ACTIO: Docência em Ciências
ISSN: 2525-8923

http://periodicos.utfpr.edu.br/actio

Multisensory didactics and physics education: an inclusive proposal on heat absorption by objects of different colors for students with visual impairments

Natã Nadher Rezende Feitoza
natanadher.re@gmail.com
orcid.org/0009-0000-7736-1822
Universidade Federal de Itajubá (UNIFEI), Itajubá, Minas Gerais, Brasil

Denise Pereira de Alcantara Ferraz
deferraz@unifei.edu.br
orcid.org/0000-0002-1491-5741
Universidade Federal de Itajubá (UNIFEI), Itajubá, Minas Gerais, Brasil

ABSTRACT

This study aims to analyze the viability of applying an inclusive practical-experimental activity on heat absorption, using the Multisensory Didactics as a theoretical approach. The theoretical framework is based on teaching practices that incorporate multiple senses to promote learning, especially for students with visual impairments. The experiment involves five screens of different colors, each identified with the corresponding color in Braille and a tactile tape, facilitating reading by individuals with visual impairments who master the Braille system. These screens are exposed to a light source, which provides heat to them in pairs, allowing comparisons between color and heat absorption. The research adopts a qualitative methodology, composed of two phases: the first phase involved the participation of two individuals with visual impairments, with the intention of validating the usability and accessibility of the activity, while the second phase consisted of testing the activity with a class of non-visually impaired students. One of the main focuses of the analysis was the time required to interpret the results, considering the temperature variation and the identification of the screen colors, since time is a crucial factor to ensure equitable interaction between students with and without visual impairments. Although the interpretation time between the visually impaired volunteer and the test group presented a significant difference, this difference was minimized when compared to the performance of the Braille teacher, who participated in the validation. The activity demonstrated great potential for inclusive learning, being accessible to both typical students and those with visual impairments, promoting an equitable and enriching teaching experience.

KEYWORDS: Physics Teaching; Inclusive Education; Blind's Education.

Didática multissensorial e o ensino de física: uma proposta inclusiva sobre absorção por objetos de cores diferentes para estudantes com deficiência visual

RESUMO

Este trabalho tem como objetivo analisar a viabilidade de aplicar uma atividade prático-experimental inclusiva sobre absorção de calor, utilizando a Didática Multissensorial como abordagem teórica. O referencial teórico fundamenta-se nas práticas de ensino que incorporam múltiplos sentidos para promover a aprendizagem, especialmente para alunos com deficiência visual. O experimento envolve cinco anteparos de cores diferentes, cada um identificado com a cor correspondente em braille e com uma fita tátil, o que facilita a leitura por pessoas com deficiência visual que dominam esse sistema de escrita. Tais anteparos são expostos a uma fonte luminosa, a qual fornece calor para pares de anteparos, permitindo comparações entre cor e absorção de calor. A pesquisa adota uma metodologia qualitativa, composta por duas fases: a primeira envolve a participação de duas pessoas com deficiência visual, com o intuito de validar a usabilidade e a acessibilidade da atividade, enquanto a segunda fase, por sua vez, consiste em testar a atividade com uma turma de alunos normovisuais. Um dos focos principais da análise é o tempo necessário para interpretar os resultados, considerando a variação de temperatura e a identificação das cores dos anteparos, visto que o tempo é um fator crucial para garantir uma interação equitativa entre alunos com e sem deficiência visual. Embora o tempo de interpretação entre a voluntária com deficiência visual e a turma teste tenha apresentado uma diferença significativa, esta foi minimizada quando comparada ao desempenho da professora de braille, que participou da validação. A atividade, além de promover uma experiência de ensino equitativa e enriquecedora, demonstrou um grande potencial para a aprendizagem inclusiva, sendo acessível tanto para alunos típicos quanto para aqueles com deficiência visual.

PALAVRAS-CHAVE: Ensino de Física; Educação Inclusiva; Educação dos Cegos.

INTRODUCTION

Physics teaching, especially in non-formal settings, has been recognized through research as a relevant area for both research and scientific literacy, as well as for the training of future teachers (Jacobucci, 2009; Gruzman & Siqueira, 2007; Monteiro et al., 2014). However, when incorporating Special Education into the Inclusive Perspective, Physics teaching presents challenges, even when mediated by practical-experimental activities — a common approach in museums and science centers. This is because traditional teaching in these contexts is generally based on visual and auditory stimuli. In this scenario, Multisensory Didactics emerges as an alternative by promoting activities that diversify sensory channels, allowing interaction through other senses, in addition to vision and hearing (Guridi, Darim & Crittelli, 2020; Ferreira, Camargo & Santos, 2011).

