A Teaching Philosophy on University Physics Education

V. Tanrıverdi
tanriverdivedat@googlemail.com
February 4, 2020

Today, we can see that science has changed our lives in many ways. One side of this change is related to technological developments, and our daily life has changed with cell phones, computers, means of transportation, medical, measurement or scientific equipment, or other similar products of science. These also improved our way of doing science. Another important consequence of science is seen on intellectuality equally important with technological developments, but this deserved importance is not seen in the community yet. One of the most influential changes in the intellectual structure is seen during the change of our ancestors’ world view with the Copernican revolution done by Copernicus, Galileo, Kepler and many others in the 17th century. This change affected not only scientists but also other people by destroying the geocentric thoughts and leaving homocentrism groundless. After this revolution, it is realized that we are not at the center of everything, and we live together with others. Similar changes in intellectual structure are also observed during 20th century. These show that science is one of the most important human activities affecting life on Earth in several ways. Since physics is one of the main branches of natural science, its education should be consistent with the importance of science. So, physics students should be educated according to the needs of science since some of them will be scientists in the future. To do that, we need to teach students what science is and how science progresses by teaching them the intellectual background as well as scientific paradigms, e.g. Newtonian physics, electromagnetic theory. Teaching Newtonian physics, electromagnetic theory, classical mechanics, quantum mechanics and statistical thermodynamics is important since
they are the core theories developed within centuries. However, being a scientist or physicist requires knowledge of not only core theories but also other aspects of science.

We need to show students why science is vital. With science, our life becomes better, which is a fundamental fact, and it can easily be recognized. However, there are other important effects of science in the intellectual structure of society. Some false beliefs are eliminated from society by the help of science, which is related to seeking the truth. Seeking the truth has many important effects on human beings, without it, we could fail in many topics.

As already mentioned, some of the students will be scientists in the future, and one of the basic functions of a physics department is to educate such students. These students need to know how scientific developments are carried out, which should be adequately taught in different courses. Some parts of the scientific developments should be covered within a course on the history of science, which is needed to recognize how scientific thoughts have started and how scientists gave explanations on nature in both quantitative and philosophical ways. The modern part of them should be explained in other lectures, e.g. how those modern thoughts or paradigms had been developed, and in which experimental and/or theoretical background they were needed, and what they explain exactly, and what their role is in the following scientific developments.

One of the most important bases of science is seeking the truth. We seek the truth by following the steps of the scientific method. A law should go through steps of the scientific method or a hypothesis should have properties that can go through steps of the scientific method to be considered as scientific. A researcher needs to know the intellectual background and steps of the scientific method by heart, so do future researchers or students. Then, physics education should embody the steps of the scientific method. Since the scientific method consists of many steps and each step requires a considerable amount of work, some basis of these steps should be appropriately implemented in different courses.

Firstly, we should provide a suitable environment for questioning and critical thinking to the students since scientific development starts with questioning. Questioning and critical thinking can be initiated during the lectures by giving a chance to students for asking questions. However this is not enough, we also need to teach students how to ask good questions by showing them how to question a scientific paradigm; i.e. how they are related with nature, and how they are consistent with experiments, and what the hypotheses of
a studied paradigm are and how they are applied.

The second step of the scientific method is gathering information. To teach it, we should give homework and ask them to prepare projects.

Thirdly, we should mention how our equations describe natural phenomena since we model nature by equations, and models are another crucial part of the scientific method. It is one of the tools of science, which makes it possible to progress in science. It is very hard for us to consider nature as it is, and it is also very hard to write and solve the equations written to explain nature. To be able to do so, we sometimes need to idealize and we sometimes need to construct models. There are very few cases that we can solve very close to natural phenomena. Therefore, we should explain our particular equations and explain why they work.

Lastly, students should also learn how to analyze their data or results. After analyzing their results, they should write their procedure and results, so we should give a chance to students to write their work. After they wrote their work, the instructor should show them their mistakes, in both calculations and assumptions. This procedure is based on some steps of the scientific method.

It is better to mention here from the projects and research homework since they are some small partial applications of the scientific method. Homework is an important part of the lectures and serve in various ways, and this essential part should be carefully prepared to bring experience to the students, not only on solving some important problems but also perceiving relations between equations and nature, and doing calculations in detail and repeating them in many similar cases, and making assumptions and approximations, and so on. Here, it is needed to emphasize the importance of repeating calculations for similar cases. In science, we do repeat calculations for similar cases many times because some of them can give results that are unexpected according to deductions of the current paradigm. Such results can help to improve the current paradigm, and in rare cases, they can show us signs of a new paradigm. Then, we should provide a chance for students suitable to make some research by homework and research project in some courses to help them gain basic skills related to the scientific method.

