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Simulations development for inclusive physics education

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ABSTRACT

In this paper we present the development of two simulations that demonstrate the importance of the relationship between the inclusion process and the teaching of Physics. The simulations were designed so that their use, in the classroom or as a complementary form of study, would favor inclusive education. The innovation of these simulations is related to the capture of some data directly by the cell phone, that is, the simulation work using the cell phone as a virtual laboratory, while presenting the experimental behavior and explaining the physical processes. This work presents the creation and use of simulations and the importance of study and research in inclusive education not only for future teachers, but for students from any area of knowledge, since a culture of respect and inclusion must be experienced at any time in school and in the society.

Keywords: Technical Education; Physics teaching; Inclusion, STEM.

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INTRODUCTION

Inclusive education is a reality of the school environment. Each year, regular classrooms receive a larger and more diverse number of students (Censo da Educação Básica, 2019) who were previously served only by special schools. However, receiving these students does not, in fact, characterize an inclusive education when many teachers and educational institutions do not know how to include these students in the learning process (Peres & Martins, 2021), and continue to maintain their methods of teaching, in most cases, expository, comparative and quantitative, which often, does not reach even typical students, that is, those who do not have any specific educational need and, therefore, will not objectively reach atypical students either, for example, those with specific educational needs.

In this work we report the creation of two simulations that throughout their development were designed for inclusive education, making them accessible by all students, in a more equitable way throughout the learning process. In addition, we will present the simulations created and how they can help students of special education at educational institutions. For Sassaki (2003), education in Brazil, one of the signatory countries of the Salamanca Statement (ONU, 1994), has already gone through the phases of exclusion, segregation, integration and inclusion. The decree 7611/2011 for special education and specialized educational service in the school environment (Brazil, 2011). Ensures that special education in Brazil with special care must be integrated into the pedagogical project of each school. Thus, inclusive education, a term that describes a general approach to special education, takes place when schools and, consequently, classrooms, welcome all types of students, regardless of their specific educational needs, religion, race or their economic and social situation. An inclusive educational environment must be welcoming, respect differences, enable equity and have adequate structure, such as resource rooms, ramps for the disabled, trained teachers, interpreters for the hearing-impaired and also inclusive teaching materials.

Learning is more than internalizing knowledge, the learning process requires an attitudinal change towards the environment in which one lives and must allow this change to make sense (Dos Santos et. al., 2019). In addition, working on inclusive education not only with future teachers or education professionals is also an important issue, since inclusion should not only happen in inclusive schools, but also in society as a whole. Thus, working on inclusive education with technical high school students allows for a greater dissemination of the subject, promoting school socialization for all people, whether they are disabled, of different nationalities or races, who participate in another religion or social environment. The research on inclusive education permeated by integrated technical high school allows the generation of more respectful and ethical behaviors among all citizens in social life. For effective inclusive education to take place, it is important that in addition to prepared institutions and education professionals with continuing education, there are also pedagogical resources, inclusive materials and assistive technologies that allow the inclusion of all who attend educational institutions. In this sense, the use of computers helps the process of inclusion in many situations, whether in communication, through specific software for screen reading or even for the use of alternative augmentative communication, which is a tool that allows communication between people who have expression difficulties, whether they are autistic with low functionality, people with cerebral palsy, among others (Sartoretto & Bersch, 2010), either as a tool that allows access to virtual laboratories or even serving, the computer itself,

as a learning tool. As learning tools, we can mention websites and simulations in general, which allow students to use them in a more practical way, often replacing laboratories, allowing students to understand some processes, whether in technical education or at other levels, including in subjects considered more difficult such as science, technology, engineering, and mathematics (STEM), in addition of course, the use of computers to access video classes, remote study, films and other content that are part of the learning process. Considering, therefore, the learning process and inclusion, this work presents the creation of two simulations related them to the learning of inclusion already in the technical high school, raising awareness, inclusion and the creation of technological teaching materials that at the same time that are developed towards inclusion, they allow independence and a possibility of an effective and efficient learning process for all citizens, whether they have specific educational needs or not.

SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS AND THE RESEARCH ON INCLUSION IN THE TECHNICAL HIGH SCHOOL CONTEXT

In the 1950s, there was an educational reform in science in the United States, when this country began to seek a trip to the Moon (Bybee, 2013; DeBoer, 2000; Hahn, 2023). At this time, curriculum change, in science and mathematics, was developed and created for everyone (Koehler, 2016; Hahn, 2023), however, this everyone still did not include people with disabilities. The curriculum based on the STEM methodology, whether in STEM teaching, where the way of teaching is a complement to the disciplines involved in the term STEM, or in the STEM area, where there is an integration of the areas involved in the term (Breiner et al., 2012; Bryan et al., 2016; Holmund et al., 2018), can be an aid in inclusive education since with different approaches, science content, in particular, physics, can be learned in an inclusive way, that is, accessible to all people and being an excellent ally in scientific areas, making students better develop their skills (Hahn, 2023). Inclusive education has been, through present legislation in the signatory countries of the Salamanca Statement (Uno, 1994), discussed for more than twenty years. However, unfortunately, even today, in some countries it is not widespread and finds several barriers in several schools. In order to promote inclusive education in a technical high school in the south of Brazil, and to show the importance of respecting differences, scientific initiation is carried out with students linked to high school technical courses and who have the possibility to develop inclusive teaching materials in their areas of technical training, with scholarships. In order to make accessible teaching materials that can be used by all students who have or do not have specific needs, some students from technical courses in studies and research related to inclusive education and, in this way, develop in their technical areas, promoting respect, interaction, knowledge and, as a result of these aspects, true educational inclusion. An inclusive school is a quality school, where differences are respected, where the opportunity to knowledge is for everyone. In an inclusive school, the most important thing is to get to know the student, carry out diversified activities and provide opportunities for the learning process for everyone (Santos, 2022).

For the development of the simulations considered here, first and for a few months, we discuss about inclusion and accessibility issues with high school students of computer science, where concepts such as scientific methodology, accessibility, special education and different specific needs were evaluated in order to show them the importance of research, inclusion, the

creation of accessible educational materials and recent existing research on inclusive physics education. This process was relevant, as indicated by Fleuri (2009), as education as knowledge is important for the dissemination and guarantee of fundamental rights. Through the process of researching and developing materials for inclusive physics teaching, high school students gain a deeper understanding of the value of inclusion and the importance of ensuring that all students have access to education. This unique perspective on the learning process also enables students to view their classmates with a greater level of respect, particularly those who may not have the same level of access or resources. It is up to the teacher, however, to know how to use different tools to reach all students (Alves et. al., 2021) and in this sense, to create simulations that allow, in addition to learning, the autonomy of students with disabilities it was one of the focuses of this work. Following a review of the specialized literature on the indicated topics, questions about the discipline of Physics were discussed and to the development of prototypes of adapted materials that could be made to allow the learning of Physics by all students. It is important to emphasize, in this process, that in a professional teaching institution, the discipline of Physics has a small number of classes during the week and, therefore, the research motivated the students about the discipline also increased their interest and the search for knowledge by the students involved in the research. It was then sought to create tools that would make Physics learning more real, more technological and, therefore, within the reality of the students, since as Garcia (2010) indicates, Physics activities should be more focused on practical issues to be better understood. In this way, the creation of simulations, allows better accessibility and also more meaningful learning by different students, whether they have or not specific educational needs. For the development of the two simulations, considering the learning process in the discipline of Physics, students from the technical high school computer course were sought after by their professional training profile. The curriculum of this course brings subjects such as: computer architecture and organization, laboratory of architecture and operating systems, programming logic, among others, where the students learn about computer assembly, programming in several languages, creation of systems, web development and Android application creation. The use of simulations in physics teaching is not new like the simulations created by Colorado University (Phet, 2002) or Physlet created at Davison College (Christian & Belloni, 2023), however, creating a tool thinking about that its use can be of wide access, giving opportunities to all students to participate in the learning process in an egalitarian and fair way, is an important way of making education. It is worth mentioning that technological artifacts, if used properly in the school environment or on account of it, enable the discussion of diverse topics related to human rights in a critical way (Santos & Farias, 2009) and thus, technology is allied to the inclusion process in order to create spaces for debates, learning, ethical and professional training.

Thus, the use of technology and the help of training professionals in this area, become even more important considering the aspect of career and professional development for the construction of a truly democratic society whose education becomes really accessible to everyone.