Science teaching through experimental activities is widely recognized as an effective pedagogical strategy, both for the appreciation of teachers and for the positive perception of students involved in these practices (Galiazzi et al., 2001; Reginaldo, Sheid & Gullich, 2012; Cassano, Muzzio & Góes, 2022). These activities can be structured in different ways: they can foster student autonomy, encouraging more open investigations and scientific maturity, or function as a starting point for the introduction of new concepts, as well as for the verification of theories already taught. Regardless of the approach adopted, experimental activities have the potential to promote the learning of scientific concepts, even when used only as a demonstration (Araújo & Abib, 2003).

One of the strengths of teaching Physics through experimental activities is the openness to error and the complexification of concepts. The construction and reconstruction of ideas promotes the understanding that science reproduces reality within specific limits and conditions, facilitating its understanding (Malheiro, 2016).

In this context, this article investigates the applicability of a practical-experimental activity aimed at teaching Physics, articulated with Multisensory Didactics (MD), with an emphasis on usability and accessibility. The experiment explored the absorption of light by objects made of the same material, but with different colors, using temperature as an indicator of the interaction between light and object. Based on the principles of MD, the activity was adapted to include tactile tapes written in Braille, allowing each color to be identified by name, which expands the possibilities of sensory interaction.

The central issue of this research is the accessibility and usability of the practical-experimental activity, with special attention to the inclusion of visually impaired students in activities with typical students. In this sense, equity in interactions between participants is a fundamental concern, raising the question of to what extent the adaptation of the activity can compensate for the needs of students with disabilities without creating segregation, that is, without dividing the activities into "specific for people with disabilities" and "for teaching Physics in general." The central purpose of the work is to prevent adaptations, instead of fostering inclusion, from accentuating the division between different student groups. To this end, this research had as its general objective to investigate the feasibility of implementing a practical-experimental activity based on Multisensory Didactics. As specific objectives, it was proposed: A) evaluate the usability and accessibility of the experimental activity in classes composed of students with and without visual impairment; and B) identify the inclusive potential of the experimental practice as a mediator of equitable interactions between different groups of students.

This paper is structured as follows: in addition to this introduction, which contextualizes the theme and objectives of the research, Section 2 presents the theoretical basis that supports the study. Section 3, in turn, details the methodology used, while Section 4 presents and discusses the results obtained. Finally, Section 5 summarizes the conclusions of the study and proposes directions for future research.

THEORETICAL BASIS

This work is based on the understanding of disability from the historical-cultural theory, which sees it not only as a physical/biological condition, which must be treated by medical means with the sole purpose of normalizing the individual, but also as a phenomenon constructed historically and conditioned by the cultural context in which the individual lives. From this perspective, the impact of disability on a person's life can vary significantly depending on the sociocultural environment in which they are inserted. In certain contexts, for example, disability can result in social exclusion, while in others, it can be minimized or even go unnoticed (Leite & Lacerda, 2018). An example that illustrates this variation is that of the Urubu Kaapor tribe, in which, due to the high number of people with hearing impairments, a linguistic system of its own was developed that fully integrates deaf individuals into community life (Abreu & Periva, 2022).

In this sense, disability, in a human context, is an experience strongly influenced by the sociocultural context. Proof of this is the existence of cultures that lead individuals to believe that people with disabilities carry divine traits or to see this group as a threat that must be exterminated from the environment. Therefore, disability should not be denied, but rather circumvented, with mechanisms that Vygotsky calls “compensation”. This means that it is necessary to focus on the potential present in the individual with disability and seek, through this, their development (Adams, 2020, p.12). When aiming at building a more inclusive society, the concept of Universal Design for Learning (UDL) (Zerbato & Mendes, 2018) emerges, which inspires approaches such as Multisensory Didactics (MD). MD, initially presented by Soler (1999), proposes a reformulation of pedagogical practices so that teaching contemplates several sensory channels, reaching a broader and more diverse audience.

In the traditional educational context, the emphasis is predominantly on the visual and auditory senses (Guridi, Darim & Crittelli, 2020; Ferreira, Camargo & Santos, 2011). MD breaks with this limitation by proposing a teaching that encompasses not only sighted and hearing people, but also explores other sensory channels, such as touch, temperature and balance. In this way, MD aims to promote a more inclusive education, benefiting all students, with or without disabilities.

In line with this perspective, it is clear that sensory diversification in education is not only advantageous for students with disabilities. As demonstrated by Hehir et al. (2016), inclusive education generally brings positive or neutral results for students without disabilities, with the exception of severe cases. Thus, in addition to DM offering opportunities for effective participation for students with disabilities, it also enriches the learning process for typical students.

Practical experimentation is seen as a positive way to diversify the approach and is valued for its use, especially when dealing with science teaching (Reginaldo, Sheid & Güllich, 2012). However, there are different possible approaches for experimentation to be used in classes or in science centers.

