



Curriculum Thinking in the Teaching of Newton's Second Law

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Abstract

Based on the requirements for teachers to educate and nurture students, and taking into account the cognitive development level of middle school students, this paper emphasizes the socialist educational perspective of moral and character development in middle school physics instruction. Using the teaching of Newton's Second Law as an example, it explores how to cultivate ideological and political education (IPE) within this section of the curriculum. The discussion focuses on five key areas: fostering a sense of responsibility through IPE, integrating dialectical thinking into IPE, understanding the law of quantitative and qualitative changes within IPE, nurturing an innovative spirit via IPE, and prospects for establishing a comprehensive IPE system in middle school education.

Subject Areas

Senior High School Physics

Keywords

Secondary School Physics Teaching, Curriculum Thinking, Moral Education, Newton's Second Law

1. Introduction

In May 2020, the Ministry of Education issued the Guidelines for the Construction of Civics and Politics in Higher Education Programs (hereinafter referred to as the "Outline"), which detailed the significance of the construction of Civics and Politics in Programs, which detailed the significant meaning, goals, key content, system design, classification advancement, evaluation system, and incentive mechanisms of curriculum-based ideological and political education (IPE), etc., aiming to promote the in-depth development of IPE in higher education

institutions [1]. Curriculum-based IPE aims to enhance students' professional knowledge and ability during professional course teaching, while addressing students' ideological issues and strengthening their ideals and beliefs. Therefore, integrating IPE into disciplinary courses is a crucial means of ideological cultivation. "Physics Compulsory Course I" represents the beginning of students' understanding of the relationship between physics and societal development and serves as the foundation of modern science. The advancement of modern science is also supported and driven by the field of physics. The study and application of Newton's Second Law is one of the core elements of this course. Integrating ideological and political education into it is a topic worthy of in-depth exploration.

The foundation of "curriculum-based ideological and political education" lies in the curriculum itself. Without robust curriculum development, the function of ideological and political education becomes unsustainable and lacks substance. Therefore, respecting the principles of curriculum development and effectively strengthening curriculum management are fundamental to the successful implementation of "curriculum-based ideological and political education." Three teachers from East China University of Science and Technology (ECUT), Meng Zhang, Lu Yang and Yan Li, have integrated Marxist philosophical elements with IPE in the teaching of Newton's Laws of Motion. They utilized Marxist dialectical materialism and philosophical thought to enhance students' understanding of physical knowledge and laws through classroom-based IPE [2]. Xiaoguang Sun, a teacher at Guangzhou City Polytechnic Institute, used an online platform "Super Star Learning Channel" to release a questionnaire survey titled "Understanding Students' Acceptance of the Integration of Ideological and Political Elements into Newton's Laws". The results showed that the majority of students supported the integration of ideological and political elements into university physics teaching practices (53% found it very necessary, 31% found it acceptable, totaling 84%) [3]; Zheng Limin, Li Liping, and Ge Xianghong, three teachers from Zhongyuan University of Technology, designed an online teaching case of ideological and political elements that integrates the spirit of fighting the epidemic, by comparing historical facts of the past and present, using heuristic teaching methods [4]. Professor Wang Qing from Tsinghua University, in her construction and contemplation of IPE in physics professional courses, has proposed that the presence of ideological and political elements in the course teaching should not be the sole criterion. What is more important is the process of reshaping and building new courses led by IPE. The "Outline" also points out: To implement the fundamental task of cultivating talents with good moral character, it is necessary to integrate value shaping, knowledge impartation, and ability cultivation, which should not be separated. Comprehensively promoting the construction of IPE in courses is to embed value guidance in the impartation of knowledge and the cultivation of abilities, helping students to shape the correct worldview, outlook on life, and values. This is the inherent meaning of talent cultivation, and it is also an essential content. Teachers should re-examine the curriculum with a moral education

perspective, fully explore ideological and political elements, integrate moral education into professional teaching, or awaken the moral education connotation inherent in the profession itself, and promote the effectiveness of IPE to reach a higher level [5].

In the process of implementing curriculum-based IPE, several challenges arise, such as the unresolved issue of the disconnection between course instruction and IPE, and the separation of teaching and educating [6]; the tendency to label or superficially add IPE elements to the curriculum [7]; and the lack of alignment between IPE initiatives in higher education and those in basic education. This study aims to focus on the “education” orientation, integrating the characteristics of the physics discipline, to provide practical approaches for embedding IPE elements into middle school physics, with the hope that these practices can be widely adopted in middle school physics instruction.

