Revista ARACÊ
ISSN: 2358-2472

PROPOSAL FOR INCLUSIVE TEACHING OF PHYSICS WITH MANIPULABLE MATERIALS: ATOMIC MODELS MADE WITH MIRITI

https://doi.org/10.56238/arev7n3-280

Submitted on: 02/27/2025 **Publication date:** 03/27/2025

Angela Costa Santa Brigida[1], Cledson Santana Lopes Gonçalves[2], Larissa do Rosário de Araújo[3], Daniana de Costa[4], Lília Cristina dos Santos Diniz Alves[5], Francisco Flávio Cavalcante[6] and Júlio Silva de Pontes[7]

ABSTRACT
The research presents a didactic proposal with the objective of elaborating an inclusive experimental material, to assist People with Disabilities in regular classes in Physics classes. Concepts of the atomic theories proposed by scientists Dalton, Thomson, Rutherford and Bohr were explored and atomic models made with miriti, a Brazilian palm tree widely used in local handicrafts in the state of Pará, were produced, which were represented by balls of different sizes to simulate each of the atomic structures. The material was constituted as a didactic alternative, in view of its use as a support resource by high school teachers to make the teaching and learning process more meaningful. The suggestion presented provides students with a better understanding of the concepts of Physics through handling and interacting with the fruits of Miriti.

Keywords: Inclusive education. Teaching of Physics. Experimentation. Miriti. Atomic models.

[1]Dr. in Electrical Engineering from the Federal University of Pará
Federal University of Pará Campus Ananindeua
Email: acsbrigida@ufpa.br
ORCID: 0000-0002-8523-6156
[2]Dr. in Physics from the University of Porto
Federal University of Pará Salinópolis Campus
Email: cledson.s.l@gmail.com
ORCID: 0009-0006-4694-9424
[3]Graduated in Physics from the Federal University of Pará
E-mail: alary0017@gmail.com
ORCID: 0009-0001-3943-3714
[4]Dr. in Education from the Federal University of São Carlos
Federal University of Pará Salinópolis Campus
Email: danianacosta@ufpa.br
ORCID: 0000-0002-8523-6156
[5]Dr. in Science and Mathematics Education from the Federal University of Pará
Federal University of Pará Salinópolis Campus
Email: liliadiniz1802@gmail.com
ORCID: 0000-0003-2423-797X
[6]Degree in Physics from the Federal University of Pará
E-mail: ffcavalcante1@gmail.com
ORCID: 0009-0003-1105-7715
[7]Dr. in Mathematics Education from the Pontifical Catholic University of São Paulo
Amapá State University Macapá Campus
Email: julio.pontes@ueap.edu.br
ORCID: 0000-0003-1687-1508

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

When one thinks of Physics classes, the image of a traditional class based, above all, on the mechanical memorization of mathematical formulas useful for solving exercises is recurrent. Since this discipline uses mathematical models and representations for the interpretation of empirical data, explanation of everyday phenomena and applications in various sectors in the industry. This context has contributed, over the years, to this discipline carrying with it a stigma of complexity, generating a certain disinterest in students. In addition, most public schools do not have science laboratories, making learning difficult, because in the so-called "monotonous" classes, this distances teachers and students from the real reason for teaching and learning.

All this negative context has a huge weight for students with disabilities[8], so that this whole situation ends up creating an even greater barrier to their development. According to Yoshida (2018), the school must welcome all children (with and without disabilities), and the segregation of children with disabilities ceases to exist from the coexistence with other students. In addition, it is the responsibility of the school's management team to enforce the rights of each student. Therefore, there is a gap that must be filled, that is, it is necessary to develop materials and methods that provide inclusion in the teaching of Physics, contributing to the progress of all students, always with respect and understanding.

Among the pedagogical proposals that can be suggested to overcome this problem, we have the one that defends the importance of the didactic laboratory (of practical-experimental activities) in Physics classes, proposed by Pereira and Moreira (2018). Such experimental activities can stimulate the active participation of students, fostering their creativity and interest and involving them in the teaching and learning process. They provide a motivating, stimulating and pleasant environment, rich in challenging situations that, when well worked by the teacher, make learning more meaningful. Thus, Sopran (2013, p. 4) states that "in the elaboration of strategies to solve a question proposed experimentally, there is an expansion of thought and language is modified according to what is intended to be explained".

According to Rosa and Rosa (2012), experimental practices should prioritize the construction of knowledge, and not only the performance of technical procedures, in the form of "prescriptions". With this, the authors advise the elaboration of methodological materials and the performance of experimental activities. Thus, adaptable and low-cost

[8] Expression used by the Convention on the Rights of Persons with Disabilities (UN, 2006).

Revista ARACÊ
ISSN: 2358-2472

experiments facilitate the teaching and learning process and can be used as inclusive didactic tools, as they arouse interest and curiosity. Therefore, practice is of paramount importance for the inclusion process in the classroom, since everyone can participate effectively.

