Subatomic Physics: A Key Component to Secondary Education

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Abstract

Subatomic physics, one of the most rapidly developing research areas, studies the building blocks of our universe such as quarks and leptons. In most schools, university students can explore these exciting discoveries through up-to-date physics courses and research projects. However, secondary students around the world are not as fortunate. Mainly, material included in secondary physics courses are pre-20th century classical mechanics, which many students perceive as dry. The article demonstrates that in most countries, subatomic physics topics are placed at the end of the curriculum, as optional, if at all. At the same time, some teachers feel more confident in teaching subatomic physics versus astronomy, which is included more often. The article explores the advantages of subatomic physics being included in the secondary school curriculum, with examples from the literature review and suggestions for curriculum updates.

Keywords*: subatomic physics, nucleus, elementary particles, cosmos*.

1. Motivation

There is a shortage of physicists in almost all parts of the world and this situation will become more problematic in the next decade. However, subatomic physics can help excite students to study physics and physics-related fields such as engineering, especially female students who are underrepresented in physics in most countries.

2. Introduction

What is the origin of mass? What is the nature of the dark matter? Do neutrinos hold the key to understanding the dominance of matter over antimatter in our universe? Subatomic physicists are working to answer these and many related questions, and we may soon see a revolution in our understanding of the nature of matter and its interactions [1].

However, subatomic physics is absent from most secondary curriculums around the world. Secondary education is considered as the last formal years of education offered before the student can choose to proceed to post-secondary education. The students in secondary education are being deprived the opportunity to be a part of the subatomic physics research community. Students who express interest in subatomic physics in secondary school should have the opportunity to delve deeper into the thought-provoking topic with entry into post-secondary institutions. In secondary schools, the physics curriculum should be updated frequently hence the students are given the opportunity to learn and explore new topics. Various countries around the world have completed studies to detect if subatomic physics should be included in secondary curriculum worldwide. In the following article, two tests performed in Europe will be explored deeper and some suggestions will be declared for secondary curriculum updates.

3. Subatomic Physics in Secondary Schools

In secondary schools around the world, the majority of subjects included in the curriculum to be covered, consists of updated subject areas such as mathematics, chemistry, biology, etc. Yet, studies show that the physics courses offered in secondary schools worldwide includes the same topics from the pre 20th century such as classical mechanics. For many students, these topics are dull, resulting in the students losing interest and potentially not wanting to peruse their physics education past secondary school. Physics is always being updated and refreshed, including the topic of subatomic physics. The lack of updated physics in secondary curriculums is potentially one of the factors that is affecting the low number of physics university majors across the world.

European Journal of Physics Education completed a study, “Prospective Physics Teachers’ Views on Their Knowledge about the New Concepts in Turkish High School Physics Curricula”, aimed at observing teacher’s knowledge for different physics topics and updating the curriculum based on the results. The main goal was to investigate prospective physics teachers views on their knowledge about topics to be included in the new physics curricula, investigate the sources of their acquired knowledge about the new concepts, and to explore if there was differences in views on knowledge about these new physics concepts among prospective physics teachers of different genders, years of study and university. The teachers were advised to select subjects on which they felt most knowledgeable. In terms of subatomic physics, the study was successful. As it is known, astronomy is one of the most popular topics of physics. The results showed that high school teachers were deficient in concepts particularly related to the subjects, astronomy and sound. Before the study, the team from European Journal of Physics Education predicted that high school teachers would be more knowledgeable in subjects like astronomy and have more issues with the tougher topics like subatomic physics. Contrary to their expectations, the teachers considered themselves as more knowledgeable in the topic of subatomic physics. The final results demonstrate that teachers have more knowledge to teach the students topics involving subatomic physics. If teachers are knowledgeable about a subject, then they should be given the opportunity to have subatomic physics incorporated in the curriculum. This will permit teachers to educate students on the topics they have the greatest knowledge in. This will correspondingly benefit the students to better comprehend the topics. To gather additional results from the study, numerous topics involving physics were compared. Two of the five topics revealed as most knowledgeable were concerning topics of subatomic physics. These topics are quarks and de Broglie Hypothesis. The three other concepts were related to the optics and classical mechanics, both of which are very popular in secondary schools’ curriculum world-wide. The results showed 99-100% teachers said “I have no knowledge” on parallax, parsec, quasars and binary stars, compared to 43-44% who said they have no knowledge on leptons, baryons and mesons. [2] The subjects that had the higher percentage of no knowledge were in topics of astronomy the prospective teachers should be given the opportunity to teach the subjects they feel most knowledgeable in. This will allow the students to acquire a better understanding of subatomic physics.

