of one of the codes does not undo the interdependence of its material support.

Regarding the semantic-sensory aspect, the electromagnetic meanings addressed were related to two structures:
a) Meaning associated to visual representations. Examples: (1) visual records of the electrification processes (contact and induction), electric field energy lines, visual record of resistor, electric generator and receiver and magnetic dipole, visual records of magnetic field line (magnets, the Earth, etc.); (2): mathematical formalism for the treatment of electric and magnetic phenomena. Examples: Coulomb's law, electric current, the second law of Ohm, scientific notation, record of the units of magnitudes, equation and graph of the electric generator and receiver (development of problems involving calculations); and (3) use and reading of values in measurement instruments (Galvanometer, Voltmeter and Ammeter);

b) Meaning of inseparable visual representations: Examples: visual characteristic of colors associated with the phenomenon of aurora and australis borealis and visual idea of light energy.
Next, we explain the languages generating communication difficulties, examples and number of sentences by the undergraduate students.

Interdependent audio-visual/meaning associated to visual representations (89 problems).

Example: If I have q1 and q2, I have a distance; if I raise it here, it has to decrease there. This "here" number is much higher, this division will then be much lower.

Interdependent Audio-visual/inseparable meaning of visual representations (1 difficulty)
Example: The solar wind hits the magnetic field lines on earth, and this interaction causes the occurrence of auroras, and when they this, they release energy. This energy is released as light in colors of green or pink, green for oxygen and pink for nitrogen.

Independent visual and auditory/visual representations associated to meanings (1 difficulty).
Example: In metals resistivity ranges from 1.72 times ten to less than eight times hom meters to 5.51 times ten to less than eight; in the semi-conductor 3.5 times ten to five, 2.3 times ten to less than six, in insulating materials, approximately ten elevated to twelve, then the difference is very high.

Interdependent tactile-auditory/inseparable meaning of visual representations (1 difficulty).
Example: This lamp, subjected to a voltage of 110 volts, will have electric current passing through it, will also convert electrical energy into light energy (lit lamp is brought close to student B, but does not touch it)

The transmission of associated and inseparable meanings of visual representations was the basis for communication difficulties between the undergraduate students and student (B). These difficulties, through empirical language structures, were intended for visually dependent access (interdependent audio-visual) and visually independent access (interdependent tactile-auditory and independent auditory and visual). Thus, difficulties caused by visually dependent language access are based on the empirical structure and, on the semantic-sensory structure of the meanings discussed (mostly meanings related to visual representations).

The difficulties generated by visually independent language access are based on the semantic-sensory structure of the meanings discussed (inseparable meaning and linked to visual representations). Languages made up of interdependent audio-visual empirical structure represent the main communication barrier between the undergraduate students and student (B), by the number of times they were identified (around 98%), as well as by the way they organized the transmission of meanings (simultaneous observation of auditory and visual codes that give material support to the information transmission).

Languages that generate feasibility

We identified 122 communication feasibilities between the undergraduate students and student (B). These feasibilities were grouped according to 10 linguistic profiles (10 languages accessible to the students). The accessible languages were based on the following empirical structures: (a) Fundamental structures: basic auditory and visual and independent auditory, and (b) Mixed structure: interdependent tactile-auditory. The characteristics of the fundamental auditory structure are presented next. The characteristics of the auditory empirical structures and independent visual and interdependent tactile-auditory were presented earlier.

Basic auditory. Is characterized by having only sound codes. Access to languages with this empirical structure takes place through auditory observation of the codes mentioned (single support material).

Regarding the semantic-sensory aspect, the meanings conveyed by the accessible language were related to four structures.

a) Meaning associated to non-visual representations: Examples: the process of electrification by friction, electric field energy lines, symbolism of the elements of a given electrical circuit, crystal structure of a conductor, position of electrons, protons and neutrons in the atom, analogic tactile-descriptive structure of Ohm's second law (conductor area, conductor length and conductor resistivity), analogy of the ideas of potential difference, electrical current and electrical resistance, magnetic field lines, etc. The transmission of meanings for those elements mentioned took place through mockups or equipment that could be touched, handled and aurally observed. Such mockups and equipment were built by the undergraduate students.