In view of this, this research arose with the concern arising from the inclusive teaching of Physics, aiming to provide didactic material to help People with Disabilities – PwD, namely, visually impaired students in regular teaching classes, in Physics classes. Atomic models are built that will serve as complementary instruments to the classes, using as raw material the Miriti (Mauritia flexuosa), which can be easily acquired in the capital, Belém-Pará, in the northern region of Brazil. The material made can help teachers in the teaching and learning process of students with and without disabilities. In addition, this strategy aims to provide the student with a better understanding of physical concepts, makes it possible to build scientific concepts, stimulate curiosity and develop creativity and criticality.

THE TEACHING OF PHYSICS TO PEOPLE WITH DISABILITIES

Noronha and Pinto (2013, p. 3) explain that unlike Special Education, Inclusive Education encompasses the participation of all students in regular education, thus collaborating to have "a restructuring of the culture, practice and policies experienced in schools so that they respond to the diversity of students". In this way, each student is seen in a unique way, favoring solidarity.

Articles 1 and 2 of Decree No. 6,571/2008 denote that,

> Art. 1 For the implementation of Decree No. 6,571/2008, education systems must enroll students with disabilities, global developmental disorders and high abilities/giftedness in regular classes and in Specialized Educational Service (AEE), offered in multifunctional resource rooms or in Specialized Educational Service centers of the public network or community institutions. confessional or philanthropic non-profit. Art. 2 The SEA has the function of complementing or supplementing the education of the student through the provision of services, accessibility resources and strategies that eliminate the barriers to their full participation in society and the development of their learning (BRASIL, 2009, p. 26).

The National Policy on Special Education from the perspective of Inclusive Education places all students together, in the same classroom, but also monitors PwD in the SEA, paying attention to their specificities. In this inclusive context, as stated by Oliveira and Lima (2016, p. 61), the Special Education modality aims to "organize favorable environments for the development of pedagogical practices that recognize, understand and value the different learning rhythms of the subjects". SEA, on the other hand, is complementary to classes in regular education classes, contributing to the teaching and learning of PWDs. Yoshida (2018) argues that the inclusive school should welcome all children (with and without disabilities) and that the segregation of children with disabilities ceases to exist from the coexistence with other students. For inclusion to occur in the best possible way, the author also points out that it is the responsibility of the school's management team to enforce the rights of each student.

Regarding teacher training, Silva, Pena, and Vilhena (2021) point out that teachers who have knowledge of the various conditions of disabilities and the theories of learning and knowledge will be able to guarantee better teaching-learning for PWDs, favoring the development and quality of teaching for all. Thus, the author Mantoan (2003) explains that, for inclusion to happen, it is essential to make an effort for the necessary transformations to occur. Xavier (2019), when discussing the changes in the current paradigms of education, states that school change through "transformation in the curriculum and in the training and working conditions of education professionals, changes also in the context of the classroom, in the ways of working and understanding learning" is fundamental. Noronha and Pinto (2013) highlight that new pedagogical and educational practices are part of this transformation.

In turn, Carvalheiro, Silva and Santos (2019, p. 2), emphasize that "in the school environment, Physics is considered a curricular component of difficult understanding", and when it comes to PwD, the teaching of Physics becomes even more complex, which makes the issue of inclusion a great challenge. Also according to the same authors, the teaching and learning of PwD need to be carried out in order to repair the difficulties that interfere with these students having access to scientific knowledge.

Bonadiman and Nonenmacher (2007), when discussing the difficulties in teaching Physics, point out that

> [...] the low valuation of the teaching professional, the precarious working conditions of the teacher, the quality of the contents developed in the classroom, the excessive emphasis on classical Physics and the almost total forgetfulness of modern Physics, the excessive focus on the so-called mathematical Physics to the detriment of a more conceptual Physics, the distance between school formalism and the daily life of students, the lack of contextualization of the contents developed with technological issues, the fragmentation of the contents and the linear way in which they are developed in the classroom, without the necessary openness to interdisciplinary, the little appreciation of the experimental activity and the student's knowledge, the very view of science, and of Physics in particular,

> generally understood and passed on to the student as a finished product (BONADIMAN; NONENMACHER, 2007, p. 196-197)

With this, it is possible to understand that the difficulties for teaching Physics are the most varied. Bernardes (2018, p. 2), states that there is a great distance from the discipline "from those who teach it and from those who learn it", that is, there is also a lack of contextualization, a problem inferred by the students with disabilities themselves. In this sense, the author clarifies that for Physics to be apprehended to explore scientific knowledge. It is necessary to change the way in which the discipline is taught in the classroom, using appropriate teaching practices where the student is the protagonist of teaching-learning, instead of monotonous classes where the teacher is the holder of all knowledge.

In view of this, Santos, Carvalho and Alecrim (2018, p. 5) point out that Physics should not be limited only to the content and mathematics part, "but that it is effectively part of the students' daily lives, and represents some kind of meaning for those who have or do not have a disability". With this, it is essential that the form of teaching corresponds to the need for inclusion of students, so that everyone has an effective development. Costa and Barros (2015, p. 2) also point out some common difficulties found in Brazilian public schools, which have aggravated the lack of interest and difficulty in understanding the subject. These are: "absence of the science laboratory, due to decontextualized teacher training, the unavailability of technological resources and the devaluation of the teaching career".

