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On the Reform of Education Methods that Adapt to STEM Development Demand

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Abstract: The maintenance of competitiveness in the complex world in the 21st century cannot be isolated from scientific and technological innovation and talent training. As a brand-new form of education, STEM has become the focus of attention. The reform of education methods involves a global, long-term and strategic planning for development of education. The exploration of STEM education models requires not only the consideration of regional realities, but also international experience, etc. This paper analyzes the connotation and characteristics of STEM education, attempting to offer a plan for the reform of education methods that adapt to STEM development demand.

Keywords: STEM; Reform of education; Project-based Learning.

1. Introduction

In recent years, in the era of the Industrial Revolution 4.0 represented by intelligence, the society demands scientific labor force with new technologies and interdisciplinary ideas. Therefore, everyone should possess the ability to adapt to the needs of today and the future society. In the context of the two visions of social sustainable development and personal happiness, STEM education is demanded by the times. STEM education allows the formulation and provision of innovative solutions to daily or social problems using science, mathematics, technology, engineering and other knowledge. It commits to training future talents that meet the needs of society. The paper focuses on designing education methods that adapt to STEM development demand.

2. The Connotation of STEM Education

As early as in 1986, the National Science Board (NSB) of US published the report of "Undergraduate Science, Mathematics and Engineering Education", also known as the Neal panel's report. It was the first policy guidance document on STEM education in the United States, and also the beginning of the development of STEM education [1].

"STEM" officially appeared as an educational term in 2001, when the National Science Foundation (NSF) of US first adopted the acronym "STEM" to refer to the courses of science, technology, engineering and math, indicating the official emergence of STEM education. The connotation of STEM education has not been restricted to the four disciplines of science, technology, engineering and mathematics since the beginning -- NSF has defined a wide range of STEM fields, which cover not only such common scientific domains as mathematics, natural sciences, engineering, computer and information science, but also such social sciences as psychology, economics, sociology and political science.[2]

In 2015, Professor Carla Johnson of Purdue University began to lead the formulation of the "STEM Road Map", a STEM curriculum plan for primary and secondary school students across the United States, which defines a new concept of STEM education. She pointed out that STEM education can be regarded as a teaching methodplogy, but it should be deemed more as a teaching idea or teaching philosophy. STEM education covers science inquiry, technology and engineering design, mathematical analysis, and 21st-century interdisciplinary themes and skills, and strives to deliver on standards-based teaching of science and mathematics.[3] This definition's cognition of integration exceeds the previous emphases just on content levels by attaching importance to the independent value of different STEM disciplines and the interaction between them, while highlighting the attention to students' integrated thinking process and skills. Therefore, it represents a new level of the integrated conceptualization of STEM (As shown in figure1).

To maintain competitiveness in today's complex world in the 21st century, talents should develop the ability to fast master new knowledge and skills to solve complex problems, and collect and evaluate information, especially the ability to obtain information from various digital media. STEM education helps to cultivate students' scientific inquiry ability, innovation awareness, critical thinking, information technology ability and other requisite skills and innovation ability in the future society, and may continue to benefit learners in their future life and work.

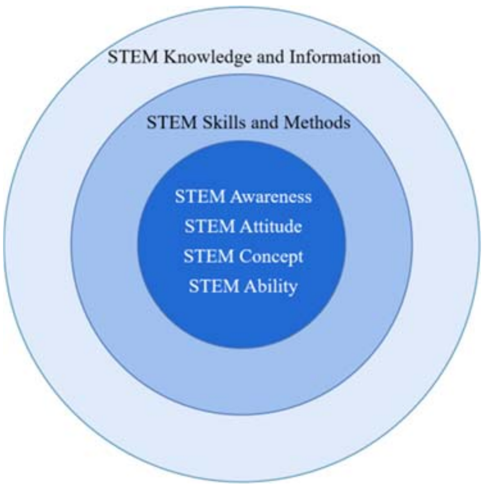

Figure 1. The integrated conceptualization of STEM

3. Characteristics of STEM Education

3.1. Promotion of In-depth learning and social growth

As a national strategy, STEM education is not only reflected in some courses and learning activities, but also more importantly, brings a concept, learning orientation and corresponding learning methods. With the Framework for 21st Century Learning, many elementary and middle schools in the United States regard “4C”[4] (creative thinking, critical thinking, cooperation ability, and communication ability) as the key goal of future talent training, and closely integrate STEM education into it to promote improvement of normal education and teaching.

3.2. Balance between academic orientation and application orientation

The core feature of STEM Project-based Learning (PBL)[5] is interdisciplinary real-situation-based learning. It emphasizes the social and practical nature of learning, allowing learners to gradually understand concepts in the practice of real problems, and through “learning—practice”, cultivate their scientific exploration and problem-solving thinking and skills, stimulate their cooperation and innovation awareness, and help them find future professional interests.