b) Meaning of secondary sensory relation - Examples: danger of lightning, purpose and operation of a lightning rod, ray effects on electrical appliances, construction and operation of the Faraday cage, operation of a receiver, discovery date of amber, construction date of electrification equipment, origin of the capacitor, name of who discovered the lighting rod, date of Coulomb's law, date and creator of the battery, strongest developmental period of electricity, electrical components and the electrostatic studies, the function of the electroscope, etc;

c) Inseparable meaning of non-visual representations - Examples: electric current heats the shower, electric current produces shock, in any receiver there is energy loss in the form of thermal energy, 90% of the electricity in a lamp is transformed into heat energy, electric current heats the wire conductor, electric current heats the lamp, texture and hardness of a HD magnet, etc;

d) Meaning without sensory relationship - Examples: proton/positive charge, electron/negative charge, neutron/neutral charge, what is magnetic field, what is electric field, the purpose of the capacitor is to store electrical energy, difference between positive and negative electricity, electric current produces a magnetic field, meaning of electricity.

Next, we explain the languages that generate communication feasibilities, examples of the undergraduate students' sentences and the frequency they were used.

Basic auditory/meaning of secondary sensory relationship (27 feasibilities).

Example: Science is not complete, nor is Einstein's theory true. As scientists say, there is not one truth but truths; one theory complements another.

Interdependent tactile-auditory/meaning linked to non-visual representations (26 feasibilities).

Example: In your left hand, if you continue to the left across these triangles here, its representation is the negative charge that is in your right hand; this is the positive one, you will notice that parts of these wires are not smooth, in fact some will have little arrows that were hung around those wires that are showing direction. In this case, you will observe that it indicates that the line of the electric field always leaves the positive charge to go to the negative one.

Independent auditory and visual/meaning of secondary sensory relationship (24 feasibilities).

Example: The first reports on electricity were at around 640 BC with Thales of Miletus. What did Thales of Miletus do at this time? He discovered the property of amber.

Basic auditory/meaning linked to non-visual representations (17 feasibilities).

Example: Imagine two positively charged spheres: positive spheres repel, one then goes to one side and the other goes to the other side, to opposite sides, let's assume that one goes to your right and another goes to your left.

Independent auditory and visual/meaning linked to non-visual representations (10 survivals).

Example: Andrew Marri Amper observed that a wire carrying electric current shows a certain movement when it is in a magnetic field.

Interdependent tactile-auditory/inseparable meaning of non-visual representations (5 feasibilities).

Example: These electrons tend to all go in one direction, but they clash with these balls representing the atoms, and the shock they have with the atoms causes them to heat, each atom heats up.

Independent auditory and visual/meaning has no sensory relationship (5 feasibilities).

Example: In the first half of the nineteenth century, it was proved that electric current produces a magnetic field.

Basic auditory/inseparable meaning of non-visual representations (4 feasibilities).
Example: An example of the effects of current is the shower device that heats the water.

Basic auditory/meaning without sensory relationship (3 feasibilities).
Example: According to Faraday, the magnetic field is an area in which there is a magnetic interaction between two objects that have magnetic properties. The idea of a magnetic field is complicated because the field is not a tactile thing, you cannot touch it, you cannot feel it, you cannot see it, it is something that is dispersed in the air, is not something with which you can have direct contact.

Interdependent tactile-auditory/secondary sensory relationship meaning (1 feasibility).
Example: This that your hand is touching is a voltmeter (undergraduate's hand leading Student B). It measures the voltage and measures the current depending on how you hold the button.

For the undergraduate students and student (B), there was the transmission of associated and inseparable meanings of non-visual representations, as well as unrelated sensory and secondary sensory relationship. This transmission was through languages comprising empirical structures of visually independent access, namely: basic auditory, independent auditory and visual and interdependent tactile-auditory. Next, we analyze the accessible and inaccessible languages in the communicational context in which they were employed.

Communicational context

Once the suitable and unsuitable languages were identified and characterized, we worked towards understanding in which communicative contexts these languages were used. We defined the communicational context based on two variables: time of activity and standard discourse. In other words, to determine the communicational context, two categories will be related, that is, the visually impaired student's participation in the activities (time category), as well as the discursive characteristic established on these occasions (standard discourse category).