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RESULTS AND DISCUSSION

Simulations and Applicability

Information and communication technologies (ICT) are allies of the educational process and, mainly, of inclusive education. In addition to efficiency during the pandemic, and in the future of the educational process, they are indispensable tools for the continuity of the teaching and learning process. In general, ICTs are thought as individual tools, and, in many situations, working in group seems to be unnecessary when these technologies are used (Rodrigues, 2012), however, creating inclusive information technologies makes it an important tool for the process of re-signification of ICTs, since, even when used individually, it allows the user, whoever he may be, greater access and possible understanding of what is intended to be learned. In addition, of course, to allow the exchange of experiences, when this tool can be used by all individuals, whether with or without specific needs. For the development of the simulations presented here, the applicability of the tool was studied as enabling it to be used by students with physical disabilities of upper limbs, blind students, autistic students and deaf students, in addition to thinking about the universal design, considering the development of a tool usable by any other students, characterizing the inclusion of all.

Technically, for the development of the simulations, we opted for the JavaScript programming language associated with HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) (Duckett, 2016), which are generally used for web applications. HTML, the hypertext markup language, and CSS, the style definition language of HTML elements, were used together to develop the program's interface, such as the positioning of buttons and texts. JavaScript was used for the logical part of the simulation, such as performing mathematical calculations, network requests and event control. For the visualization of the study objects, such as the inclined plane, block and vectors, the HTML Canvas element was used, in which, with the use of JavaScript, lines, circles and texts can be drawn in a customizable way, creating the entire simulation. The Electron tool (Zhao, 2013), an open source software, was used to convert the simulations into a portable executable program, whose installation is not necessary, that is, without the need for an internet browser. To increase the dynamics of the simulations, giving a more laboratory and tactile aspect for the activities, cell phone sensors were used to collect data in real time, connected to the computer via WiFi (via local network), using the Phyphox application (Staacks et al., 2018), a free app available for Android and Ios.

The simulations are not accessed directly from internet sites, they need to be run on portable[1] computers considering the importance of the relationship that the cell phone and the simulator must have, both being on the same Wifi network. Therefore, unlike the standard simulations, these simulations must be downloaded on the computer, both of the students, if they use them at home, and of the teachers who will use them as a tool in the teaching process, in the classroom. The main objective of the simulations is that they are easy to handle, inclusive and allow physics learning in a way that makes it possible to perceive, with the help of the cell phone, of some modifications how the luminosity intensity or the angle of inclined plane that are not commonly used for the learning process in the classroom.

[1] The download address for the executable simulators (.exe) can be found at the end of the references.

Inclined Plane Simulation

The first simulation presented here seeks to facilitate the understanding, in a more interactive way, the behavior of a block on an inclined plane. This subject, due to its mathematical aspect, often ends up being a barrier for students with intellectual disabilities, for example. In this sense an image related to movement can improve the learning process, disregarding the mathematics of the problem. Thus, the use of the simulation by the teacher, as a tool associated with a teaching methodology, includes the student with a disability, while improving the learning experience of other students, enabling the same learning process, in the same space, considering the existing differences. The simulation makes it possible to choose four different materials between the block and the inclined plane to study the friction force. This consideration is important because through its students can perceive that different materials will generate different movements of objects on the surface. In the simulation, each force acting on the block over the inclined plane is represented by its vectors and explained by text and by a voice synthesizer, that is, the explanatory texts about the forces are also heard without the need for a screen reader. The mass of the block that slides on the surface of the inclined plane and the local acceleration of gravity can also be modified in the simulation and, one can compare two planes with blocks of different masses, different local accelerations of gravity and different materials, which, again, it allows a better understanding of the forces acting on the system, when comparing different situations, for example, with an object on Earth or on the Moon, and it is also possible to modify all or only one of the variables available in the simulator. The novelty in this simulation is that some data, in this specific case, the angle of the inclined plane, is collected through the Phyphox app (Staacks, et al., 2018), which is a free data acquisition application, thus making the simulation a type of virtual laboratory where data can be acquired directly from the cell phone. In order to use the simulation, the computer must be on the same wi-fi network as the cell phone that must be connected to the Phyphox app. At the beginning of the use of the simulation, a QR code will appear, after this will be necessary to permit the remote access in Phyphox setting and, this way, this code will connect the simulation to the Phyphox app that will transmit the angles read by the cell phone to the simulation and this, with the other data chosen by the user, in the simulation, will show the movement of the block over the inclined plane. Figure 1 represents the use of the cell phone and the appearance of the simulation of only one inclined plane when in operation. It is important to remember that the simulation can also compare two planes with the same angle, but with different materials and gravity accelerations.

