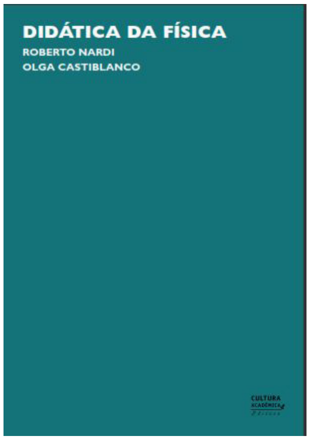
Book reviews

Roberto Nardi, Olga Castiblanco. Didática da Física. Sao Paolo, Cultura Academica, 2014. 160 pp.



This book contains a wealth of practical information for the teaching and learning of physics. It should be on every physics teacher's book shelf as a handy reference that is full of ideas on how to teach physics. The book is in Portuguese but Spanish speakers should be able to understand the basic ideas regarding teaching techniques that are presented throughout the book. English speakers can use the summary below to get many ideas to use in their own classes. The book is the result of the experiences of the authors while teachers of high school physics in Brazil and Colombia. The book is also based on past research, national and international, on the teaching and learning of physics. The goal of the book is to aid in the production of a university curriculum for training future physics teachers. The authors consider science teaching as an established research area with its own issues yet to be resolved. Training of future teachers needs fundamental reformulation based on research in recent decades. This book is available free on line at http://www.culturaacademica.com.br/_img/arquivos/11_didatica_da_fisica-WEB-otimizado-travado-v2.pdf This is a secured pdf file, which cannot be altered or printed but it can be downloaded to your device.

Following is a summary of the topics covered in the book and the authors' observations about those topics.

Literature research

The first part of the book is a summary of a literature search that the authors did. The literature search highlights the importance of preparing future teachers to be critical thinkers and to train their students in critical thinking. Future teachers should engage in metacognitive exercises to reflect on their own learning to better prepare them for such activities with their future students. Future teachers should be trained to do their own research on teaching and learning of physics. Interdisciplinary education should be part of teacher training, although a definition of interdisciplinary educations varies widely among various authors and educators. Teaching of physics is interdisciplinary just because it requires an understanding of the physical principles involved and it requires an understanding of the context in which it is taught – the classroom and the teaching strategies.

Each scientific discipline (biology, physics, chemistry, astronomy, geology...) has different research needs due to the unique knowledge base of each discipline. However, teaching of all disciplines involves common areas: social sciences, epistemology, the psychology of learning and the philosophy of science. Issues to be dealt with here are: 1. How can we use for physics teaching knowledge developed in teaching other disciplines?, 2. What types of student activities are most appropriate for learning physics? 3. How do we proceed from the simple to the complex – from basic introductory physics to advanced physics? 4. What should the sequence of topics be in the courses and curriculum?

In the literature there exists a consensus that teacher training needs to be improved. There is not consensus on how to do it. The authors attempt to identify areas of research in the teaching of physics by three brazilian authors. Various questionaires for these authors reveal a consensus only on general research areas, which are: 1. teach and learning of physics in diverse contexts, 2. curriculum development and 3. student-teacher classroom interaction. They have found that, in general in Brazil, future teachers are not well trained in physics teaching; they lack a base in interdisciplinary teaching.

They go on to say that students in the physics teaching program should learn to study their own activities as a teacher with the end of improving the processes of teaching and learning. A list of things to be studied in the teaching and learning of physics are: 1. The cognitive processes of teachers and students; 2. Communications in the classroom; 3. The planning and development of teaching processes; 4. The creation of teaching devices; 5. The use of resources such as laboratories and technologies; 6. The relationship between teacher, student and content; 7. Publicizing scientific work.

The principal objectives of a physics-teaching curriculum should be: 1. Use of interdisciplinary links for the solution of problems in the teaching of physics; 2. Overcoming "common sense" approaches to the teaching and learning of physics; 3. Teaching critical thinking not only for content but for teaching activities; 4. To teach research in physics education and to apply physics teaching research; 5. To develop a professional identity specifically for teachers of physics. According to the literature, physics teaching is not just the teaching of content, but deals with questions such as: what physics topics to teach, how to teach them, how to detect and deal with preconceptions and how to generate models and practices appropriate to each type of content and in each context.