To illustrate, Higa & Oliveira (2012) present three models of learning through experimentation. The first conception uses experimentation to validate and verify the theory previously taught by the teacher/book/didactics; the second model understands experimentation as a process of discovery, that is, through an inductive process, the individual achieves the objectives; finally, the third conception treats practical-experimental activities as an introduction of students to the methods of science, based on a set of steps and rules. Regardless of the conception of learning through a practical-experimental proposal, experimental activities demonstrate great potential for the inclusion of people with disabilities (Camargo, 2017).

It is important to highlight that the proposal presented here is centered on Special Education from the perspective of Inclusive Education. The objective is to include students from the target audience of special education, with specific emphasis on students with visual impairments. Camargo (2017) reinforces that all students are the target audience of inclusive education, but that Special Education (PAEE) includes students with disabilities, global developmental disorders and those with high abilities or giftedness.

Finally, the theoretical lens that permeates Multisensory Didactics and inclusive education in this work is Vygotsky's Historical-Cultural Theory, for which human development occurs through social interaction. Based on this thinking, it can be seen that knowledge is constructed in a collective process, historically situated (Barbosa, Miller & Mello, 2016; Pereira, 2022). Mediation is central to this process and can be done by instruments and signs, which facilitate communication, as in the case of speech, writing and gestures. The instruments, in turn, expand the subject's interaction with the world, as in the use of tools. Although mediation does not lead to automatic learning, it has the potential to transform and improve student performance in a given activity, as exemplified by pole vaulting, in which the introduction of poles made of new materials allowed results above expectations (Martins & Moser, 2012, p. 12).

> The process of mediation, through instruments and signs, is fundamental for the development of higher psychological functions, distinguishing man from other animals. Mediation is an essential process to make possible voluntary, intentional psychological activities, controlled by the individual himself (Oliveira, 2008, p. 33).

That said, mediation is "[...] the process of intervention of an intermediary element in a relationship" (Oliveira, 2008, p. 26). Therefore, the experimental apparatus, together with the signs, are configured as elements of mediation of knowledge about heat absorption for students with and without disabilities, in a process of association.

What sets humanity apart from other animals is its remarkable ability to communicate through signs, which allows it to transcend mortality through teaching and learning. However, this process is only viable within a sociocultural context, since it is a product of social interactions. For example, an individual who is born isolated, without contact with other humans, may have difficulty developing a language and writing system as complex as that learned in society. Even if this person comes to interact with the social world later, their integration will be a challenging process, showing that human development intrinsically depends on interaction with other individuals.

> A primate can learn a great deal through training, using its motor and mental abilities; however, it cannot be made more intelligent, that is, it cannot be taught to solve more advanced problems independently. Therefore, animals are incapable of learning in the human sense of the term; human learning presupposes a specific social nature and a process through which children penetrate the intellectual life of those around them. (Vygotsky, 1991, p. 59).

Therefore, the specific social context shared by humans is what makes their abilities unique, distinguishing them in quantity and quality from the abilities of other primates. Although other animals can use tools to perform certain activities, this use occurs predominantly through imitation, without the capacity for abstraction necessary for more advanced cognitive development. Thus, a primate cannot develop higher psychological functions, such as speech, memory, concept formation and the expression of emotions (Vygotsky, 1991).

For Vygotsky, human development, especially with regard to the so-called higher psychological functions, is made possible through the process of mediation. Signs play a crucial role in mediating our thinking, and can be represented by words, images or other symbols. In order to acquire new knowledge, mediation through speech, words, images or language is necessary, since even the act of thinking involves a process of mediation (Martins & Moser, 2012; Vygotsky, 1997).

METHODOLOGICAL PATH

This research is characterized as a qualitative study, which requires, according to Godoy (1995, p. 21), an integrated analysis, as it involves phenomena that cannot be dissociated from their contexts. In the case of qualitative research, which involves people, the researcher acts as an instrument when going into the field with the aim of raising points of view relevant to his/her investigation.

The research used a multisensory activity focused on the absorption and reflection of light by objects of different colors. Two visually impaired people participated: one who had been blind since birth and the other who lost his sight in adulthood. For comparison purposes, data were also collected from a test class composed of students in the final years of high school, who interacted with the proposed activity. This was inspired by the approach of Ribeiro and Oliveira (2011), but underwent several adaptations and modifications to increase its effectiveness in execution.

Figure 1

Proposed experimental activity on heat absorption.

Source: Own authorship (2024).

Figure 1 shows three different screens, all made from the same material (ethylene vinyl acetate, EVA). This choice was made to standardize comparisons and to ensure a low specific heat, facilitating temperature perception. In total, five screens were built: white, black, blue, yellow and red. The lamp used is a common drying lamp, with a power of 250 W. It was selected for its ease of movement and efficiency in generating heat.