2. The Role of Ideological and Political Education in Cultivating a Sense of Responsibility

When teachers explain the concept of Newton’s Second Law solely from a knowledge perspective, along with its dry and tedious formulas, it is often difficult to motivate students, resulting in poor teaching outcomes. Simply combining physics knowledge with Marxist philosophical ideas in a straightforward manner, or quoting political slogans during lectures, can come across as forced and unconvincing. Such an approach, which appears to incorporate ideological and political elements for the sake of it, not only fails to achieve the educational goal but may also provoke student resentment, making it counterproductive [8]. By integrating IPE with current national and societal issues, students can resonate with contemporary developments, thereby fostering a strong interest. This approach not only makes the lessons more relevant and engaging but also helps students connect their learning with the broader context of societal progress. For example, the exploration of the space field in our country as a guide, the basis of human survival is to find resources; space resources are now becoming one of the important resources that each country is seizing; space power determines the future of a nation or a country’s rise and fall. And the exploration of the field of space is the first is the need to “up”, then how can the satellite “up” it? It needs rockets. Then, the launch of China’s force arrow one rocket as an example, to create a physical situation. **Figure 1** gives the framework of the teaching design, through the definition of Newton’s second law of force, mass, acceleration, and analyze the factors affecting acceleration. Finally, questions are set up, the first of which is: how can a satellite be provided with an upward force? The second question: How can a satellite escape Earth’s gravity and rise into space? The third question: what conditions are required for a satellite to move around a star into space? Teachers must point out that these three questions are progressive, each of which has extremely far-reaching theoretical value and application value, and all of which have an important role and impact on the development of our country in the field of space.

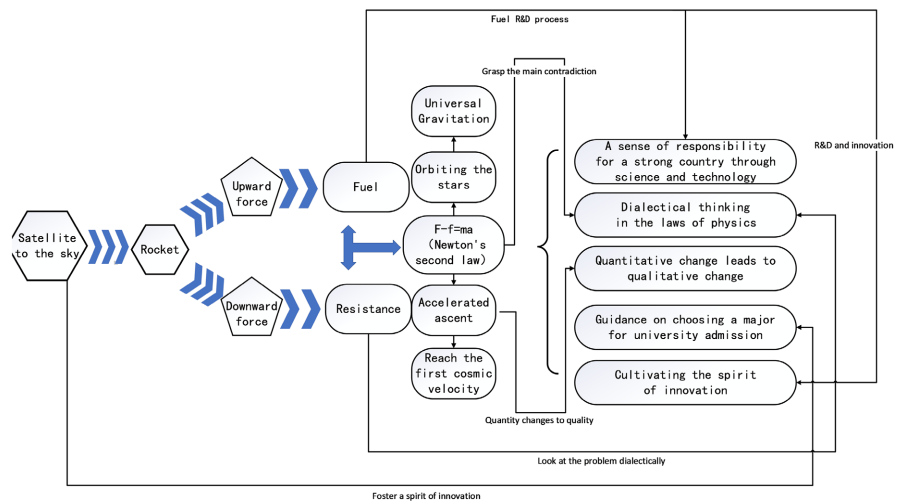


Figure 1. Instructional design framework.

The first question: how do you provide the upward force on a satellite? It needs to be propelled by a rocket, which needs to be powered by a fuel that is chosen to be both lightweight to reduce the overall weight of the rocket and effective in propelling the rocket into the sky. Rocket fuel also needs to be reliable and safe to avoid accidents during liftoff. In addition, the economics of rocket fuels need to be considered in order to reduce the cost of space exploration.

Guiding students to understand that the essence of education is to promote the comprehensive and free development of individuals is crucial. Education should be a unity of truth-seeking, goodness, beauty, and innovation. It involves the pursuit of knowledge without being confined to mere possession of it, fostering innovation, and gradually building a broad yet specialized knowledge framework through incremental progress. These are core competencies that students in the new era must possess. Teachers should guide students in a way that gradually reveals the depth of knowledge, leaving them eager for more and continuously engaged with the course content. This approach helps maintain a lasting sense of curiosity and, subconsciously, increases students' awareness of current affairs, fostering a sense of historical mission.

