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Stem Education Concept and Maker Education in New Era

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***Abstract*—With people's gradual attention to the concept of innovative education, STEM and maker education concepts have been applied in the field of education. This article introduced the concepts, development, relevant theoretical research and application of STEM and maker educations in the field of education. It is suggested that the STEM and maker education concepts should be enhanced in education and its universality in practical education should be improved. The publicity and professional training for STEM education concept and the education and professional training of STEM and maker educations should be strengthened. Building multi-function maker education experimental teaching platform can accelerate the process of education innovation and expand the influence of new education module.**

Keywords—STEM education concept; maker education; innovative education

I. INTRODUCTION

The 21st century is the era of information technology with the rapid development of new various technologies. It is also an era in which economics, politics and society are undergoing a major transformation. The changing technology is breaking the traditional way of life and business. Education innovation plays an increasingly important role in personal cultivation and national development. In recent years, China has repeatedly proposed to build innovative countries and cultivate innovative talents. However, the cultivation of talent is inseparable from education. Therefore, education innovation has its necessity and urgency[1-2]. In order to achieve this goal, It is necessary to start from the following two aspects: First, cutting-edge technology should be applied to the education industry so that school students can understand the latest developments in new technologies. The second is to cultivate students' innovative ability and manual operation ability, in order to promote the rapid development and transformation of China's education[3-4]. This study mainly analyzes the new application of STEM education concept in the context of the new era and the prospect of the new education mode that it is combined with maker education in education.

II. APPLICATION OF NEW EDUCATION MODE IN EDUCATIONAL INNOVATION

A. STEM education concept

1) Introduction of STEM education concept

STEM education originated from the United States. It was based on the "core accomplishment" concepts of "creativity and problem-solving, critical thinking, communication and collaboration, and learning skills and lifelong learning". From a literal perspective, STEM is a cross-domain integration of science (S), technology (T), engineering (E), and mathematics (M), as shown in Figure 1. The core of STEM is: discovering problems → designing solutions → using science, technology, and mathematics to solve problems → using rational methods to verify the solution. In this process, STEM courses especially focus on promoting students' creativity, and multidisciplinary cross-disciplinary integration, which is the key to fostering children's international competitiveness. Therefore, the major U.S. universities including Stanford, Berkeley, and MIT have set up STEM research centers. Chicago has a STEM incubation base. The U.S. government has incorporated it into the country's core strategic level to support it.

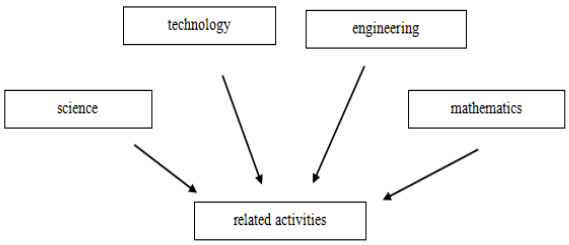

Fig. 1. STEM Interdisciplinary Integration Model

2) The Application of STEM Educational Concept in Education

STEM as a concept of scientific literacy education originated in the United States and widely recognized by other countries, it has attracted more and more attention. Now it has been integrated into elementary, junior high, high schools, university and other different education stages and has been highly praised by educators[5-7]. Many scholars have done a lot of research work in this field of education, including

theoretical development, teaching models and applications, etc. These are all conducive to the rapid integration of STEM education concepts into educational innovation in the context of the new era[8]. The leader of the Wisconsin Center for Education Research(WCER) believes that more emphasis must be put on in order to help students understand and value STEM disciplines. The National Research Council's (NRC) of the US held two seminars in June and October 2008 to examine evidences for selective and effective practices in undergraduate science, technology, engineering, and mathematics (STEM) educations. WCER begins to use this information in its education for sustainable development. College students have certain learning abilities, hands-on foundations, and the ability to quickly absorb new knowledge and new concepts. The launch of STEM education concepts on university campuses will be a great success. Accumulated valuable educational application concepts, paving the way for education for elementary, middle and high schools.

STEM education not only advocates learning abstract knowledge through self-study or teacher teaching, but also emphasizes students' hands-on and brain-taking and participation in the learning process. STEM provides students with hands-on learning experiences. Students apply the learned mathematics and scientific knowledge to solve problems in real world. For example, scholar Li and his cooperators used LEGO as a modular teaching aid to train students to grasp engineering concepts such as gears and moments[9].Students can build LEGO components to test relevant principles, not only to understand physical concepts and knowledge, but also to experience the important role of these knowledge in the engineering design experience, which connect abstract knowledge with real life, and embody the experience characteristic of STEM education. STEM education emphasizes that students can acquire the ability to contextualize knowledge, and to understand and recognize the knowledge representation of different situations. That is, they can identify the nature of problems and solve problems flexibly according to the background information of knowledge. Through the cultivation of the STEM education concept, students are better able to apply the knowledge they have learned in the book to practice. They will continue to think and continue to sum up in practice to find new ways to solve problems and continuously improve their ability to do so. Combining theory with practice by applying knowledge to practice.