Figure 2

Bulkheads with the name of each respective color written in Braille.

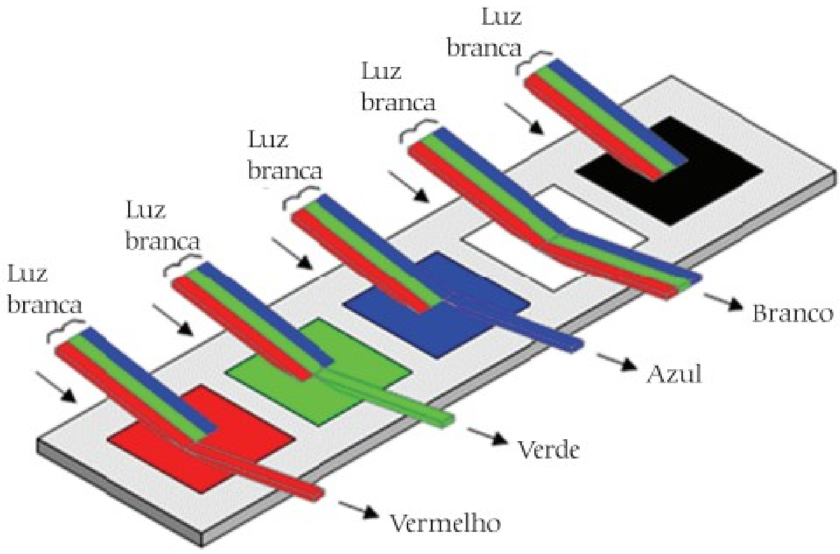
Source: Own authorship (2024).

As shown in Figure 2, each screen was marked with a Braille inscription indicating its color, facilitating tactile identification. In addition to the writing, each screen has a tactile tape on the back, chosen to be easily recognized by its texture. Each tape has a different texture, ranging from smooth, rough, hairy, and bumpy. Thus, even if they do not yet understand Braille, visually impaired individuals will be able to participate in the experiment using the tactile tapes.

The central physical concept of this work addresses how objects of different colors absorb and reflect light in different ways. Visible light, an electromagnetic wave, interacts with objects according to their wavelength, that is, the color of these objects. This interaction can generate temperature variations, since each material reacts uniquely to radiation of certain wavelengths. When the object receives radiation from white light (Figure 1), it heats up. To facilitate the observation of this phenomenon, the screen was coated with EVA, a material with low specific heat, which results in a more significant temperature variation when compared to materials with higher specific heat.

Figure 3

Absorption of white light by objects of different colors.



Source: Cavalcante, Baladon and Teixeira (2016).

Figure 3 illustrates the absorption of white light by different colors. Ideally, black absorbs all radiation, while white reflects all incident radiation. Thus, darker colors tend to absorb more white light, while lighter colors absorb less. This variation in absorption results in differences in temperature, especially when comparing objects made of identical materials.

The first stage of the investigation, which involved people with disabilities, was carried out at a different time from the second stage, which included the test group. This is because situational issues made this division more viable for both groups within the time constraints. To validate the usability of the experiment and to investigate the promotion of accessibility in the practical-experimental activity, the activity was carried out with the two people with visual impairment and the test group, following a similar procedure in both cases.

In practice, the screens were exposed in pairs to the light source for a period of 1 to 1.5 minutes, with the aim of standardizing the temperature conditions. After exposure, each screen was given to the participant so that he could perform his tactile and sensory interpretation. The procedure was repeated by changing the color combinations in pairs, such as: black with white, red with yellow, and so on.

The first stage involved the voluntary participation of two people from the Itajubá Support and Integration Center for the Disabled (CAIDI): a student and a teacher. The participants are between 40 and 60 years old, since the Center is mainly aimed at adults. The student, named Toph, lost her vision in adulthood and is adapting to learning Braille. She is familiarizing herself with the letters of the writing system in question, starting with the words most commonly used in everyday life, which may influence the results. Toph's teacher, who we will call Dora, was born visually impaired, is a Braille teacher and has extensive command of the language. Comparing the data of a person who is beginning to explore tactile language and someone with years of experience is essential to diversify the results and the possibilities of interpretation.

The second stage included five female students and one male student, all from the Preparatory Course for Assistance Center for Intelligence and Culture (CACIC), an institution focused on preparing low-income students for college entrance exams, accepting those who are in the third year of high school or who have already completed basic education. The test group is composed of two 17-year-old female students (still in the third year of high school) and the remaining participants are 18 or older. For simplicity, the six students will be identified as A through F.