Analysis Categories

Category 1 (time). This concerns the instructional space determined by the undergraduate students to organize the presence of the visually impaired student. These were two spaces: for the episodes, and the particular episodes.

a) **Episodes:** This concerns the common teaching spaces for students with and without visual impairment, in other words, the times in which all students were engaged in the same tasks coordinated by the undergraduate students. A key feature of the episodes is not differentiating the contents, methodological strategy and instructional resources for students with and without visual impairments.

b) **Particular episodes:** This relates to the teaching space that only had the presence of student (B), That is, it took place separately and concurrently with the classes for students without visual impairments. The central feature of these episodes is the differentiation of the teaching resources used, the methodological strategies employed and the content or its approach, when compared to the participation of students without visual impairments.

Category 2 (Standard discourse). This category is based on the ideas of Mortimer and Scott (2002), and will be used as theoretical reference in the interpretation of the standard discourse of the group activities in electromagnetism. This characterizes the interactive relationships between the undergraduate students and students. This characterization will be done according to two discursive dimensions; interactive or non-interactive discourse, and dialogical or authority discourse.

The difference between the interactive and non-interactive discourse is by identifying the number of "voices" participating in a particular discursive event. Thus, Mortimer and Scott (op. cit.) defined as interactive discourse that which has the participation of more than one person, and non-interactive discourse as that which occurs with the participation of only one person. For example: if in a class only the teacher speaks, the discourse is not interactive, while if during class there is student participation (doubts, questions, etc.), the discourse is interactive.

The differences between dialogic and authoritative discourse takes place considering one or more discursive contents. As indicated by Mortimer and Scott (op. cit.), if more than one "voice" is considered, the discursive standard is dialogical, while if only one "voice" is heard and accepted, the standard discourse is of authority. In other words, in dialogic discourse, various types of opinions or viewpoints are accepted, and in the discourse of authority, just one opinion or viewpoint is taken into account.

With the relationships in the dimensions described, Mortimer and Scott (op. cit.) defined four patterns that characterize the discursive interactions between teachers and students in the science classroom. These standards are:

a) Interactive/dialogic: the exploration of different ideas, points of views, issues, questions, etc. This kind of discursive standard is based on dialogic argumentation, whose characteristics are as follows: (a) the occurrence of sharing ideas (students/students and students/teacher); (b) clashes of ideas among class participants; (c) active participation of students in the discussion process through the explanation of ideas, conclusions and internal conflicts.

b) Non-interactive/dialogic: reconsideration of teachers regarding different viewpoints, highlighting similarities and differences of the students' ideas. In an argumentative dialogue, a teacher's role is to mediate the students' ideas. This mediation can take place through a non-interactive/dialogic discourse, in which the teacher takes on the role of organizing the ideas discussed by combining the similar and different points of views.

c) Interactive/authoritative: in order to achieve a predetermined goal, the teacher guides the students through a set of questions and answers. This standard discourse is based on a Socratic argumentative profile, whose characteristics are as follows: in a Socratic argument, the teacher has the role of conducting the scientifically accepted ideas, using constant reformulations of questions until the students have the desired response.

d) Non-interactive/authority**:** the teacher presents a particular viewpoint without hearing the students' views. This type of standard discourse is characterized by a rhetorical argument, because the teacher has the role of convincingly transmitting contents.

With the categories presented, the communication context is defined by the relationship: *(Time)* + *(Standard discursive)*

Next, we explain and analyze the relationship between communicational context and suitable and unsuitable languages. This is to understand which are the communicational contexts that favor and hinder the use of accessible languages to visually impaired students.

DATA ANALYSIS AND RESULTS

Thus, 92 (4 linguistic profiles) communication difficulties were identified for student. As for viability, there were 122 (10 profiles linguistic) – a total of 214 occurrences of difficulty/ feasibility. Next, we explain the relationships: communication context/language generating difficulty and communication context/language generating feasibility.

Communication context/language generating difficulties

Table 1 shows the relationship between the communicational context and the language generating difficulty, as well as the quantitative impact of this relationship. The communicative contexts and languages are shown in a decreasing sequence of occurrence.