The second problem: How can a satellite escape the Earth's gravity to enter space? To solve this problem, a force analysis of the rocket and satellite is required. Construct an ideal model, rockets and satellites in the process of the sky, by the upward traction provided by fuel combustion, by gravity and air friction downward resistance f , the use of Newton's second law of the overall force analysis, $F - f = ma$ it can be concluded that rockets and satellites of a certain mass, the fuel to determine the case of a fixed value of resistance, combined with the kinematics of the speed formula, through simple calculations can be concluded that how much acceleration is needed in order to swing the earth's gravitational force. The teacher can use the history of rocket development as an example. Teachers can take the history of rocket development as an example to guide students to

associate the development of China's modern aerospace industry, it is because of the selfless dedication of a group of scientists such as Xuesen Qian, Jiadong Sun, Xinmin Ren, Yonghuai Guo, Ji Qian, Weilu Huang, Shoue Tu and other scientists, in order to promote the progress of China's aerospace industry, laying the technological foundation for our country to become a major aerospace country. It cultivates in students a spirit of exploration in physics knowledge and a strong desire to bring honor to the country.

Third question: What conditions are required for a satellite to move around a star into space? Construct an ideal model, the satellite around the planet can be approximated as a uniform circular motion, maintaining the satellite's gravity to provide centripetal force so that the satellite around the planet to do approximate circular motion $F_n = m_a = m \frac{v^2}{r}$, triggering students to think, although in the study of Newton's second law of the students have not studied circular motion and gravity chapter, but from the perspective of the coherence and developmental aspects of the physics learning system, the need for students to understand the basics of this part in advance, in the process of teaching can be briefly mentioned to stimulate students' curiosity to pave the way for subsequent learning. The teaching process can be briefly mentioned to stimulate students' curiosity to pave the way for subsequent learning. In the explanation of this problem at the same time teachers to guide students to associate, in the family needs every relative with "gravity" to cohesion, in the class needs every student and teacher with "gravity" to unity, in the country more needs the party and the whole country with "gravity". "Gravitational force" to build, the teacher took the students to recall the history of China's modern development, after the modern era, more than 100 years of China's accumulation of poverty and weakness, the tragic fate of being bullied. Because the party with the gravitational force to pull the people of all ethnic groups in the country, the people of one heart and one mind, hard work, in order to achieve the world impressed by the great achievements.

Teachers can explain the gap between China and the world's leading level in the field of space exploration to stimulate students' patriotic enthusiasm and encourage them to learn the basic theories well, contributing to the development of China's space technology. Additionally, teachers can also guide students to discover physical laws from aspects such as the selection of rocket shell materials, satellite operation phenomena, and rocket transportation technology. They can explain the areas where our country is leading and lagging, inspiring students to have a sense of national pride and confidence, and cultivating their enterprising spirit and sense of social responsibility. At the same time, students can also collect materials in their fields of interest and conduct in-depth research on these areas. This approach not only helps students understand the current state of space technology but also encourages them to think critically and independently. By engaging with real-world applications and challenges, students can better appreciate the importance of their studies and how they can contribute to the future of space

exploration and technology. This can be a powerful motivator for students to excel in their studies and to pursue careers that can have a significant impact on the field.

In summary, as long as the students' initiative and enthusiasm are stimulated, unexpected positive outcomes can be achieved.

3. Cultivating Dialectical Thinking through the Integration of Ideological and Political Education into the Curriculum

One of the pivotal competencies in the field of physics is the development of students' capacities for scientific inquiry and logical reasoning. These capacities are fundamental to students' profound learning and advanced cognitive processes, and their significance cannot be overstated. Consequently, during routine instructional activities, educators must deliberately foster and nurture the students' capabilities in scientific exploration and rational argumentation, aligning with the standards of the compulsory education physics curriculum as stipulated by the Ministry of Education of the People's Republic of China [9]. This section elaborates on how to cultivate students' logical thinking and scientific inquiry from the perspective of dialectics of contradictions and the principle of change leading to qualitative change.

3.1. Primary and Secondary Conflicts

In dialectical materialism, it is stated that the primary contradiction holds a dominant position in the development process of things and plays a decisive role in their development. The secondary contradiction is in a subordinate position and does not play a decisive role in the development of things. Therefore, when solving problems, it is necessary to adhere to the correct methodology, that is, to focus on grasping the main contradiction and the main aspect of the contradiction, to focus on the key points and the key elements, which will be conducive to the resolution of the problem.