After the two stages, the data were analyzed according to Yin (2016), whose procedure is developed in five stages: compile; decompose; recompose; interpret and conclude. The five phases developed are non-linear, in order to allow a transition and a return to the previous steps, such as decomposing and recomposing again after a certain interpretation. The procedure results in a narrative, which is constructed according to the interpretation and conclusion of the data that were organized following a sequence favorable to its understanding.

Both moments were recorded and transcribed, with the aim of producing the data presented in this work. Regarding the ethical procedures established for research involving people, all actions were reported to Plataforma Brasil, where the project was submitted to an ethics committee. From then on, the study received the Certificate of Presentation of Ethical Appreciation (CAEE) with the following identification: 75825323.5.0000.5094.

RESULTS AND DISCUSSION

The application of the practical-experimental activity allowed us to collect comparative data on the time needed to interpret the screens, considering the time spent to identify the temperature and color, in addition to determining which object has the highest temperature based on the sensory interpretation of each participant. Although the sensory medium has limitations in measuring temperature, isolated and paired comparisons can facilitate the teaching of physical concepts.

The time for interpreting the screens is crucial, as it allows for more inclusive interaction between all participants in the experimental activity. This dynamic allows visually impaired students to not only participate, but also discuss the results obtained by themselves.

Table 1.

Accounting for the time needed for the visually impaired person to interpret the screen.

Colors displayed in comparison	Time of exposure to the light source	Time taken to interpret the bulkhead
black and white	1 minute and 10 seconds	30 seconds (black) and 20 seconds (white)
red and blue	1 minute and 10 seconds	10 seconds (red) and 1 minute and 22 seconds (blue)
blue and yellow	1 minute	13 seconds (blue) and 16 seconds (yellow)

Source: Own authorship (2024).

Table 1 shows the times Toph took to interpret the displays on display. There was a significant increase in the time it took to identify the word "blue" in Braille, which can be attributed to her learning process, since she had just begun to recognize the initial letters of the alphabet and had not yet learned the letter "z". However, after performing the experiment with the blue and yellow displays, Toph was able to more easily identify the color and interpret which one had the highest temperature.

While Toph took a considerable amount of time to interpret the screens, Dora completed the same route in an average of just 10 seconds by comparison. Braille writing requires the user to have quick interpretation skills; the tactile tape offers the advantage of not requiring mastery of Braille. However, for the tape to be effective, it is essential that the person has prior contact with the screens, allowing them to become familiar with and memorize the meaning of each texture associated with a color.

During the experiment, in addition to identifying the writing on each screen, Toph was also asked to report her sensory perception in each comparison. When exposed to the white and black screens, she commented: *“This one. Wow, it’s really hot… Black.”* Then she reaffirmed: *“The black got hotter.”* This statement indicates the effectiveness of the experiment for the first two colors. Even after some time of exposure to the heat source, Toph was able to perceive the difference in temperature, stating: *“Yes, it did. Now it’s cooling down. But it’s still very different.”*

However, not all results were as expected. During the comparison between the red and blue screens, for example, Toph expressed: *“They both seem to be… It seems like they’re the same, the same temperature. It’s not… Not hot like the black was, you know?”* This suggests that there was not enough of a temperature difference for her to be able to identify the colors red and blue effectively. This result reveals a limit of the activity, since, when comparing the blue and yellow, Toph reported that the blue was at a higher temperature, which was already expected. Therefore, it is recommended to avoid comparing darker colors to increase the efficiency of the evaluations or, alternatively, to explore them in order to encourage students to formulate hypotheses.

Similarly, the activity was applied to a test class, previously described, composed of six selected students with a profile close to that of the general education public, specifically students from public high schools.

Table 2.

Accounting for the time needed for the visually impaired person to interpret the screen.

Colors displayed in comparison	Time of exposure to the light source	Average time taken to interpret the bulkhead
black and white	1 minute	6,5 seconds
red and blue	1 minute	5 seconds
red and yellow	1 minute	3 seconds

Source: Own authorship (2024).

As shown in Table 2, the students in the test group, composed of sighted individuals, interpreted the screens in a very short time. Color interpretation is almost instantaneous for people without visual impairment, which results in rapid interaction during the activity. This justifies the emphasis on interpretation time, seeking to bring interaction closer to a diverse audience.

Similarly, students in the test class showed expected responses when comparing the temperatures between the different colored screens. For example, Student A, when interacting with the screen in the first display, asked her classmate, *"This black one is hotter, right?"* She then added that the temperature difference compared to the white screen was *"considerable."* This response demonstrates the effectiveness of the activity in providing a clear understanding of the temperature differences between the objects on display.

