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ORIGINAL RESEARCH PAPER

Modern Physics in Iranian High School Textbooks

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ABSTRACT

Most advances in science and technology, during the past two centuries, rely on modern physics concepts developed in the early 20th century. The reliance is so profound that any improvement in science and technology literacy falters without an effective presence of these concepts in physics education. Taking a textbook evaluation perspective, the present study shows the extent to which the main parts of Iranian high school textbooks comprise of classical physics. It also discusses some complications and obstacles to the inclusion of the modern conceptions. The remarkable advancements in science and technology over the past two centuries are deeply rooted in modern physics concepts, developed during the early 20th century. These concepts, including quantum mechanics and relativity are essential for fostering science and technology literacy, yet their integration into physics education remains a challenge. This study evaluates Iranian high school physics textbooks, focusing on the dominance of classical physics, such as Newtonian mechanics, and exploring obstacles to incorporating modern physics. The findings emphasize the need for curriculum reform and updated educational standards to align with contemporary scientific knowledge and ensure a comprehensive understanding of modern physics.

Keywords:
Science education; Physics education; Modern physics; Physics curriculum; Literacy of science and technology

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1. Introduction

Over the past two centuries, many innovative and remarkable advances in science and technology have profoundly affected our lives. Specifically, advances in satellite communication, computer and smartphone technologies have made it possible to develop various internet-based life activities. Given such a huge and fast scientific development, it is not so hard to predict that even further fascinating capabilities such as quantum computing, space travels, virtual reality, nano-medicines (Freitas, 1999) and a number of other technologies enter our lives in near future.

Most of the advances, as abovementioned, rely on two revolutionary physical theories developed during the first quarter of the 20th century: Theory of relativity and the quantum theory. These theories have very profound effects on our view of the universe that physics beyond them is named by the term modern physics (MP).

MP affects our lives in two ways. First, it has revolutionized our philosophical and scientific world view. Second, it has a strong influence on daily life by introducing various technological innovations. Some examples are the global positioning system (GPS) (Faraoni, 2013) nowadays used for navigating aircrafts, ships and vehicles; fission-based nuclear energy dating back to the last mid-century as well as fusion-based nuclear energy that seems to be accessible in near future; marvelous tools for studying human bodies, treating diseases and improving health; and advanced electronic devices and communication systems which all have their origins in semiconductor chips. The list goes on.

Despite the important role of modern technologies in our lives, few individuals have even a slight understanding of how the scientific enterprises operate. Such a gap between technological advances and scientific/technological literacy of individuals in a society can potentially slow down scientific developments both in developed and developing countries. The gap, hence, needs to be filled by appropriate education policies and plans made by science education policymakers and discourse communities if they wish to increase effective participation of citizens and prepare them for living in the new century.

In our view, an important practical way to fill the gap between technological advancements and technological literacy is to gradually integrate MP into the school curricula. Following this proposal, we first study how the Iranian education system deals with this issue. Then, in section 2, we briefly offer a simple analysis of Iranian textbooks of the Ministry of Education (MOE) upper secondary schools. Accordingly, we discuss that there is a small share of MP in these textbooks. In section 3, we present some obstacles to including modern conceptions in high school curricula. Finally, in section 4, we outline our conclusions.

2. MP in Iranian physics textbooks of MOE

In Iran, physics, chemistry and biology are taught under the heading of ‘science’ courses during the first three years of secondary education. Starting from the tenth grade, physics is taught as a separate course in two general branches of science and mathematics. In upper secondary education, physics is taught over three courses, i.e., physics 1, 2 and 3, during the 10th-12th grades. As to the textbook contents, different physics-related topics that are mainly covered and taught during the three courses are presented in tables 1a, 1b and 1c.

Table 1a. The percentage of the topics covered by Iranian MOE physics 1 textbook (grade 10 of upper secondary school)

Topics	Units & measurements	matter	Work & energy	Heat & temperature	Thermodynamics
%	15	19	19	31	16

Table 1b. The percentage of the topics covered by Iranian MOE physics 2 textbook (grade 11 of upper secondary school)

subject	charge	DC current	magnetism	Induction and AC current
%	36	30	18	16

Table 1c. The percentage of the topics covered by Iranian MOE physics 3 textbook (grade 12 of upper secondary school)

subject	Motion in one dimension	Circular motion	waves	Interaction of waves	Atomic physics	Nuclear physics
%	18	21	18	16	14	13

The tables indicate that the topics of physics 1 and 2 are totally devoted to classical physics and only %27 of physics 3 topics are devoted to quantum ideas such as, atomic structure (photoelectric effect and Bohr’s model) and nuclear structure (nuclear fission and fusion).