The original formula for Newton's second law is $F = \frac{\Delta(mv)}{\Delta t}$, which shows that the force on an object is proportional to the rate of change of the object's momentum. This formula can also be written in vector form. Any formula used in physics needs to be applied within certain conditions. As you learn more, in relativity, mass $m = \frac{m_0}{\sqrt{1 - \left(\frac{u}{c}\right)^2}}$ (the mass of a point of mass m varies with u and is m_0 of

the point of mass at rest), so Newton's second law $F = m\vec{a}$ no longer holds. However, $F = \frac{\Delta(mv)}{\Delta t}$ still holds. Newton's second law in secondary school is

both different and related to Newton's second law of relativity. In secondary school physics, the main focus is on low-speed macroscopy, so only is considered, which captures the main contradiction in current physics learning and ignores the secondary contradiction of mass change in relativity theory, in order to achieve the purpose of preliminary application of Newton's second law.

3.2. Dialectical View of the Problem

Newton's second law also contains dialectical ideas. Everything is composed of two contradictory sides, and the two sides of the contradiction are both opposing and united, promoting the development and change of things [10]. In explaining Newton's second law, analyze the issue of satellite launch. Fuel provides an upward force that is essentially determined as the fuel is selected, and in an ideal state, air resistance remains constant. Analyzing the relationship between m and a in the equation $F = ma$. From $F = ma$, it can be seen that when F is constant, m and a are inversely related. From a dialectical perspective, analyzing the contradiction between m and a . How are m and a balanced in real situations? In other words, which is the primary contradiction between m and a ? In previous courses, students have already mastered the methods of calculating force and motion as well as Newton's Third Law. Teachers guide students to perform force analysis under ideal conditions. Generally, we aim for rockets to transport as much material as possible while also ensuring that they achieve sufficient acceleration to reach the first cosmic velocity. By determining an appropriate m , one can subsequently determine the a to achieve a relatively balance state.

Guide students to see the essence through the phenomena. Identify the dialectical relationship between a and m , and apply it to practice. In this way, not only can the carrying efficiency be improved, but also the calculations can be ensured to conform to reality.

4. The Law of Quantitative and Qualitative Change in Ideological and Political Education within the Curriculum

When studying the chapter on motion and forces, we began with Galileo's exploration of forces. Galileo noticed that when a ball rolled down an inclined plane, its speed increased, and when it rolled upward, its speed decreased. This led to the conjecture that when the ball rolled along a horizontal plane, its speed should not increase or decrease. In reality, even when rolling along the horizontal plane, the ball will roll slower and slower, and finally stopped, Galileo believes that this is the result of friction. Without friction, the ball would move forever. Galileo then designed a series of experiments to verify the conjecture.

According to Galileo's conjecture modern man restored Galileo oblique experiment stroboscopic photographs shown in **Figure 2**.

The French scientist Descartes also studied this problem. He believed that if an object in motion was not acted upon by a force, it would continue to move at the same speed and in the same straight line, neither stopping nor deviating from its original direction. On the basis of Galileo and Descartes experiments, Newton, through a large number of experimental studies, put forward a basic law of dynamics: all objects always maintain a state of uniform linear motion or a state of rest, unless the force acting on it forces it to change this state. As Newton continued to deepen his accumulation, he further extended Galileo's idea to the occasions of forceful action, and eventually put forward Newton's second law of motion.

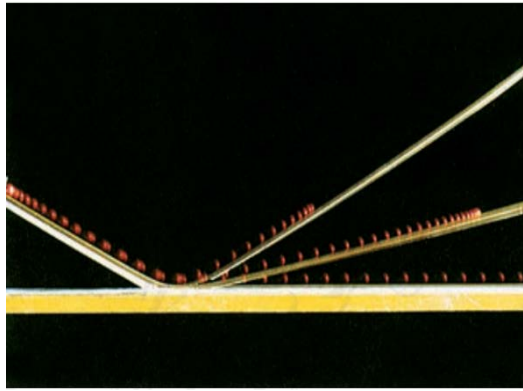


Figure 2. Stroboscopic photographs of Galileo's oblique experiments performed in modern times (combined figure).