When comparing the red and blue screens in terms of temperature, a subtle difference was observed involving Student F, who commented that *"the difference is very small"*. Before carrying out the activity, the students believed that the red screen would be warmer, but after practicing, they realized that the blue screen had a higher temperature. This prior perception may be rooted in prior knowledge, such as the association of the color red with a warm tone and the color blue with a cool tone, common in art studies. Although this interpretation is subjective, it is important to recognize it as a valid lens through which the student can understand and describe the world.

In the comparison between the yellow and red screens, the temperature differences were more evident, as highlighted by Student D in a conversation with Student E: *"See? The red one is hotter."* The ease of applying and reapplying the heat source to heat the screens allowed for a deeper reflection on the results of the test group. When asked which of the three comparisons was easiest to distinguish, Student B, unexpectedly and in contrast to her colleagues, responded: *"For me, no. For me, it was now on the red one."* Thus, while it was expected that the comparison between black and white would be more easily differentiated in terms of temperature, Student B brought a different perception.

However, when repeating the comparisons, Student B revised her opinion, recognizing that the distinction between the white and black screens was, in fact, more evident in sensory terms than that between red and yellow. Carrying out the experimental activity in a group favored interaction among the students, stimulating discussions about the answers. Student E commented: *“The hypothesis is what I know. The thermal sensation of black is much greater than that of white,”* and Student F suggested: *“She must have felt it wrong.”*

It is positive to observe the presence of divergences among students, as this can encourage the collective construction of explanations about the results. Although it is not possible to reach a consensus on the explanations, the formulation of hypotheses and the awareness of the subjectivity inherent in sensory measurements are crucial skills for scientific knowledge.

The two phases of the research, although carried out separately, demonstrated the potential of practical-experimental activity as a mediation instrument for learning in a multisensory approach. Although the difference in interpretation time between Toph and the test group is significant, this can be attributed to Toph's learning context, as she is still familiarizing herself with Braille letters. On the other hand, Dora, due to her experience with this writing system, took an average of 10 seconds to interpret the screens, presenting a performance similar to that of the test group composed of sighted students.

The usability and accessibility of the experiment were successfully tested, as evidenced by Toph's speech when interacting with the black and white screens after exposure to heat: *"It's the black one, it absorbs more. Look how hot it is still."* When commenting to Dora about the perception of the same effect on clothes, the teacher asked: *"Is that really true?"* Toph, who had experiences as a sighted person before losing her vision, already had the notion that dark fabrics retain more heat on sunny days, while Dora, who has been blind since birth, was unaware of this phenomenon.

Thus, while the experimental activity provides Toph with a reminder of a previously learned concept and the reason for part of her experience as a sighted person, for Dora, it represents the construction of knowledge that was previously inaccessible. Mediation, by operating as a facilitator for students considered typical, enables learning for students with disabilities, especially those with visual impairment.

The results obtained by the test group indicated that the students were able to generalize the physical concept about the absorption of heat by materials of different colors. Although Student C initially stated that *“yellow will be the hottest,”* shortly after interacting with the activity, he concluded: *“The darker the color, the more heat; the lighter the color, the more it reflects.”* He then reformulated: *“The darker the color, the more it absorbs; the lighter the color, the more it reflects.”*

These observations demonstrate the potential for generalization of knowledge, which is a central goal of the experiment and an important feature for learning scientific concepts. However, it is essential that the conditions and limits are clearly defined. For example, the experiment was simplified by using all the shields made of the same material, ensuring a standardized specific heat and equal conditions of exposure to the heat source. In reality, different materials and other forms of heat transfer influence the process, and generalization can lead to a limited understanding of physics.

The relationships established by the students in the test group were similar to the observations made by Toph. For example, Student D explained that the temperature difference occurs *"because of the color. It's like wearing a black shirt on a sunny day… You'll die."* These results indicate that sighted people have an easier time relating the temperature of the object to the heat absorbed, because their previous experiences influence their perception of the world.

As stated by Camargo, Nardi and Veraszto (2008), inclusive education aimed at people with visual impairments faces the challenge of communication barriers. There are human expressions and experiences that are difficult to translate, such as the concept of transparency. For someone with no prior experience related to vision, many scientific definitions become difficult to communicate, as certain words intrinsically carry notions that are exclusively normal-sighted.

CONCLUSION

This study used a practical-experimental experiment based on Multisensory Didactics (MD) as a proposal for the inclusion of people with disabilities in Physics teaching, with an emphasis on the absorption of heat by bodies of different colors. This is because traditional teaching, which relies predominantly on memories and visual and auditory skills, presents significant challenges for inclusion, especially for students with visual impairment (Camargo, 2012). Thus, the focus on visual impairment in this study is justified, since the expansion of sensory pathways makes learning more accessible to a diverse audience.