Table 2 indicates the percentage of physics contents of the whole physics textbooks 1, 2 and 3. The evidence shows that ‘relativity’ is not included in these textbooks and only %9 of the topics are devoted to quantum physics.

Table 2. The percentage of the major topics in physics textbooks 1, 2 1nd 3 of Iranian MOE upper secondary high schools

subject	mechanics	Electricity & magnetism	Heat & temperature	quantum physics[1]	relativity	others[2]
%	20	30	16	9	0	25

Although classical physics was formulated during the 17th to 19th century, still it has a central role in school physics curricula. It should be noted that classical conceptions such as conservation of mass, conservation of energy, absoluteness of space and time intervals and gravitational force in Newtonian gravity are just approximations of the corresponding modern concepts. They may give students an incorrect and simplistic image of science as long as they are taught with no reference to their limitations and the need for paradigm change (Fischler & Lichtfeldt, 1992; Gil & Solbes, 1993).

3. Some obstacles to entering MP in physics curricula

We are living in a scale in which all bodies move with speeds much lower than the speed of light and the sizes of bodies are much larger than those of atoms and subatomic particles. The laws of classical physics, which are consistent with our physical intuition, govern the world of this scale. For instance, when a teacher tries to teach the Newton's laws, she/he may simply use students' everyday experiences as a resource in naturalistic instructional settings. In this case, both teachers and students are at convenience because they do not need make extra efforts to improve the learning process.

On the other hand, scientific/technological advances of the 20th century had led us to have an access to another scale in which speeds are comparable to the speed of light and the scale in which objects are of the sizes of atoms and subatomic particles. The physical phenomena of these scales are far from being accessible in everyday life and that is why they are less intuitive. Teachers have to use complicated tools and issues to make the learning process more effective. This scale problem may be regarded as one important obstacle to integrating MP into physics education. It, however, may be circumvented by using appropriate teaching methods such as modelling and analogies (Kaur et al., 2017a, b, c). It is shown that using these methods in classrooms helps students to gain conceptual understanding (Treagust et al., 1992; Coll et al., 2005). For instance, the concept of gravity in general relativity and its connection with curvature of the four-dimensional spacetime can be taught by using an elastic membrane stretched across (Kaur et al., 2017a). The membrane represents a two-dimensional flat surface and models a four-dimensional spacetime. Putting any mass on this surface will cause it to distort and curve. Adding any other masses or balls to this curved surface makes them move on a curved background towards each other and simulate the gravitational force.

[1] Basics of atomic and nuclear physics
[2] This issue contains measurements and units, fluids and properties of matter, waves and light.

Another obstacle is the way the MP theories are made. In fact, theories of MP are formulated by complicated mathematical structures. Students should be familiar with vector spaces and tensor analysis to learn mathematical structures of quantum physics and relativity. Since this level of mathematics is complex and counter-intuitive, the structures do not seem to be suitable for school students. Needless to say, classical physics can also be extremely mathematically complex, however its complex issues are not included in the school physics curricula. Basic concepts of the MP are simple and can also be taught without recourse to complex and abstract mathematical structures.

4. Conclusions

Science plays an increasingly important role in our lives. It improves the quality of our living and gives a better understanding of the world around us. Despite this, there is no simultaneity of the rapid advances of the modern societies and individuals' scientific literacy development. The existence of this gap is more crucial in developing countries because it can significantly slow down scientific and technological developments.

One way of filling this gap is to incorporate MP into the high school curricula. The need for updating school physics curricula has been previously addressed by some research (e.g., Aubrecht, 1989). Additionally, there is an international consensus around the need to include MP contents in high school physics curricula (Petri & Niedderer, 1998; Walwema et al., 2016; Stadermann et al., 2019). Inspired by this, we analyzed physics textbooks of Iranian MOE upper secondary schools. The results revealed that over %90 of the textbooks contain classical conceptions while no concept related to Special Relativity was found. Such a small portion of MP and particularly zero share of Special Relativity in high school main sources, consequently affect STEM (Science, Technology, Engineering, Mathematics) education (Hestenes, 2015; Liu et al., 2023) which is considerably required for the enhancement of economic development, international competitiveness and job creation.

In this paper, we have argued that one reason for the small share of the MP in school physics curricula might be the less intuitive nature of its concepts compared to that of the classical physics. Further, the mathematical structures of the MP theories are usually too abstract and complex to let students easily understand, while are more suitable for the skillful and gifted students (Johnston et al., 1998). Although both reasons are valid and may be regarded as two important obstacles to the integration of the MP into the school physics curricula, they can be simplified through adopting appropriate teaching methods (such as modelling and analogy) and avoiding the mathematical complexities (Kaur et al., 2017a, b, c).

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