Regarding the problems in the relationship between the special school and the regular classroom, Santos, Carvalho and Alecrim (2018) state,

> Unfortunately, as in Brazil, there is a lack of knowledge of specific areas for special education professionals and a lack of knowledge of special education for regular classroom teachers, who often do not realize the need for attitudinal changes for a true process of inclusion of students with specific needs. There is also a lack of a more integrated inclusion process, that is, the students assisted by special education, in many moments, do not participate in the breaks with the other students, because they remain in the service room to make snacks, while the other students are in the schoolyard (SANTOS; OAK; ALECRIM, 2018, p. 9).

Thus, the authors sought to draw attention to the separation that still exists in some Brazilian schools in relation to PwD. Due to the lack of knowledge of the specific areas, both of Special Education professionals and of regular school teachers, it is difficult to welcome and teach students with disabilities in regular schools. For Sathler (2014), it is

Revista ARACÊ
ISSN: 2358-2472

necessary to have in schools the implementation of new teaching methods that meet the specificities of each enrolled student, through the elaboration of inclusive teaching materials that stimulate their cognitive development, especially those of students with disabilities.

Therefore, it is of paramount importance that the way of teaching Physics to students with disabilities is not restricted only to orality and writing, however, it aims to meet their singularities and develop their potentialities, through new pedagogical practices, so that the classes are satisfactory for them.

PLAYFUL STRATEGIES FOR TEACHING AND LEARNING ATOMIC MODELS

When it comes to teaching practices, Bernardes (2018) explains that it is essential that the student is the protagonist in the classroom. It is the teacher's duty to create an inclusive environment where students' skills are not limited only to orality and writing, but that aims at the specificities of each student, so that quality teaching is guaranteed. In view of this, we present four playful strategies to facilitate the teaching and learning of atomic models. In the first two, the authors focused on inclusive education. In the others, however, the focus was not on the inclusion of PwD, but could also be used for this purpose.

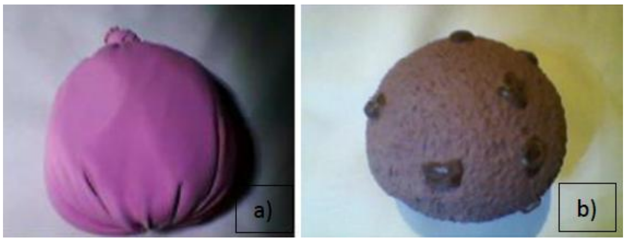
Razuck and Guimarães (2014) proposed in their work the development of alternative teaching materials to assist the teaching of blind students, which were called prototypes, to represent the atomic models of Dalton, Thompson, Rutherford and Bohr. For the Dalton model, a billiard ball was used (Figure 1).

Figure 1 – Representation of the Dalton model (billiard ball)

Source: Razuck and Guimarães (2014)

Revista ARACÊ
ISSN: 2358-2472

Figure 2 – Representations of Thompson's Model: a) Balloon filled with corn starch; b) Sphere made of cement putty



Source: Razuck and Guimarães (2014)

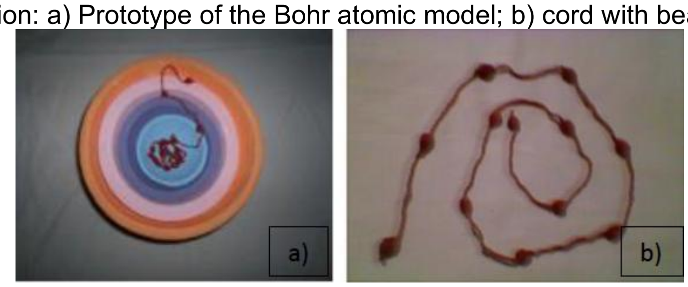
For Thompson's model, two prototypes were made. The materials used in the first (Figure 2.a) were: an inflatable balloon, cornstarch (to fill the balloon) and beads. Razuck and Guimarães (2014, p. 144) state that "when handled, it is possible to feel the internal beads, which represent the electrons". In the second prototype (Figure 2.b), a sphere made of cement and paraffin putty was used. The materials used to make the Rutherford model (Figure 3) were: wire in circles and Styrofoam balls of different colors.

Figure 3 – Prototype of Rutherford's atomic model

Source: Razuck and Guimarães (2014)

For Bohr's model, the prototype (Figure 4.a) was made with painted bands of Styrofoam balls, hollow and overlapping Styrofoam balls, and a cord with crocheted beads (Figure 4.b).