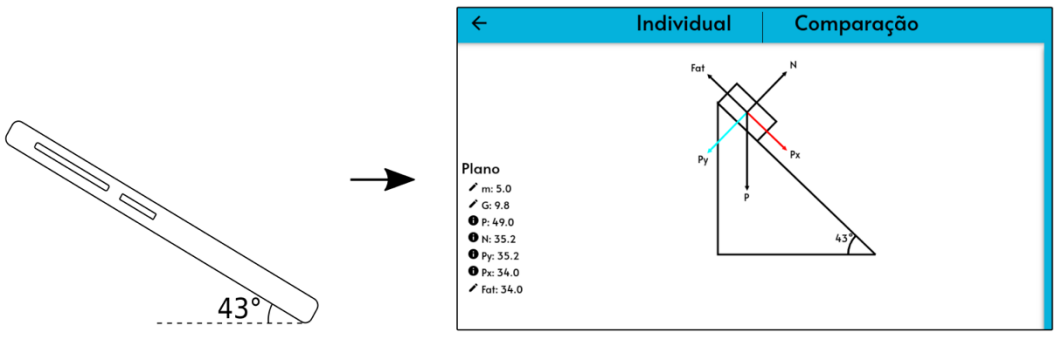

Figure 1. Drawing on the left represents the position of the cell phone that is connected to the Phyphox app, while the figure on the right is the image of the simulation, on the computer screen, which varies the angles of the inclined planes, according to the variation of the angle of the cell phone.

This simulation, with the help of the Phyphox app, is an excellent virtual laboratory, because with the help of the app it makes the simulations more realistic since some data are not chosen by the user, but collected by the cell phone. The possibility of acquiring data directly by mobile phone movement, not just choosing values, makes this simulator even more accessible to students who need tactile material to understand some more technical aspects or that are difficult to understand more abstractly, for example. It is important to remember that the accessibility of the simulation can also be evaluated through the fact that all the physical concepts that are explained in the texts, in Portuguese, are also explained through sound, that is, the voice synthesis of Google translator is used and reads the texts of the explanations existing in the simulation.

Wave Simulation

This simulation enables the students to perceive how a wave amplitude varies with the intensity of light. For this, unlike other existing simulators, the light sensor data is captured by the cell phone and sent to the simulator, using the Phyphox app. With this process, in the study of light as a wave, the transverse waves generated on the computer screen, by the simulation, allow the visualization of the increase or decrease of the wave amplitude, showing that the wave intensity is a characteristic related to the amplitude of the wave and not to its frequency, which is often confused by students. This simulation also allows the comparison between two waves, varying or not their frequencies and also their speeds, allowing the understanding of the relationship between the amplitude of a wave and its intensity, for example. In addition, the variation of physical parameters, speed and frequency, in the comparison of waves, allows a greater understanding of the characteristics of a wave, relating them to the wave aspects that are captured by the cell phone, generating a more effective learning. Figure 2 shows the relationship between what happens with the light intensity on the cell phone light sensor, which is sent by the Phyphox app and the simulation screen. With regard to the teaching and learning process, it is worth mentioning that the image is an important item for the learning of deaf students, with intellectual disabilities and also for those with autism spectrum disorder. Thus, even though many physical phenomena are not linked to the visual sense, the images, through the use of simulators, become important to help the learning process of these students. It is also important to emphasize that a simulator, alone, does not generate learning, it is just another tool in the development of the teaching and learning process and must be used as another element to enable the inclusion and improvement of knowledge, on the part of the students. The students, currently, seek technological aids to complement their studies and, in this aspect, the simulations provide a more active way of learning, since with their help, the student has more autonomy and seeks his/her meaningful learning through issues more related to their daily lives (Barbosa & Moura, 2013).