Newton once said, "If I see further, it is because I stand on the shoulders of giants." Newton accumulated experience on the basis of the experiments of his predecessors, and eventually put forward the three laws of physics, causing qualitative changes in physics. At the same time, in the process of the satellite in the sky acceleration continues to increase, the satellite speed quantitative change accumulation reaches a certain level will produce qualitative changes, so that the satellite to get rid of the earth's gravity. The idea of qualitative change caused by quantitative change in scientific exploration refers to the fact that in scientific research, through continuous observation, experimentation and verification, the accumulation of a large amount of data and experience, and ultimately fundamental changes in the understanding of scientific phenomena, the process of scientific development and the law of qualitative change caused by quantitative change fits. The idea of quantitative change causing qualitative change is widely used in different disciplines, such as physics, mathematics, chemistry and other disciplines. In the field of physics, the idea of quantitative change causes qualitative change is applied, such as in quantum mechanics, with the continuous accumulation of experimental data, people gradually discovered the quantum superposition, quantum entanglement and other strange phenomena, thus changing the understanding of the material world. In the discovery of the theory of relativity, Einstein through continuous thinking and exploration, and finally put forward the mass-energy equation $E = mc^2$, reveals the relationship between mass and energy, thus changing people's understanding of energy and matter.

The idea that quantitative change causes qualitative change in scientific exploration tells us that scientific research is a process that requires long-term accumulation and practice, and that only through continuous observation, experimentation and verification can we constantly deepen our understanding of scientific phenomena, discover new laws and establish a more perfect theoretical system. In students' life and learning, quantitative change is the process of accumulating knowledge and experience, while qualitative change is the fundamental change that occurs after the accumulation of knowledge and experience to a certain extent. Let students realize that learning is a process that requires long-term

accumulation and practice, only through continuous learning, continuous practice, continuous accumulation, and continuous improvement of their thinking and ability, can the final qualitative change be caused by the daily quantitative change, and ultimately achieve the fundamental goal of learning.

5. Cultivating an Innovative Spirit Through Ideological and Political Education within the Curriculum

By explaining Newton's Second Law using the aforementioned methods and providing a simple analysis of satellite launch issues, students are guided to develop a strong interest in the field of physics. This approach encourages students to conduct literature research in areas of interest, identify problems, and focus on studying and researching these issues. It lays a solid foundation for cultivating their scientific innovation awareness. Two cases are provided here for the purpose of sharing with peers.

Case 1: Studying Newton's Second Law to analyze satellite launch issues reveals that there is significant room for progress in China's rocket fuel sector. Students are encouraged to explore innovative approaches to discovering new types of energy with higher combustion efficiency and environmental benefits, aiming to enhance the global competitiveness of the country's aviation fuel industry and contribute to national aerospace endeavors. Students should conduct literature research in this direction, identify existing problems, and focus on studying and researching these issues.

Case 2: Analyzing satellite launch issues through the study of Newton's Second Law reveals another critical problem: how rocket materials can withstand high temperatures and pressures while maintaining an acceptable density. By discussing issues encountered in satellite launches, such as the physical principles of rocket flight, how to determine rocket trajectories, and how to recover detached rocket stages, teachers can stimulate students' curiosity. Students are encouraged to actively search for information, engage in group discussions about potential problems, and develop relevant physical models and experimental instruments. Visiting university research centers for internships can significantly enhance students' enthusiasm for innovation and motivation for learning.

For middle school students, while it is important to acquire and collect ideological and political education (IPE) materials, it is even more crucial to integrate IPE elements effectively into middle school physics teaching [11]. There are many similar cases in the middle school physics curriculum. Teachers must continually inspire students' innovative spirit to enhance the overall national capacity for innovation.

6. Prospects for Establishing a Middle School Curriculum-Based Ideological and Political Education System

Middle school physics should focus on the integration of ideological and political education (IPE) elements. While IPE emphasizes the spiritual cultivation of

students, it does not mean that IPE should be free from evaluation [12]. In the context of moral education, the evaluation of learning outcomes should shift from the traditional “error reporting” approach to exploring the essence through phenomena, identifying issues in IPE teaching from multiple angles, and improving IPE teaching design. The evaluation standards should move away from a sole focus on “scores” to a dual evaluation of “moral and intellectual” development. This means assessing both students’ knowledge acquisition and their emotional attitudes and values developed through learning, achieving a comprehensive evaluation of knowledge, emotion, intention, and action [13]. By exploring IPE within the Newton’s Second Law curriculum, we aim to create an educational atmosphere that fosters moral development, integrate IPE elements into teaching methods, and nurture individuals with noble character, preparing them as well-rounded socialist builders and successors for the new era.

Conflicts of Interest

The authors declare no conflicts of interest.

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