Table 1 indicates that the linguistic profile generating difficulty was more common in certain communication contexts.

This analysis emphasizes the communication context/inaccessible language relationship for the student blind at birth. These numbers indicate eight important characteristics of the communication difficulties:

a) a majoritarian presence of difficulties related to the interdependent empirical audio-visual structure;
b) a majoritarian presence of difficulties associated to the meanings related to visual representations;
c) the difficulties from the interdependent audio-visual empirical structure were practically entirely related to the meanings associated to the visual representations;
d) the inseparable meanings of visual representations discreetly participated in the set of communication difficulties;
e) there were no difficulties in the particular episodes;
f) the episodes common to all students were mainly characterized by the use of interdependent audio-visual empirical language structure;
g) interactivity proved to be a discreet factor of difficulty;
h) there were no relationship difficulties: interactivity/visually independent empirical language structures (interdependent auditory-tactile and independent auditory and visual);

Table 1. Shows the variables: communication context and inaccessible languages

Communicational context (right) Language (below)	non-interactive/ authority episode	interactive/authority episode	Frequency/Percentage horizontal
Interdependent audio-visual / meaning linked to the visual representations.	85	4	89/96.74%
Interdependent audio-visual / inseparable meaning of visual representations	1	0	1/1.08%
Independent visual and auditory / visual meaning of representations	1	0	1/1.08%
Interdependent tactile-auditory / inseparable meaning of visual representations	1	0	1/1.08%
Frequency/percentage/ vertical	88/95.65%	4/4.35%	Total 92/100%

Communicational context/language generating feasibility

Table 2 explains the relationship between communicational context and language generating feasibility, as well as the quantitative impact of this relationship. The communicative contexts and languages are shown in a decreasing sequence of occurrence.

Table 2 indicates that the linguistic profile generating feasibility was more common in certain communication contexts. The data indicate ten expressive characteristics of the communication feasibilities for the electromagnetism group:

a) Prevalence of viabilities in the communicative contexts common to all students;

b) Prevalence in the contexts common to all students, use of empirical structures: basic auditory and independent auditory and visual;

c) Prevalence of feasibilities related to the meanings of secondary sensory relationship (factual contents);

d) The "non-interactive" and "authority" elements were appropriate for the secondary sensory relationship meanings;

e) Frequent occurrence of feasibilities related to the meanings of inseparable non-visual representations in episodes characterized by the "interactivity" element;

f) The particular episodes facilitated the use of interdependent tactile-auditory empirical language structures, as well as the meanings related to non-visual representations;

g) Occurrence of viability related to the interdependent auditory-tactile empirical structure in episodes of non-interactive/authority and interactive/authority;

h) The occurrence of feasibility related to the electromagnetic meanings without sensory relationship;

i) Higher number of feasibilities in interactive communication contexts and/or of authority;

j) The occurrence of: feasibility/interdependent audio-visual empirical structure relationship;

Table 2. Shows the variables: communication context and accessible languages.

Communicational context (right) Language (below)	Non-interactive/ authority episode	Interactive/ authority episode	Interactive/ authority particular episode	Interactive/ dialogical episode	Non-interactive/ authority particular episode	Frequency/ Percentage/ horizontal
Basic auditory/meaning of secondary sensory relationship	8	15	4	0	0	27/22.13%
Interdependent tactile-auditory/meaning associated to non-visual representations	4	8	11	0	3	26/21.31%
Independent auditory and visual/meaning of secondary sensory relationship	23	1	0	0	0	24/19.67%
Basic auditory/meaning associated to non-visual representations	6	7	0	4	0	17/13.93%
Independent auditory and visual/meaning associated to non-visual representations	5	3	0	2	0	10/8.20
Interdependent tactile-auditory/inseparable meaning of non-visual representations	1	4	0	0	0	5/4.10
Independent auditory and visual/unrelated sensory meaning	4	1	0	0	0	5/4.10
Basic auditory/inseparable meaning of non-visual representations	1	2	1	0	0	4/3.28%
Basic auditory/unrelated sensory meaning	2	1	0	0	0	3/2.46%
Interdependent tactile-auditory/secondary sensory relationship meaning	0	0	1	0	0	1/0.82%
Frequency/Percentage/Vertical	54/44.26%	42/34.43%	17/13.93%	6/4.92%	3/2.46%	Total 122/100%

Particular episodes: feasibility that generated difficulties at methodological level

We now discuss a factor interpreted as a methodological difficulty, in other words, the occurrence of particular episodes during the activities of the electromagnetism group (see feasibility f). Note that that we are not opposed to individualized attention to any students, only that which represents an exclusionary differentiation.