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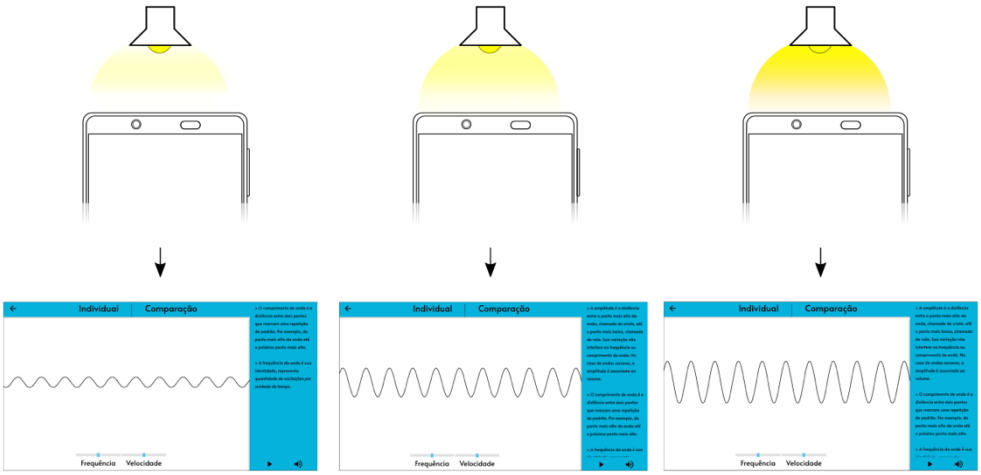

Figure 2. Representation of what happens in the simulation (bottom figure) of transverse waves, whose amplitudes can be varied with the light intensity that reaches the cell phone sensor connected to the app (top figure).

During the development of simulators, we worked with ICTs as assistive educational technologies, aiming the inclusion process from the beginning of the tool's creation to its final use in the classroom.

FINAL CONSIDERATIONS AND SUGGESTIONS

Inclusive education indicates that society must accept differences and do not permit discrimination between people. In this way, information and communication technologies, as assistive educational technologies, allow the teaching and learning process to be accessed by any students, anywhere.

Presenting the simulations created by a technical high school student aims to demonstrate, first, the importance of applied inclusive education, that is, the students themselves understanding the need for the construction of assistive technologies and to learn physics by STEM method (Timms et. al., 2018; Park et. al., 2020), considering that they use technologies and engineering to helps the learn of another students. Next, we want to emphasize that the use of some tools, built with the universal design for learning in mind (King-Sears, 2009), both by teachers as a teaching tool and by students as a learning tool, helps the process of knowledge and assimilation of the content of the Physics discipline. In addition, the use of simulations, with the help of the Phyphox app, provides a more practical process in schools that may not have laboratories that can be used in Physics classes, or even a good internet connection that can access various simulations from different websites, and these simulations presented here need only with mobile data from cell phones to connect to the portable computer. The tool is, therefore, an inclusive aid to the development of young students who need a more concrete process for their human and cognitive development. In addition, the learning process by simulations fosters in students a scientific possibility and an anticipatory attitude towards their discoveries that generates greater knowledge (de Jong, 2006).

Finally, presenting the simulations and allowing them to be used by other teachers and students, with or without disabilities, is a way of disseminating and improving the inclusion process in schools that still need more training and more engagement of professionals to make sure that education, at any level, in addition to academic and professional training, must also be guided by the formation of citizens concerned with a more egalitarian and increasingly democratic society. To improve the quality of physics teaching for all students of different learning levels, it would be important to increase research on inclusive teaching materials, inclusive simulations and other assistive technology.

DECLARATIONS

Data Availability

Adress for access to simulators: https://drive.google.com/file/d/1v1qf6sPY5M5GiR_V926EEHtB0_yx6TZ9/view?usp=sharing.

Ethical Approval

This study is a teaching application. No studies have been conducted in humans. Ethical sensitivity was shown during the development process.

Authors Contributions

David Lucas Pereira Gomes did the simulations and helped correct the article in English. Reginaldo Ferreira and Angela Maria dos Santos wrote the article and guided all the work carried out.

Conflict of Interest

There is no conflict of interest between the authors.

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