Teaching quantum particles in one and three-dimensional boxes

Jizreel Pereira da Silva
School of Education, International University Center, Paraná, Brazil

Abstract: The work was developed with the purpose of showing the difficulties of teachers and schools for the insertion of topics of modern and contemporary physics in high school and showing the importance of its use to adapt to the social reality. We present the theoretical development developed in the classroom, with appropriate tools to the accessible language, showing the aspects of energy and probability of the particle in a region configured for the work in question. After the theoretical treatment, operations were developed with virtual experiment so that the students perceive in a visual way, the descriptions of the equations proposed to solve the determined functions. We analyze procedures and discuss the results. Finally, we consolidated the belief in the use of alternative methods in the classroom, showing the motivation of the students for the introduction of the theme, where they had initial contact of quantum mechanics, although we once developed topics of the old quantum mechanics, such as Heisenberg's uncertainty principle, Planck's constant, photoelectric effect, and Bohr's atom.

Keywords: particle; unidimensional; three-dimensional; energy; box.

INTRODUCTION Society is increasingly modernizing with technological innovations, artificial intelligence, among other methodologies that seek to facilitate social life, reducing time for activities that would require more time. The school receives this consequence of what happens in society and automatically forces the school and teachers to obtain alternatives for their didactic activities so that teaching becomes attractive and effective. For the case of this work, we began the discussion with the difficulties presented by teachers and schools for the insertion of themes of modern and contemporary physics in high school, presenting the theoretical apparatus in its development, obviously working with mathematical tools suitable for students, ending with the virtual experiment carried out by the students of the 3rd year of a class of a public school in São Cristóvão-RJ, consolidating the discussions with analysis of the results.

DIFFICULTIES TO INSERT QUANTUM MECHANICS TOPICS IN THE EDUCATIONAL PROCESS There are many challenges that schools and teachers face in inserting quantum mechanics topics into the educational process. For those

who managed to insert themes of this nature, they certainly continue to face problems, such as adequate material, didactic transposition, and equipment for the use of experiment and even the low number of programs that deal with subjects on Modern Physics. There are several justifications for the use of quantum mechanical topics, such as the recognition of Physics as a human enterprise, awakening and increasing curiosity on the part of the student, presentation of current Physics and its world of research and attraction of young people to the scientific career. [1] For Terrazzan the physics of high school developed in the classroom is from the period from 1600 to 1850 and for Garden, War and Chrispino:[2][3] Focused basically on studies that go little beyond classical mechanics, High School Physics does not present motivating agents for a student who is faced with a physics that is not willing to discuss or modify and does not allow him to understand the actuality that is exposed to him in everyday life. Scientific questions more interesting to this student can be found on the internet, magazines, reports shown in television news and television documentaries (...), but not in the classroom. This distance seems inconsistent with current interests. In addition to the PCN+ and the motivation generated in the students, the teachers also share the ideas of teaching FMC in the classrooms as the importance of a Physics that is extremely necessary to understand the great theoretical and technological innovations of today and that could bring more meaning to learning in the classroom [3]. There is a consensus among researchers who are dedicated to thinking about treatment in the educational context on modern topics of physics. Through interpretive research in relation to the contents of books that address themes of this nature, thought experiments are conceptual tools that enable the study of the physical world by scientists. It is observed the presence of relativity and quantum mechanics in its majority and that have undergone language adaptations, but with content strongly for scientific dissemination.

In the belief of Pospiech cited by Silva and Almeida, he believes it is impossible to talk qualitatively about quantum theory, due to the need to develop concepts and terms through the daily experiences of students, because he believes that language would only be appropriate if it were to use concrete physical objects. Pospiech defends the discussion of philosophical aspects, such as the questions of reality and objectivity of nature. Paulo and Moreira, cited by Silva and Almeida, sought to analyze how high school students would construct fundamental quantum concepts. After the application of the didactic methodology, the students believed that in science there are no absolute truths. In the case of teachers, regarding their

conceptions about the teaching of Modern Physics in high school, some teachers still do not treat it with priority. Their claims are due to the scarcity of time, the large amount of content to be worked on. They believe they have difficulty transposing the equations and their structure in an accessible way, in view of the perception of the predominant mathematical formalism. In other cases, they believed they did not have autonomy for the didactic treatment [4]. There are teachers who believe that to insert Modern and Contemporary Physics in high school should close all classical physics content. Other teachers believe that students encounter difficulties in their bases, so they do not believe it is possible to treat quantum theories [5]. Based on all this reality, this work aims at an introduction of quantum theory through the treatment of particles in a box with one and three dimensions, through the experimental use of a simulation.

FINAL CONSIDERATIONS The work sought to highlight the need to insert quantum mechanical topics, in view of the need to adapt to reality. There are difficulties in various segments of the school, because it is still necessary a more solid discussion on the part of the coordinators and teachers for its use, because there are teachers who did not have in their training, contact with modern and contemporary physics and those who had, present a discourse of superficial contact, developing a thought that has no preparation to address themes of this nature in the classroom, nor to think of alternative tools for the didactic process. In the case of this work, we sought to bring the students closer to the initial contact of quantum mechanics, following the development of the old quantum mechanics through the concepts of the Bohr atom, Heisenberg's uncertainty principle, photoelectric effect, as well as Planck's constant, developed in the works of black body radiation. The students showed satisfaction and motivation to carry out this work, even considering difficulties for the mathematical treatment, because it is natural the perception of most students a certain difficulty in the mathematical basis in works of this nature. It is important that teachers and the school believe in this possibility of using alternative tools to improve the teaching-learning process, where it favors students in the absorption of knowledge, as well as for the teacher in his proposal for elaboration in the teaching plan.

REFERENCE

[1] Osterman, F. C., & Moreira, M. A. (2000). A bibliographic review on the research area “Modern and contemporary physics in high school”. Investigations in Science Teaching, vol. 5(1).
[2] Terrazzan, E. A. (1992). The isertion of modern and contemporary physics in the teaching of physics in the 2nd grade school. Caderno Catarinense de Ensino de Física, vol 9(3), pp. 209-214.
[3] Jardim, W. T., Guerra, A., & Chrispino, A. (2011). Bibliography review: modern physics and its relevance in high school. In: National Symposium on the Teaching of Physics, vol 18, MA, Brazil.
[4] Silva, A. C., & Almeida, M. J. P. M. (2011). Quantum physics in high school: what the research says. Brazilian Notebook of Physics Teaching, vol. 28(3), pp. 624-652.
[5] Monteiro, M. A., Nardi, R., & Filho, J. B. B. (2009). Difficulties of teachers in introducing modern physics in high school: the need to overcome technical rationality in formative processes. São Paulo: UNESP, Academic Culture, pp. 145-159.
[6] Pereira, G. C., & Custodio, R. (2021). The particle in the box: semiclassical, quantum and numerical solutions. Chemkeys Magazine, vol. 3, e021004, pp. 1-10. DOI: https://doi.org/10.20396/chemkeys.v3i00.15963.
[7] Custodio, R. (2021). Quantum Mechanics. Chemkeys Magazine, vol. 3, e021001. DOI: https://doi.org/10.20396/chemkeys.v3i00.15466.
[8] Sousa, A. C. M., Franco, C. C. C., & Guimarães, K. F. (2013). Learning quantum mechanics in high school through educational software. Journal of Education Research Meeting, Vol 1(1), pp. 5-18.
[9] Chen, C., Davu, R., & Zelaya, I. (2018). Particles in 1D and 3D boxes. Wolfram Demonstrations Project. https://demonstrations.wolfram.com/ParticlesIn1DAnd3DBoxes/