Figure 4 – Representation: a) Prototype of the Bohr atomic model; b) cord with beads covered with crochet



Source: Razuck and Guimarães (2014)

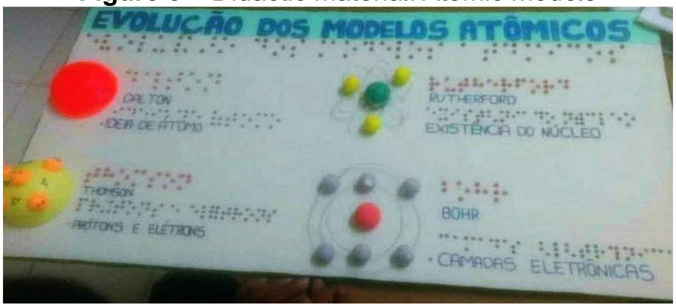
Razuck and Guimarães (2014) expose how the application of the prototypes occurred. According to the authors, the application was made in the school's coordination

Revista ARACÊ
ISSN: 2358-2472

room. At first, some questions were asked about the understanding of atomic models. Then, an activity called "Imagining the Invisible" was introduced, in which "a sealed box containing objects that cannot be seen or handled directly was used". After some questions about the students' previous knowledge about the subject addressed, the application of the prototypes began.

Silva *et. al*. (2017), in their work, aimed to know the difficulties faced by a blind student regarding the discipline of Chemistry at the Federal Institute of Maranhão (IFMA), and prepared a didactic material to enable the learning of atomic models. To make the didactic resource, Styrofoam balls in different sizes and colors were used. The material was also adapted in braille for the blind student to read. The authors report that the application of the didactic material took place with an introductory class on the study of chemistry until they arrived at the term "atomic models" (Figure 5).

Figure 5 – Didactic material: Atomic models



Source: Silva et. al. (2017)

Andrade (2015, p. 48), in his work, used models and modeling to build the atomic models. The work was divided into two parts, the first being a verification of the theme "atomic models" in the Science textbooks approved by the PNLD/2014 and, the second part consists of "the implementation of a didactic module elaborated from the main difficulties encountered in the teaching of atomic models to students of the 9th grade of Elementary School". With this, the students were instructed to elaborate representations of the atomic models, using modeling clay, beads and white sheet. Below we can see the models made by the students.

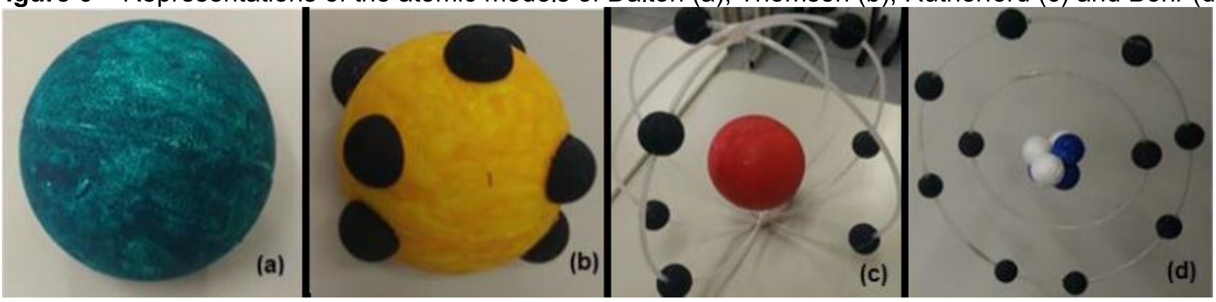
Table 1 – Atomic Models made by the students

Representation of the atomic model		
From Dalton	**By Thomson**	**From Rutherford**
		

Source: Adapted from Andrade (2015)

Camargo, Asquel, Oliveira (2018) discussed the classes planned and taught by them on atomic models. The classes were divided into three parts, the first being an introduction to the subject. In this class, students were instructed to draw the models according to the characteristics taught in class. After this moment, the students had access to the representations of the atomic models. To make the models, Styrofoam balls of different sizes and transparent hoses were used, as shown in Figure 6.

Figure 6 – Representations of the atomic models of Dalton (a), Thomson (b), Rutherford (c) and Bohr (d)



Source: Camargo, Asquel, Oliveira (2018)

Then, the atomic models were explained in a contextualized way through comparisons with the billiard ball (Dalton's atom), the raisin pudding (Thompson's atom), the solar system (Rutherford's atom), among others. In class 2, the authors introduced a game entitled "Atomic Quiz", which was prepared by the authors themselves. And finally, in class 3, the authors gave a test to the students regarding what they had learned about the three classes taught.

Therefore, given all the above so far, it is possible to note the importance of using strategies that involve experimental practice so that all students, and especially PwD, can have access to a more productive class. In this way, generate positive results, where students better understand the subjects taught in Physics. As a consequence, it is possible

Revista ARACÊ
ISSN: 2358-2472

to minimize the problem of educational inclusion of students with disabilities in regular classrooms, through the use of inclusive didactic resources.