Particular episodes result from trying to overcome communication difficulties, therefore, can be seen as a paradoxical question. These difficulties were predominantly found in communicative contexts, which used an interdependent audio-visual empirical language structure. In other words, when seeking alternatives for the communication problems, the undergraduate student/teachers placed the blind student in a corner of the classroom, separated from the other students. This practice was similar to the main class, characterized by low-voiced dialogues (in whispers), and coordinated by a different teacher than the one ministering the activity to the seeing students. Moreover, during the particular episodes, topics discussed during the class differed from those of all students, which divided the blind student's attention with regards to the explanations for the particular environment and the common environmental.

Therefore, particular episodes comprised segregative learning environments within the classroom and represent a methodological difficulty to be overcome. The individual attention observed in communication contexts, which expected such practice with all the students, was not considered in the particular episodes.

DISCUSSION

We observed that the difficulties for the effective participation of blind students were predominantly related to the use of interdependent audio-visual empirical language structures in non-interactive/authority contexts. In these environments, inseparable and interrelated meanings and visual representations were related. As an alternative to the difficulties in the context considered, the undergraduate students-teachers conducted individualized and simultaneous attention events, which created a difficult methodological setting, namely the creation of a segregated environment within the classroom. However, the tactile mockups were used in those environments, which established channels of communication between the teacher and blind student (use of interdependent tactile-auditory empirical language structure).

However, non-interactive/authority episodes were adequate to transmit secondary sensory relationship meanings, as well as without sensory relationship. In general, these meanings were conveyed by basic auditory and independent visual and auditory empirical language structures. Another important aspect is that the interactive episodes facilitated the transmission of meanings related to non-visual representations, which is a fundamental factor to establish communication channels between the teacher and blind students in electromagnetism activities. This area of physics predominantly deals with meanings of empirically not observable phenomena, and therefore become perceived or represented by records or visual schematics (e.g., electric field energy lines and magnetic field lines).

Thus, we observed particular episodes in the activities of the electromagnetism group. In these episodes, there was a predominant use of interdependent tactile-auditory empirical language structure, such a structure is suitable to transmit meanings related to non-visual representations. Moreover, these episodes represent an exclusionary differentiation with regards to the effective participation of blind students in activities. For this reason, it is important to seek electromagnetism activities in communicative contexts that favor individualized attention for all students, with or without visual impairment. In other words, individualized attention to blind students during the main lesson is perceived as inadequate, and furthermore, by a different teacher than the one coordinating that class. In general, in these separate environments, the contents covered differ from those in the classroom and divide the blind student's attention.

CONCLUSIONS

This article presented a study that identified the main barriers visually impaired students face in Physics classes. Was aimed at understand that communication contexts favor and complicate the participation of visually impaired students in electromagnetism activities. Therefore, the study defined, from empirical and semantic-sensorial structures, the languages used in the activities, as well as the moment and the standard discourse these languages were used. With the outcome, it identified a strong relationship between the uses of the interdependent empirical audio-visual language structure in non-interactive episodes of authority, the decreased use of this structure in the interactive episodes, the creation of segregated learning environments within the classroom and the frequent use of interdependent tactile-hearing empirical language structure in these environments.

Finally, communication is a central variable for school inclusion of visually impaired students. The creation of appropriate communication contexts has the potential to include such students in the intrinsic teaching/learning processes. Without appropriate communication contexts, students with visual impairments will be in a condition of exclusion within the classroom. By setting up a suitable communication environment, these students will have the basic structural conditions for the effective participation in teaching/learning processes of electromagnetism.

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