This research focuses not only on the number of people trained to learn through experimental practice, but also on the quality of this execution. In this sense, it is important to consider factors that favor interaction in situations of equality between different audiences, such as the time needed to interpret the multisensory activity. Reflecting on reading and response time is essential to ensure effective interaction between the experimental activity and its participants.

The results demonstrated that the experiment has great potential for learning for students with and without visual impairments, as evidenced by the changes in initial concepts about heat absorption after the activity was carried out. Thus, the experiment is aligned with the principles of Multisensory Didactics (MD), presenting an accessible nature that allows its effective application by all students.

Thus, in line with Hehir *et al* (2016) regarding the outcome of inclusion, activities such as this one based on Multisensory Didactics, in addition to enabling accessibility for students with disabilities, can also facilitate the learning process of typical students. Therefore, there is a need for future studies to focus on learning in a broader way.

The objective of an inclusive experiment should include students with disabilities, aiming at accessibility and usability, that is, it must focus on equity between different audiences. Therefore, the proposal moves away from adapted activities, which are aimed solely at students with disabilities, and approaches Multisensory Didactics, in an attempt to universalize practical-experimental activity.

The experimental activity proved to be positive both for the diagnosis and for the consolidation of knowledge about heat absorption. For example, many participants initially believed that the red screen would have a higher temperature compared to the blue one, due to the common association between red as a warm color and blue as a cold color. Without the sensory interaction provided by the activity, this confusion between different knowledge could be difficult to resolve.

It is important to recognize that the inherent limits of any experiment must be considered in its design and application, especially in activities adapted to include the largest possible number of participants. Modifications and simplifications made to the experiment may lead to alternative conceptions in students, such as the idea that only the color of the object influences heat absorption. Although no alternative conceptions resulting from the proposed activity were identified, it is recommended that further investigations be carried out to explore the limits and epistemological obstacles present in activities developed according to the principles of Multisensory Didactics.

ACTIO, Curitiba, v. 10, n. 1, p. 1-18, jan./apr. 2025.

ACKNOWLEDGMENTS

We would like to thank the Minas Gerais State Research Support Foundation (FAPEMIG) and the National Council for Scientific and Technological Development (CNPq).

REFERENCES

Abreu, F. S. D., & Periva, P. L. M. (2022). Deficiência e Teoria Histórico-Cultural: por que se voltar a Vigotski ainda é necessário? *in:* Abreu, F. S. D. et al. Diversidade e Inclusão: o que a Teoria Histórico-Cultural tem a contribuir? Curitiba: editora CRV.

Adams, F. W. (2020). A percepção de professores de ciência frente aos desafios no processo de ensino e aprendizagem de alunos público alvo da educação especial. ACTIO, Curitiba, v. 5, n. 3, p. 1-23.

Araújo, M. S. T., & Abib, M. L. V. S. (2003). Atividades Experimentais no Ensino de Física: Diferentes Enfoques, Diferentes Finalidades. Revista Brasileira de Ensino de Física, v. 25, n. 2.

Barbosa, M. V., Miller, S., & Mello, S. A. (2016). Teoria Histórico-Cultural: questões fundamentais para a educação escolar. São Paulo: Cultura Acadêmica Editora.

Camargo, E. P., Nardi, R., & Veraszto, E. V. (2008). A comunicação como barreira à inclusão de alunos com deficiência visual em aulas de óptica. Revista Brasileira de Ensino de Física, v. 30, n. 3.

Camargo, E. P. (2017). inclusão social, educação inclusiva e educação especial: enlaves e desenlaves. Ciência & Educação, Bauru, v. 23, n. 1, p. 1-6. https://doi.org/10.1590/1516-731320170010001

Cassano, A. R., Muzzio, A. L., & Góes, A. R. T. (2022). Investigando indícios do desenho universal e desenho universal para a aprendizagem em pesquisas que abordam jogos na matemática. ACTIO, Curitiba, v. 7, n. 3, p. 1-23.

Cavalcante, M., Balaton, M., & Teixeira, A. C. (2016). Estudos das cores com arduino scratch e tracker. Física na Escola, v. 14, n. 1, p. 28.

Galiazzi, M. C., Rocha, J. M. B., Schmitz, L. C., Souza, M. L., Giesta, S., & Gonçalves, F. P. (2001). Objetivos das Atividades Experimentais no Ensino Médio: A pesquisa coletiva como modo de formação de professores de ciências. Ciência & Educação, v. 7, n.2.

Godoy, A. S. (1995). Pesquisa qualitativa: tipos fundamentais. Revista de Administração de Empresas, v. 35, n. 3, p. 20-29. https://doi.org/10.1590/S0034-75901995000300004

Gruzman, C., & Siqueira, V. H. F. (2007). O papel educacional do Museu de Ciências: desafios e transformações conceituais. Revista Electrónica de Enseñanza de las Ciencias, v. 6, n. 2, p. 402-423.