ATOMIC MODELS MADE WITH MIRITI

According to Alencar and Lopes (2003), the *Mauritia flexuosa*, popularly known as miritizeiro, is a Brazilian palm tree that has several functionalities, "and each region has a specific use". The harvested fruit is called miriti or buriti and is abundant in the floodplain area, it is found in several states of Brazil such as Amazonas, Amapá, Bahia, Ceará, Goiás, Maranhão, Mato Grosso, Minas Gerais and Pará. This palm tree can also be found in other Amazonian countries, such as Peru, Bolivia, Colombia, Venezuela, Ecuador, however, in each country, the palm tree receives a specific name. According to Silva (2017), miritis are used as a form of handicraft. They are very common in the northeast of Pará, especially in the city of Abaetetuba where toys made with this fruit are easily found.

Figure 7 – Miriti

Source: Silva (2012)

Regarding the teaching of Physics, Alencar and Lopes (2003) state that the miriti toy can be easily applied, because using the products that are part of the student's life, the Physical Sciences will be learned more by conviction than by imposition. Also according to the authors, several toys made of miriti have the ability to move and can emit sounds, and can therefore be used as resources to study various phenomena and physical laws of mechanics, acoustics and waves, gravitation, among others. Thus, miriti toys, as they are a manipulable material, are a good alternative as pedagogical resources.

Nascimento (2020) supports the use of miriti toys in schools, from the early grades, as a form of pedagogical alternative to help regular school teachers ensure better teaching and learning for students. Allowing them to understand matters related to Physics via materials that dam their regional culture. Still from the author's perspective, different ways

Revista ARACÊ
ISSN: 2358-2472

of teaching Physics through a proposal to link the discipline to the student's daily life. The author aimed to arouse the curiosity and interest of students in Physics. The project was directed to the teaching modality from 6th to 9th grade, being a facilitator of teaching and learning in the teaching of Science, based on the idea that through the miriti toy it is possible to work on sustainable development, in addition to "recognizing and defining a problem, collecting, organizing and analyzing information, data and opinions that generate alternative solutions" (NASCIMENTO, 2020, p. 2).

Cavalheiro, Silva and Santos (2019), in their work on the teaching of Physics to PwD students, used miriti as a pedagogical resource, through the making of a prototype of the Photoelectric Effect. The application of the work was based on a questionnaire given to a blind student, in which there were questions related to the subject addressed. Then, the prototype of the EF (Photoelectric Effect) was presented to the student so that she could have the tactile experience and could better understand the subject. The authors emphasize that they had the help of a LIBRAS interpreter teacher so that the second questionnaire was passed on to the student. The same procedure was performed with a second blind student. As a result, it was found that the teaching and learning process is more advantageous when teachers use materials that aim at the inclusion of all students.

Brígida (2009), in her work, addressed the production of miriti toys to use them in the teaching of science. Miriti toys such as soca-soca and corró-corró, among others, were used as a didactic resource to assist in the teaching and learning process of students from a public school where there was no Multidisciplinary laboratory, contributing to making Physics, Chemistry and Biology classes more meaningful. As a result, it was possible to perceive that the students were able to make a relationship between the contents covered in the classroom and the daily life. This project won the 1st place at the II State Fair of Science and Technology, held in Belém by the Executive Secretariat of Education – SEDUC and an Honorable Mention of Science and Technology, from the United Nations Educational, Scientific and Cultural Organization – UNESCO at the Brazilian Science and Engineering Fair – FEBRACE, held in São Paulo.

Alencar and Lopes (2003), in their work, presented some miriti toys that are very common in the northeast region of Pará, explained how they worked, identified the physical and mathematical concepts present in each one in a simplified way. As a result, the authors found the Amazonian richness present in miriti toys, and verified that they can be used as a didactic resource to assist the teaching of Physical Sciences.

Revista ARACÊ
ISSN: 2358-2472

In view of the above, it is noted that miriti can be used as raw material for the manufacture of manipulable didactic materials, being a facilitator of knowledge, because in the classroom students do not present the same characteristics in relation to the acquisition of knowledge. Manipulable materials allow students to build new ideas, where many observe that their thinking and knowledge are not far away and it is possible to create interaction, criticality and overcoming challenges, in addition to stimulating attention, learning, creativity and memorization.

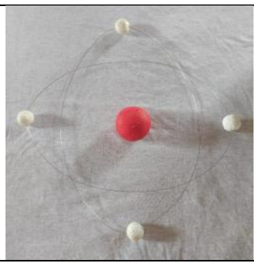
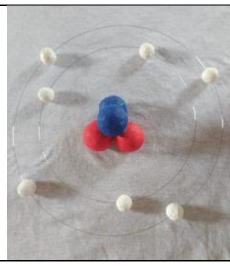
METHODOLOGICAL PROCEDURES

The development of a didactic proposal for the inclusive teaching of Physics regarding the atomic theories that are part of the content of Modern and Contemporary Physics is presented. It is the construction of a didactic sequence for the teaching of atomic models, which can be applied in regular high school classrooms, and can contribute to overcoming the exclusion of students with disabilities. Thus, the following materials were used to make the models: 18 miriti balls, of different sizes and colors; wire; glue; and 10 beads.