In Canada specifically, the students who choose to have physics as their optional science course for the most part are lacking the subatomic physics aspect. Out of 13 provinces and territories, there is only four that include subatomic physics in the curriculum. When included in the curriculum, subatomic physics is never a full unit, however only a subtopic covered in one or two classes.

When students in secondary schools have the opportunity to learn about exciting and new events in the world, they have the chance to succeed and make new discoveries. This was proven by a group of secondary students in Ontario, Canada. Subatomic physics is included in the Ontario secondary schools’ curriculum. A group of 12 students were enrolled in a physics class when they decided to form a Physics Society, the “Charging Cavaliers”. They were the first team from America to win Beamline for Schools competition. The students put forward their best subatomic physics experiment and won against 178 other teams from 43 countries. The win allowed the students the opportunity to travel to Fermo, Italy and run their subatomic physics experiment at CERN, the Center for European Nuclear Research. The team’s goal was to find something that particle physicists with PhDs and high-tech equipment have been unable to find after decades of searching-elementary particles that have a fractional charge. [3] The teacher that was in charge of the project said “If we do find something, we’re opening a whole new door on particle physics” [3] In secondary schools, many students are very bright and have the opportunity to succeed in big ways. Physics is a very versatile topic which many can perceive as difficult. If an introduction to subatomic physics was offered in high school, then the transition to university level physics will as a result, be easier to comprehend. Subatomic physics in high school curriculum will allow students to have more opportunities, like the Beamline for Schools competition. Young bright minds can help discover the pieces of the subatomic puzzle that are absent. One of the four provinces and territories that includes subatomic physics shows positive results from the inclusion of subatomic physics in the curriculum.

The European Journal of Science and Mathematics Education published an article that described a study that’s aim was to come up with a new teaching concept for subatomic physics in schools around the world. This study was not specifically for secondary education. Subatomic physics could potentially be

traced back to the fundamental interactions that began the world, therefore the topic is adequate to teach any age group. This study in particular was completed on students 12 years of age. The anticipated outcome was to derive a successful new way to teach subatomic physics that will not be perceived as challenging. The teaching concepts that were introduced was permanent model character, linguistic accuracy, and innovative typography illustrations. The study was also designed to provide students the ability to construct comprehension on their own, based on the material provided. The concepts were linked to daily life examples with the use of bright diagrams and photographs. They formed 11 key ideas to be tested. Of these 11 ideas, only two of them showed poor acceptance by the students results. The two were number XI which focused on compounds and key idea II which focused on permeant model character. [4] Overall, this poor acceptance could be avoided if the students had additional years in school. From the three key teaching concepts, two came back as successful. The typographic illustrations and linguistic accuracy lead to broad acceptance. However, the permeant model character was poorly accepted and was hardly used with problem solving questions. The results indicated that 12-year-old students have the capability to comprehend subatomic physics. This leads to the idea that secondary students are capable of learning subatomic physics in their physics classes. Secondary students learning physics already have a basic physics background from general required science courses. If subatomic physics was being taught to secondary students in a similar approach as the study, the results should be successful. The age difference between a student in secondary school and age 12 will be crucial for comprehension in subatomic physics. Secondary physics curriculum should include subatomic physics in a way that relates to subjects the students have previously learned.

4. Conclusion

In summary, subatomic physics is not a significant topic that is included in secondary curriculum. However, when subatomic physics is included, the students benefit greatly. The opportunity would be there for the students to win awards with the subatomic physics community and broaden their knowledge with updated physics. The students would also have the opportunity to participate in hands on activities with subatomic outreach programs around the world. Subatomic physics is a broad topic with plenty of challenging aspects, but, if taught using the three main teaching techniques and referencing already known topics from other courses, students in secondary school can excel. The students who enjoy the topic will be motivated to deeper explore subatomic physics as they enter post-secondary education. Incorporating subatomic physics in secondary school curriculum could essentially lead a student to be the next prospect that introduces a great discovery in the subatomic physics world. We urge the education community engage in subatomic physics outreach, especially to under-represented youth groups [5], and to promote the inclusion of subatomic physics into the secondary school curriculum.

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