Guridi, V. M., Darim, L. P., & Crittelli, B. (2020). Reflexões acerca da didática multissensorial aplicada ao ensino de ciências para pessoas com deficiência. Revista de Enseñanza de la Física, v. 32, número extra. https://revistas.unc.edu.ar/index.php/revistaEF/article/view/30990/31652

Jacobucci, D. F. C. (2008). Contribuições dos espaços não-formais de educação para a formação cultural científica. Uberlândia, v. 7.

Leite, L. P., & Lacerda, C. B. F. (2018). A construção de uma escala sobre as concepções de deficiência: procedimentos metodológicos. Psicol. USP, v. 29, n. 3, p. 432-441. https://doi.org/10.1590/0103-65642018109

Martins, O. B., Moser, A. (2012). Conceito de mediação de Vygotsky, Leontiev e Wertsch. Revista Intersaberes, v. 7, n. 13.

Malheiro, J. M. S. (2016). Atividades experimentais no ensino de ciências: limites e possibilidades. ACTIO, Curitiba, v. 1, n. 1, p. 108-127. http://dx.doi.org/10.3895/actio.v1n1.4796

Monteiro, M. A. A., Monteiro, I. C. C., Silva, L. F. da., & Gaspar, A. (2014). Avaliação de monitorias realizadas em um centro de ciências. Revista Centro de Ciências Naturais e Exatas, v. 36, n. 3.

Oliveira, M. K. (2008). Vygotsky Aprendizado e Desenvolvimento Um Processo Sócio-Histórico. Editora Scipione, 4ª edição.

Hehir, T., Grindal, T., Freeman, B., Lamoreau, R., Borquaye, Y., & Burke, S. (2016). Os Benefícios da Educação Inclusiva para Estudantes com e sem Deficiência. SP: Instituto Alana.

Higa, I., & Oliveira, O. B. (2012). A experimentação nas pesquisas sobre o ensino de Física: fundamentos epistemológicos e pedagógicos. Educar em Revista, Curitiba, n.44, p. 75-92.

Pereira, K. R. C. (2022). O legado vigotskiano à Educação Inclusiva - algumas reflexões *in:* Abreu, F. S. D. et al. Diversidade e Inclusão: o que a Teoria Histórico-Cultural tem a contribuir? Curitiba, editora CRV, p. 55-69.

Reginaldo, C. C., Scheid, N. J., & Güllich, R. I. C. (2012). O ensino de ciências e a experimentação. *in:* ANPED Sul Seminário de Pesquisa da Região Sul, IX. RS: Caxias do Sul.

Ribeiro, L., & Oliveira, A. (2011). Experimento de baixo custo no ensino de absorção de calor sob a perspectiva inclusiva. *in:* XIX Simpósio Nacional de Ensino de Física, Manaus, AM. http://www.sbf1.sbfisica.org.br/eventos/snef/xix/sys/resumos/T0341-1.pdf

Soler, M. A. (1999). Didática multissensorial de lãs ciências: um nuevo método para alumnos ciegos, deficientes visuales, y también sin problemas de visión. Barcelona: Ediciones Paidós Ibérica.

Vygotski, L. S. (1997). Obras Escogidas V: fundamentos da defectologia. Madrid: Visor.

Vygotski, L. S. (1991). A formação social da mente. Livraria Martins Fontes, São Paulo, 4ª edição.

Yin, R. K. (2016). Pesquisa qualitativa do início ao fim. Porto Alegre, RS: Penso.

Received: Oct. 20, 2024
Approved: Apr. 9th, 2025
DOI: https://doi.org/10.3895/actio.v10n1.19327

How to cite:
Feitoza, N. N. R. & Ferraz, D. P. A (2025). Multisensory didactics and physics education: an inclusive proposal on heat absorption by objects of different colors for students with visual impairments. ***ACTIO***, 10(1), 1-18. https://doi.org/10.3895/actio.v10n1.19327

Address:
Natã Nadher Rezende Feitoza
Rua Padre Marino, n, 544, Bairro São José, Pedralva, Minas Gerais, Brasil.

Recebido: 20 out. 2024
Aprovado: 09 abr. 2025
DOI: https://doi.org/10.3895/actio.v10n1.19327

Como citar:
Feitoza, N. N. R. & Ferraz, D. P. A. (2025). Didática multissensorial e o ensino de física: uma proposta inclusiva sobre absorção por objetos de cores diferentes para estudantes com deficiência visual. ***ACTIO***, 10(1), 1-18. https://doi.org/10.3895/actio.v10n1.19327

Correspondência:
Natã Nadher Rezende Feitoza
Rua Padre Marino, n, 544, Bairro São José, Pedralva, Minas Gerais, Brasil.