For Dalton's atomic model, a miriti ball (60 mm) representing a massive sphere was used. For Thompson's atomic model, a yellow miriti ball (55.9 mm) was used to represent the nucleus and white beads (7 mm) glued to its exterior to represent the electrons. In the case of Rutherford's model, wire was used to represent the orbitals around the nucleus with white dots (19.5 mm) attached to them representing the electrons (similar to the planetary system), and a red miriti dot (50.9 mm) in the middle to represent the nucleus. In the Bohr model, wire in circles was also used to represent the electron shells around the nucleus (stationary orbitals), with the white balls (19.5 mm) fixed to them, representing the electrons. The Miriti balls in the middle represent the nucleus, the blue balls (41.7 mm) are the neutrons and the red ones (44.4 mm) the protons. The red dots are slightly larger than the blue dots to make it easier for visually impaired students to identify them.

Revista ARACÊ
ISSN: 2358-2472

Table 2 – Representation of Atomic Models made with miriti

Atomic Model			
From Dalton	**By Thomson**	**From Rutherford**	**De Bohr**
			

Source: The authors (2022)

The proposal presented here consists of a sequence containing the description of how classes could be taught by teachers in order to include visually impaired students in regular teaching rooms.

For the approach of atomic models in inclusive education, it is proposed to explore the physical concepts present in each model, using touch to differentiate each one of them, because according to Belarmino (2008 *apud* Menegazzo, 2011, p. 11.806) "it is possible to perceive shapes, weights, textures beyond temperature in this sense, due to the large number of receptors existing in the skin".

STAGE I: PRESENTATION OF THE PHYSICAL CONCEPTS AND THE EXPERIMENT

The teacher can start the class by talking to the students about what will be done. Then, ask the students questions: What is the atom? What do you mean by atomic models? After the students answer, the teacher contextualizes the subject, explaining that everything we know comes from matter, which is made up of atoms. Then, it presents the materials used to make the models, so that they can be identified by the students. Students with visual impairment will be able to do tactile recognition of the materials. Continuing, a brief history of the atom until the evolution of atomic models can be presented. When explaining Dalton's theory, the professor makes an analogy of the model with the billiard ball. At this moment, it shows Miriti's atomic model. He repeats the process with the Thompson, Rutherford and Bohr models. Explaining the experiments that led to each of the theories, he shows what each miriti ball represents, manipulating the materials and making analogies with everyday life. Thus, students are presented with the main characteristics of the structure of their atomic models.

During the manipulation of materials, the differences and similarities between the models are highlighted. At the end of the class, some questions can be asked orally to the

Revista ARACÊ
ISSN: 2358-2472

students. How: Which scientist discovered the electron? *A: J. J. Thomson*. Which model is similar to the planetary system? *A: Rutherford atomic model*. Which model is known as raisin pudding? *A: Thompson's atomic model*.

STEP II: PRACTICAL - EXPERIMENTAL ACTIVITY

The second class is practical. The class can be divided into groups in order to provide integration among classmates and facilitate the inclusion of visually impaired students. Each group manipulates the materials for the construction of the atomic models of Miriti. The visually impaired students were helped by the other members of the group and by the teacher. During the manipulation, students can be asked about the similarities and differences they perceived between the models.

For Dalton's atomic model, a Miriti ball representing a massive, indivisible sphere can be used. Thompson's atomic model, on the other hand, can be used a medium-sized miriti ball with beads glued to its exterior to represent electrons. In the case of Rutherford's model, a prototype was made using wire in circles to represent the orbitals around the nucleus, with dots attached to them representing the electrons (similar to the planetary system), and a miriti dot in the middle to represent the nucleus. In the Bohr model, a prototype was made also using wire in circles to represent the orbitals around the nucleus, with balls fixed to them representing the electrons, and Miriti balls in the middle to represent the nucleus. The blue balls represent neutrons and the red balls represent protons. The red dots should be slightly larger than the blue dots to make it easier for visually impaired students to identify them.

STEP III: TROUBLESHOOTING

At the end of the class, each student receives a series of questions regarding the classes taught, the teacher asks questions orally to the PWDs (Chart 1).

Chart 1 – Questions asked orally to PwD

No.	Issues
1	Describe the composition of the atom.
2	What are the similarities and differences between Dalton's atomic model and Thomson's atomic model?
3	What are the similarities and differences between Rutherford's atomic model and Bohr's atomic model?
4	Did the experiment facilitate the understanding of the proposed concepts?
5	Would it be possible to understand these same concepts and with the same clarity, without the experiment?

6	In your opinion, what is the importance of this method for teaching students with visual impairment?

Source: The authors (2022)

DISCUSSIONS

It is important that, before starting the theoretical explanation of the subject to be addressed, the materials are presented to the students, so that students with visual impairment use touch to identify each part of the experiment, facilitating their production of knowledge. Working with tactile didactic resources in the teaching of the visually impaired is not only important, but necessary (Medeiros, 2020). In view of this, it is essential that teachers plan their classes to explore the specificities of students, especially those with disabilities, always keeping in mind providing a more attractive class that involves students.