One fact that appears repeatedly in the literature and in their own research is the contrast between methods of teaching the future teachers and the methods they are expected to use in their future classrooms. They go on to say that the practice of physics teaching should include as a minimum: exercises of self recognition, colaborative work, analytical work and directed work. Learning technologies should be included, not as an end but as a means of addressing problems in teaching and learning. Collaborative work should encourage students to listen, learn scientific terminology and debate ideas. Based on all of the above, they propose 9 possible dynamics (methods) of interaction: 1. Of the individual with the collective – starting with individual reflections which are then transmitted within one group and then introduced to the entire class 2. Of the collective to the individual – begin with free exchange of ideas within the entire class then break into smaller groups and ending with each student doing a written summary of the ideas dealt with, 3. Group work – A major problem is divided into sub-topics, each sub-topic being dealt with by a different group. Each groups' solution is then passed to another group to be analyzed until all groups have seen every other group's solution. The professor then leads the entire class through a comprehensive review of the solution. 4. Research questionaire – the professor prepares a survey over a topic to be done at the start of class. The results of the questionaire, done anonymously by the students, is then analyzed by the class as a whole. 5. The rotation – The students sit in one big circle. Each student writes a question or statement in a notebook. The notebooks are then passed to the person on their right, who then writes an answer or comment in the notebook. When each notebook has passed by all students and returned to its owner, the professor opens the class for a general discussion of any of the topics covered by the original notebook owners' questions or statements. 6. Feedback – The professor organizes student responses to a given topic with the aim of clairifying any misconceptions or deepening the coverage of the topic. 7. The Debate – The professor presents an existing problem in academia, the literature or in society, explaining why this problem exists and why it has not yet been resolved. The students are then put into groups and given one writer's opinions on the problem. The groups then debate this problem taking the position of their paper's writer. 8. The Watch – Equal numbers of students are arranged in two concentric circles. Two students at a time interact, one on the outer circle with one on the inner circle. The interactions can deal with many different topics in many different ways. For example, the inner student can act as a recorder and record the responses of each outer student to a question. At the end, the professor opens a group discussion for further exchange of ideas. 9. Co-evaluation – Students evaluate a talk or a paper produced by another student. The professor can distribute guidelines for each evaluation.

The three teaching dimensions

The authors identify three contexts for the teaching and learning of physics that they call the "dimensions". They are: 1. The Physical Dimension – learning the concepts of physics. Included in this dimension is metacognition, the history of physics and the philosophy of physics. 2. The Sociocultural Dimension – the content and methodologies for teaching physics in diverse educational settings (psychology, language, sociology and pedagogy), and 3. The Technical Dimension – the use of technology to support learning in the classroom and to promote student interactions. This includes the laboratory, learning technologies and textbooks.

In the next section they present examples of exercises for each "dimension" that were used by them during the seventh semester of a university program in the state of São Paolo in 2012.

The physical dimension

The first is an open-ended exercise. The question is: "An object is launched straight up. What is the maximum height it will reach?" The students are first grouped in pairs to organize an approach to the problem. They found that many variables are identified and that the importance of initial conditions is recognized. It also reveals existing (continuing) misconceptions. To encourage further reflection on the problem, the follow-up question was used: "What is the role of experimentation in the solution of this problem?" The final question in this exercise was to ask the students: "What would be the first steps you would do to teach this phenomenon?"

The second exercise is one involving the history of physics regarding the nature of light. The focal point was a time line with the names of scientists located along the line. A description of light was associated with each scientist. This exercise helped the students to see how the history of physics can be used to demystify the idea of science as absolute truth and to see how knowledge is constructed through critical thinking.

The third exercise involved the use of epistemology. The students were prompted to think about the nature of time with a series of questions about time. They were then presented with definitions of time using various philosophical approaches including naive realism, empiricism, traditional rationalism and surrealism with the end of identifying where their own descriptions of time fit. The students were surprised to see the range of philosophies into which their various responses fit.

The fourth exercise involved observation. Each student was given a small branch, which had leaves on it. They were asked to describe the object, listing whatever characteristics they observed. Their observations included properties such as colors, size, leaf distribution, texture, shape, state of the leaves (living versus dead), external agents – dust, insects. The second part of the exercise was to expand the significance of observable characteristics when the system cannot be observed with the naked eye. Further group discussion expanded on the characteristics of the observer, the observed and the instruments of observation.