From the observation of American schools, the author clearly perceived the prevalence of applied courses and learning. In nearly five years, engineering technology education in primary and secondary schools in the United States has witnessed fast development. The middle school students taking engineering courses accounted for a large proportion, and a large number of learning activities are based on real situations, pointing to problem solving with focus on students' practical application. In diversified development, a class of senior high schools with focuses on applied technologies was derived. Viewed from these phenomena, the balance between academic orientation and application orientation in education should be achieved in addition to promotion of scientific and technological innovation. STEM education emphasizes the connection with reality, and the concepts of active exploration, applied practice, and interdisciplinary learning well reflect this adjustment and balance.

4. Education Methods That Adapt to STEM Development Demand

4.1. Formulation of STEM education-related policies based on specific national conditions

The primary reason why the United States has made many achievements in STEM education lies in the support and guidance of the government. For more than 30 years, the U.S. government has not made an empty promise on STEM education, but issued a series of documents to plan, support, guide, and emphasize STEM education. For example, the “STEM2026” report is a blueprint of the U.S. government for STEM education from multiple levels based on current situation and the outlook from the micro and macro respectively.

In China, STEM education has just begun. Due to the deeply-rooted test-oriented education, some cannot understand the value of STEM education. This requires governmental departments to make affirmation and guidance at macro level to strengthen the STEM education in China's education development strategy.

In terms of curriculum, the integrated experiments of STEM curriculum should be increased in elementary and secondary schools, with purposeful and consistent STEM curriculum development. Currently, the curriculum in China is still based on division of subjects, while STEM curriculum focuses on interdisciplinary courses. This requires that the American curriculum cannot be copied blindly. Instead, new STEM curriculum standards for primary and secondary schools should be formulated based on the knowledge content of students nationwide. In addition, documents can be issued to allow local education departments to develop local STEM curricula based on local characteristics and economic development, and each school may also develop respective STEM curricula based on actual conditions.

The author believes that STEM education must collide and integrate with national ideology, culture and social processes. Only STEM education with national characteristics will reflect national interests and contribute to the development of national education.

4.2. Focuses on creation of an innovative and active teaching atmosphere

The venue of STEM education is not merely limited to a single place like a classroom, but also includes science and technology museums, laboratories, and nature, etc. The corresponding concept is that classroom teaching should break the conventional one-way teaching with focus on Interaction, cooperation, and creation of an innovative and active teaching atmosphere.

It can be found from “STEM2026” that online collaboration tools, online hybrid education environments, immersive media, simulation games, intelligent tutor systems, enhancements, and virtual reality may bring remarkable changes to STEM classroom. Modern technologies and tools can greatly promote students’ interest in learning and enhance their learning motivation [6]. Therefore, in teaching, new teaching methods that meet the development of the times and needs of students should be adopted in teaching. Furthermore, different teaching methods should be chosen and flexibly used reasonably based on their advantages and drawbacks, so as to create an innovative teaching atmosphere.

Teaching activities should be linked to students’ actual life. In the past, most teaching was “idle theorizing” and divorced from reality. STEM education orients to the life, reality and the future. Take the “Canadian/American Mathematics Camp” initiated and established by the American Mathematics Base for example, students have one hour of lectures every day, two hours of outdoor study, and biweekly excursions, venue visits, and fruit picking activities. Such teaching not only expands the learning space, but also promotes students’ mental development. The exposure to physical objects brings students in-depth learning experience and stimulate their enthusiasm and fun in learning.

4.3. Create real problem situations and stimulate students' desire to explore

The main purpose of STEM education is to cultivate students’ ability to solve practical problems. Through the course learning, students can accumulate basic theoretical knowledge; but as to cultivation and development of their ability to solve practical problems, they must engage in deep learning through practice. This requires educators to create real problem situations in teaching to stimulate students' desire to make exploration, whereby cultivating their ability to solve practical problems.[7]

First, create real problem situations. Teachers should help students combine problems with real life, through which they will realize that learning is not about scores but about creation of a better life. As long as students see the value of knowledge, they are more willing to take the initiative in learning. Meaningful learning is only possible when knowledge is applied to a specific situation.

Second, raise of challenging questions. In real life, many problems are not single and simple, but complex and challenging. The raise of challenging questions can exercise students' STEM learning ability. In addition, students should be encouraged to participate in STEM-related competitions. For example, in the United States, there is an online STEM EcyberMission science competition for students in grades 6 to 9 organized by Army Education Outreach Program (AEOP) and Development and Engineering Center in cooperation with the academic community, industry, non-profit organizations, and other government agencies. In this program, students are mainly guided to apply interdisciplinary knowledge and technologies in solving difficult problems in social development.

5. Conclusion

STEM education is simple "superimposition" of various subjects, but requires comprehensive consideration of educational theory, learning technology, curriculum, and learning environment, etc. Based on the understanding of students' learning status, curriculum and learning techniques, learning environment and activities are created and designed to help students understand, correct, and improve their understanding of knowledge. In carrying out STEM project activities, different ways of guidance should be sought, so that students can demonstrate creative process in real lives and cultivate innovative thinking. At the same time, parents and the public should play a role in building a learning community consisting of teachers, students, parents, the public, etc., so as to explore the best practice models of STEM education based on local conditions.

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