The first class can be ended with some questions, as it is of paramount importance that teachers awaken critical thinking in students, instigating them to participate in the class, thus contributing to teaching and learning (Albuquerque, 2019). Cruz (2019, p. 4) corroborates this thought by stating that "the role of the teacher is very important, he is the one who will guide the reflections, problematizing situations, instigating the student to actively build his knowledge".

The second class, practical-experimental, not only helps the cognitive development of the students, but also facilitates the understanding of the contents, contributing to scientific knowledge (Cruz, 2008). The author also emphasizes that experimentation can be carried out not necessarily in laboratories, but in the classroom itself, using low-cost materials.

Initially, when students are separated into groups, because, according to Moreira (2014 *apud* Nery and Sá, 2019), the activities developed in pairs or groups that cover PwD, will make it easier for them to learn and teach the contents to be studied together. During the assembly of the experiment, the teacher should ask questions to the students to check if they are understanding the subject.

At the end, they should give a list of questions referring to what they learned about the subject in order to verify and analyze the students' answers and verify how many understood the concepts presented. The questions elaborated by teachers can be beneficial to students, as they can lead them to reflect and inquire, allowing them to explore their point of view on certain subjects (Van Zee & Minstrel, 1997 *apud* Silva & Lopes, 2015). Silva and Lopes (2015, p. 6) agree with this statement when they argue that "effective questioning requires asking open questions, which focus on understanding and interpretation, and enable alternative answers".

FINAL CONSIDERATIONS

It is known that education is everyone's right, students with and without disabilities must learn together, in the same classroom. Given this, it is of paramount importance to ensure access to quality education for them. However, Razuck and Guimarães (2014) state that the inclusion process is not easy to happen, as it is necessary for the teacher to be prepared to receive and teach all students, since it is not the student who has to adapt to the classes, but the teacher must make the necessary adaptations according to the specificities of his students.

In this regard, Fernandes *et al*. (2017) state that it is necessary to give all students the opportunity to have a quality education, through planned classes that use didactic materials that help the teaching and learning of students. When thinking about Physics classes, the use of experimentation is a good alternative, through didactic resources that make the student understand the theoretical concepts in a practical way. However, it is perceived that the scarcity of experimental classes hinders student learning, which corroborates the thinking of Gomes (2019), who states that the lack of laboratories and the lack of preparation of teachers make it impossible for experimental activities to be used as a learning resource.

This fact ends up generating exclusion in the classroom, as most PWDs are not able to follow classes with the teacher only using the board, even more so because some public schools do not have a LIBRAS teacher. Another aggravating factor is that there is still resistance, unpreparedness and lack of planning by some teachers, making it difficult for the inclusion process to happen. Teachers, most of the time, consider themselves unprepared to work with inclusive education.

With this, it is expected that the didactic proposal presented here will enable students to understand more clearly the proposed concepts through handling and contact with the materials used. It is important for teachers to use appropriate didactic resources as strategies for inclusion to be implemented in classrooms. Since, in addition to being a facilitator for the teaching and learning of students in general, it is used as a necessary tool that facilitates the learning of students with disabilities.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Albuquerque, A. G. (2019). A importância da contextualização na prática pedagógica. Research, Society and Development, 8(11).

2. Alencar, J. R. S., & Lopes, J. L. M. (2003). Elementos físicos e culturais do brinquedo e do miriti. IX Encontro Nacional de Pesquisa em Ensino de Física.

3. Andrade, J. S. (2015). A abordagem de modelos atômicos para alunos do 9º ano do ensino fundamental pelo uso de modelos e modelagem numa perspectiva histórica [Dissertação de mestrado, Universidade de Brasília]. Faculdade UnB Planaltina.

4. Barros, F. B., & Silva, D. (2013). Os mingauleiros de miriti: Trabalho, sociabilidade e consumo na beira de Abaetetuba, Pará. Revista FSA, 10(4), 44–66.

5. Bernardes, A. O. (2018). Inclusão no ensino de Física: Do currículo às práticas em sala de aula. III CINTEDI, 1–11.

6. Bonadiman, H., & Nonenmacher, S. E. B. (2007). O gostar e o aprender no ensino de Física: Uma proposta metodológica. Departamento de Física, Estatística e Matemática, 24(2), 194–223.

7. Brasil. (2009). Resolução CNE/CEB 4/2009. Diário Oficial da União, Seção 1, 17.

8. Camargo, L. C., Asquel, S. S., & Oliveira, B. R. M. (2018). Problematizando o ensino de modelos atômicos: Estudo das representações e o uso de um jogo didático. ACTIO, 3(3), 197–213.

9. Cavalheiro, E. P., Silva, B. J. S., & Santos, V. C. dos. (2019, December 3–5). O ensino de Física para alunos com deficiência: Uma proposta sociocultural inclusiva aplicada à Física moderna. Encontro Nacional de Clubes de Ciências – ENACC, Belém.

10. Costa, L. G., & Barros, M. A. (2015, October 26–29). O ensino da Física no Brasil: Problemas e desafios. Educere – XII Congresso Nacional de Educação, São Paulo.

11. Cruz, D. A. (2008). Atividades prático-experimentais: Tendências e perspectivas. Programa de Desenvolvimento Educacional - PDE Ciências.