This section ended with 27 suggested references for the reader to use as a base to generate new exercises.

The sociocultural dimension

In this section they propose the development of a transition from the identity of a university physics student to his or her identity as a teacher of physics. Teaching to four groups were studied: 1. visually impaired students, 2. grammar school students, 3. middle school students, and 4. teaching adolescents versus teaching adults. The students recognized the multiple difficulties with each group, especially the necessity of making the teaching age-specific.

Exercises were done to relate science technology to society. Students were given articles to read about topics like: 1. energy consumption, 2. global warming, 3. energy efficient light bulbs, 4. energy policy in Brazil. They were asked to decide which physics topics could be taught using each article and to propose a lesson plan to introduce the concepts and solve the problem discussed. The students came up with a wide variety of creative lesson plans, which are discussed in the book.

Exercises were done to promote the development of self-reflective teachers. Six situations were chosen based on actual experiences of the authors. Each situation described involved some last minute difficulty that required the professor to immediately adapt to the situation in order to make as good a use as possible of the time allotted for that particular class. The students read individually each situation and then reflected on how they would respond. The responses were then discussed by the group. This was followed by specific questions for the students to further develop their thoughts about any possible situation: 1. What sources could you consult, other than physics textbooks, to augment your understanding of the topic taught and to improve the lesson? 2. How would you plan, with your teaching colleagues in other disciplines, an integrated view of the sciences and mathematics? 3. How and when would you reveal to your students that you lack an understanding of a topic? 4. Given that you will inevitably confront situations requiring last minute improvisation, how could you prepare to minimize the risks associated with these improvisations? This section ended with 55 suggested references for readers to use to generate their own new exercises.

The technological dimension

First the uses of experimentation were studied. In each experiment the students were asked to describe the theory to be studied, identify the variables, parameters and constants. The authors attempted to help the students analyze experimental methods by getting them to think about the advantages and disadvantages of each experiment. The following experiments were selected both from the literature and from their own classes. 1. An Einstein thought experiment dealing with objects released in an elevator for inertial and non-inertial reference frames. 2. Newton's disk 3. Simple pendulum 4. Mechanical tractor – made with a spool, ice cream stick and rubber band.

Second, the uses of information technologies were studied. They chose to study what happens in the classroom when different types of technologies are used. They asked for students to suggest an appropriate class use for many different types of technologies: animations, educational games, simulations, search engines, sensors, distance education, out-of-class exercises and video conferencing, to name a few. They then developed exercises for five technologies: 1. audio stories – a science fiction story, 2. videos – showing how sound is produced, 3. stroboscopic photography – to study objects in free fall, 4. interactive mathematical software – studying the effect on simple pendulum period of amplitude, starting angle, length of the pendulum , and 5. on-line testing. Each student group worked on an exercise for one technology. Their results were then shared and discussed.

Third, use of bibliographical materials were studied. The authors selected five types of bibliographical resources, all dealing with the theme of motion. The resources were: 1. a book on the development of scientific ideas, 2. A physics text book – first case, 3. A physics text book – second case, 4. A textbook based on research in physics education, 5. A virtual encyclopedia (Wikipedia). 6. A book based on physics research. Each student was given a copy of the materials from each source and asked to identify the author, year produced, and give a summary of the content. They were asked to state their level of agreement with the ideas presented by each author and explain how they would use the material to teach about motion. Possible uses suggested were: introductory, to promote thinking, to use as a base for class discussion and to discuss errors in the text. This section ended with a list of 37 references for the reader to use for further ideas.

Final Considerations

The pupose of this book is to deepen the understanding that Physics Teaching is its own discipline. To that end the authors identify two related objectives: 1. To match present teaching methods for students in the Physics Teaching program with methods to be used in their future classrooms. 2. To use physics-teaching research to develp those methods. They propose doing this through the "Three Dimensions": develop understanding of the physical principles, recognize the sociocultural dimension and finally, enhance the teaching with the technology available. They encountered initial student resistance to new methods of teaching. But that resistance continually decreased as the students learned by using those methods. In Brazil there exists general agreement on what topics to teach a physics undergraduate, but there is no agreement on what should be taught in a Physics-Teaching curriculum.

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