We seek generally the truth by studying relations in natural phenomena, as a physicist. We do our research in different parts of the scientific method, and our research concern mostly small relations. This is the same all-over the world, most scientists study small questions and make small contributions to science. Big organizations and fast communications are partly responsible
from this and we should teach students that studying on small relations is common among the scientists. However, all these small contributions together with the intellectual basis become one of the most important human activities, and this collective work does what was previously done by great scientists. If we do not know the intellectual structure, we can not properly appreciate important works. Hence, intellectuality in physics should be included in courses by mentioning background, future consequences, relation with our understandings, effects on different natural phenomena and so.

Another issue is related to ethical topics. In lectures, we should restrain unethical acts not by force but by explanations. We should warn students about plagiarism, fraud and falsification, and their consequences. Other aspects of ethics should also be mentioned, e.g. ethics of the profession.

The laboratories and lectures are two main parts of the physics education where the explained procedure should be applied, and their structure should be conveniently designed according to scientific method and necessity of teaching scientific knowledge. The different parts of the scientific method or scientific way of thinking can be taught in different courses. We should teach questioning, gathering information, modeling in lectures, and testing a thought in laboratories, and we can teach analyzing results, writing and finding solutions in both.

Another necessity of a department is the integration of courses in many ways. This necessity requires studying the curriculum and syllabus of the courses considering different aspects. This integration is mainly done by scientists who write lecture books, however, some topics should be clarified in particular cases. To do this, the department should create opportunities for instructors either by meetings or providing necessary documents.

Here, it is needed to underline the integration of lectures and laboratories. In lectures, students should be prepared for the experiments, which they will do in the laboratory. This preparation should include the intellectual background of the experiment and its relation to nature and scientific development. If this integration is not well constructed, students could not perceive the results of the experiments at the necessary level. On the other side, in laboratories, students should feel the experiment’s theoretical results. A helpful way for that is letting students write conclusions and comments on the results of the experiments and its consequences in the theory.

There are other necessities for giving lectures. Following a well-prepared book for the course is mostly the best option. In some cases, using a single book is not enough and different books can be used. The preparation of
lecture notes is always necessary. Lecture notes should include not only the
derivation of equations but also explanations and assumptions, which should
be told the students in lectures.

It is necessary to emphasize that it is impossible to teach every student
at the same level. There are some eager and hard-working students, some
unwilling and inactive students and some average students. In general, aver-
age students are the majority of the class. The level of the course should not
be determined according to eager and hard-working or unwilling and inactive
students. Then, our aim should be to teach average students the necessary
skills and knowledge. To succeed, we should determine the level of introduc-
tion of each new idea according to levels of average students. We can try to
understand the level of students by asking some questions or making quizzes.
Asking questions in the class can be misleading because good answers from
one or a few students do not necessarily mean all students know at that level.
Then, it is better to make some quizzes to understand the level of average
students in necessary cases. After grasping the average level of the students,
we can make explanations according to this average level. On the other hand,
we should not forget eager and hard-working students, there should be some
hard questions for them. Including research homework or project in possible
cases will be better for all students.

The level of the course should be determined according to that an average
student who studies, tries to do all the homework and attends more than 90
percent of the lectures can pass with a fair grade, e.g. CB or BB. It should
be underlined that all must courses should have homework either once in
two weeks or every week, and its percentage in the letter grade should be
arranged due to study time. In some universities, homework affects the letter
grade by 50 percent and a student who does not do half of the homework
can not pass the course. This structure can be applied in some courses. We
can use homework as a guide for students, by using them, they can study
properly and get the thinking style of the course. There can be some hard
questions, however, they should not dominate the homework.

The attention of students is one of the key factors for the success of course
in teaching necessary skills and knowledge. We can use demonstrations, daily
experiences, some interesting results of a topic, historical developments of
topics or historical facts to get the attention. To learn how to do this, we
need to try different things. If these are not included carefully, and if lectures
are not well prepared and planned, they can be distractive and causes loss
of attention. Without attention, it becomes very hard to teach something.
When there are such problems, some instructors may blame the education system, previous education or students. All of such topics can cause problems or all of these can be problematic. Even if all the problems exist, we should try to teach the necessary skills and knowledge related to the course, which is possible. Some lecturers go further and may blame students in the class or discuss with them topics unrelated to the course, which can destroy the students’ attention or their will. Joking is another thing that we should be very careful, and unnecessary jokes should not be done in lectures. We should keep ourselves away from such harmful things.

The syllabus determines the course in various ways. We should cover the necessary topics in the syllabus. However, we should not try to explain all the details of the topics, which is impossible most of the time. We should explain the basics and necessary parts, give some details as homework and just mention some parts by leaving the remaining part to the students’ interest.

We should consider the question "Did the students get the necessary skills and knowledge from this course?" at the end of the semester. We can use the results of exams or other feedbacks to see whether we succeeded or not. We should consider how to improve these and what can be done to remove drawbacks.