12. Gomes, D. S. (2019). O uso da experimentação no ensino das aulas de ciências e biologia. Revista Insignare Scientia, 2(3, Edição Especial: Ciclos Formativos em Ensino de Ciências).

13. Mantoan, M. T. E. (2003). Inclusão escolar: O que é? Por quê? Como fazer? (1st ed.). Editora Moderna.

14. Medeiros, L. R. (2020). Utilização de modelos táteis sustentáveis como alternativa no ensino de química para alunos com deficiência visual. In B. T. de Almeida & R. de Oliveira Sá (Eds.), Discursos interdisciplinares por uma educação transformadora (pp. 205). Editora FAMEN.

Revista
ARACÊ
ISSN: 2358-2472

15. Menegazzo, R. C. S. (2011, November 7–10). Percebendo os sentidos através de experiências simples. Educere – X Congresso Nacional de Educação, Curitiba.

16. Nascimento, J. (2020). As diferentes formas de aprender Ciências através do Brinquedo de Miriti [Dissertação de mestrado, Universidade do Pará].

17. Nery, É. S. S., & Sá, A. V. M. (2019). A deficiência visual em foco: Estratégias lúdicas na Educação Matemática Inclusiva. Revista Educação Especial, 32, 1–26.

18. Noronha, E. G., & Pinto, C. L. (2013, August 23). Educação especial e educação inclusiva: Aproximações e convergências. Slideshare. https://pt.slideshare.net/slideshow/educacao-especial-e-educacao-inclusiva-aproximacoes-e-convergencias/25538825

19. Oliveira, M. H., & Lima, F. R. (2016). A educação especial no contexto da sociedade inclusiva: Construindo sentidos sobre a aprendizagem de crianças com deficiências. Cadernos Cajuína, 1(2), 59–70.

20. ONU. (2006). Convenção sobre os direitos das pessoas com deficiência. https://www.un.org/esa/socdev/enable/documents/tccconvs.pdf

21. Pereira, M. V., & Moreira, M. C. A. (2018). O que dizem as pesquisas sobre atividades prático-experimentais publicadas em periódicos brasileiros de ensino de ciências entre 2001 e 2015. Revista Thema, 15(3), 951–961.

22. Pizzani, L., Silva, R. C., Bello, S. F., & Hayashi, M. C. P. I. (2012). A arte da pesquisa bibliográfica na busca do conhecimento. Revista Digital de Biblioteconomia e Ciência da Informação, 10(1), 53–66.

23. Razuck, R. C. S. R., & Guimarães, L. B. (2014). O desafio de ensinar modelos atômicos a alunos cegos e o processo de formação de professores. Revista Educação Especial, 27(48), 141–154.

24. Rosa, C. W., & Rosa, Á. B. (2012). O ensino de ciências (Física) no Brasil: Da história às novas orientações educacionais. Revista Ibero Americana de Educação, (58), 1–24.

25. Santos, A. M., Carvalho, P. S., & Alecrim, J. L. (2018). O ensino de física para jovens com deficiência intelectual: Uma proposta para facilitar a inclusão na Escola Regular. Revista Educação Especial, 32, 1–19.

26. Sathler, K. S. O. M. (2014). Inclusão e ensino de física: Estratégias didáticas para a abordagem do tema energia mecânica [Dissertação de mestrado, Universidade Federal Fluminense].

27. Silva, C. S. Q. (2012). Brinquedo de miriti: Educação, identidade e saberes cotidianos [Dissertação de mestrado, Universidade do Estado do Pará].

28. Silva, F. J. C., Silva, M. L. N., Gouveia, A. K. S., & Santos, K. A. V. (2017). O uso de materiais didáticos para o ensino de modelos atômicos para alunos cegos. 5° CONEDU: Congresso Nacional de Educação.

29. Silva, H. S., & Lopes, J. P. (2015). O questionamento eficaz na sala de aula: Procedimentos e estratégias. Revista Eletrônica de Educação e Psicologia, (5), 1–17.

30. Silva, L. (2017, October 11–15). Brinquedos de miriti: Uma fábrica de sonhos onde não há o despertar de gêneros. 4° Congresso Brasileiro de Iniciação Científica e Design de Moda – UESP, São Paulo.

31. Silva, M. F. V., Pena, S. C. S., & Vilhena, V. D. M. (2021). Perspectivas da inclusão: Experiências e ensaios educacionais (Vol. 1, 1st ed.). RFB Editora.

32. Sopran, L. (2013). Os desafios da escola pública paranaense da perspectiva do professor. Cadernos PDE, 2.

33. Xavier, M. L. (2019). Os desafios da inclusão de crianças com necessidades educacionais especiais no ensino regular. Seminário Gepráxis, 7(7), 5746–5758.

34. Yoshida, S. (2018). Desafios na inclusão dos alunos com deficiência na escola pública. Gestão Escolar. https://gestaoescolar.org.br/conteudo/1972/desafios-na-inclusao-dos-alunos-com-deficiencia-na-escola-publica