B. Maker Education Model

1) Maker education model introduction

The maker education appeared decades later than STEM education, which clearly has the characteristics of the era with the rapid development of the Internet and information technology. It is an innovative education craze that has gradually developed inside and outside the campus with the rise of the Maker Movement and the spread of Maker culture. It uses digital technology as both the content and means of education. It is a new type of education paradigm created by the continuous integration of digital technology and education. It redefined the integrated practical and information technology courses for primary and secondary schools.. At present, adhering to the maker culture of design, production, sharing, exchange, and open source, student makers (also called "little creators") in some domestic universities, middle schools and primary schools no longer rely on expensive laboratories. Instead, under the guidance of teacher makers, they begin to touch cutting-edge information technologies (such as robots, IoT, smart homes, etc.), and tried to use simple and easy-to-use digital technologies (such as 3D printing technology and arduino, etc.) for practical purposes. They can carry out design, production, sharing and cross-time learning activities for practical needs, turning ideas into reality in hands-on and brain-creating to realize the dream of personal desktop customization.

2) The application of maker education model in education

A Beijing Jingshan School teacher, Wu Junjie has conducted interdisciplinary integration of information technology and scientific research in the development of Picoboard sensor board applications. He designed an experiment based on the Picoboard sensor board, which uses different analog quantities on the Picoboard sensor board to carry out a series of experiments. Through a series of process of experiment design, data collection, function fitting, and function application. The students were led to study the physical quantities of the external environment such as length, resistance, etc.) and the analog quantity collected on the Picoboard sensor board to see whether there is a stable correspondence relationship between the sensor value (such as the values of the slide bar and photosensitive sensor, etc.), and then to determine the physical quantity using this relationship, and finally to realize the manufacture of an automatic measuring instrument (such as a length measuring instrument, a grayscale scanner, etc.). The ingenious combination of information technology and scientific research enables students to fully perceive the importance of integrating interdisciplinary knowledge in the process of problem solvation[10].

Students of Wenzhou Middle School used the Arduino control panel to make two interactive devices with different functions - landscapes that sense changes in the external environment and electric display stands. The former focuses on sensory information and uses sensors connected to the Arduino control panel to directly monitor weather situation, and to control landscape changes on the screen to achieve real-time perception of changes in outside weather features. The latter focuses on information control. Through the program to control the motor, and automatically adjust the computer monitor stand, the purpose of preventing cervical spondylosis can be reached. These interactive devices reflect the students' ability to apply physical computing platforms to solve practical problems and their valuable artistic accomplishments and humanistic care[11].

III. THE DEVELOPMENT DIRECTION OF THE THREE STEM EDUCATION CONCEPTS AND MAKER EDUCATION MODEL IN EDUCATION INNOVATION

A. The practice of returning to the real world

STEM education concept and maker education should allow students to return to the real world. In the process of observing the world around them and paying attention to the

needs of themselves and others, they should seek ideas from multiple thematic areas for inspiration of design such as intimacy and exploration of nature, experience and integration, understanding and self-improvement. therefore, create various interactive media works that contain realistic social meanings and cultural connotations, seamlessly interfacing with science, art, life, and many other fields to understand the true essence of problem solving—from life to life. For example, some school teachers and students have used various physical computing tools/platforms to create interactive media devices for practical needs, such as voting devices consisting of multiple paper touch switches, alarms, water-saving devices, cardboard pianos, and playing pianos, etc.

Several major principles/concepts should be proficient deeply (unlike procedural knowledge)

• Keeping what you learned for a long time

• Establish a mental framework as a foundation for future learning

• Develop visualization capabilities, including the ability to criticize, interpret, build, and connect physical systems

• Develop the analytical skills and critical judgments needed to make informed decisions using scientific information

• Understand the nature of science

B. Bold practice around innovation

Pursuit of innovation is an important value orientation of maker education. Innovation may come from the discovery of small and unique needs. The way to express innovative ideas is to create personalized, intelligent, interactive media products that can bring high added value. The products may be something that can be used in life, such as temperature alarm, temperature-controlled fan, network watering device[12], remote control lamp[13], etc. It may also be something that makes people feel pleasurable, such as waterfall lights, breathing control lamp, buzzer electronic organ, music cake box[14] and so on. Teacher Wu Junjie sums up these two points to Make It Real and Make It Cool[15]. Because the interactive media works are practical and aesthetic-oriented, creators need to consider application requirements and practical difficulties to practice boldly, and continue to improve the products on the basis of listening to the opinions of the students and users around them. For example, in order to make the interactive media work to be more texture, you can make the work broader and interactive with people, and combine with knowledge of information and communication technologies. This creative interactive media works are no longer just cold devices and equipment, but smart products that intelligently solve real problems and have fun in life.

C. Emphasize interdisciplinary integration and encourage cooperation

Maker education is centered on designing computer-enhanced interactive devices and spaces. These are activities that attract students and motivate learning. It takes engineering, technology as the core with the comprehensive application of interdisciplinary knowledge and skills, and encourages students with different interest traits to participate in the collaborative exploration. For example, in May 2014, two students majoring in computer science and technology at Shanghai Normal University combined with students majoring music and arts s to work together to create a “music storm” interactive media work with fully functions, including six modules: music player, quiz, lyrics knowledge, score card game, simple electronic organ and simple electronic drum, which allow players to experience the fun of becoming band members, music connoisseurs, instrumentalists, composers and lyricists. Among them, simple electronic organs and electronic drums are made using Picoboard sensor boards, Makey circuit boards and other materials (copper foil, cardboard, sponge, etc.). This work was publicly displayed during the exhibition of creative programming by Scratch Day China in Shanghai in 2014. Its exquisite images, exquisite sound effects, and smooth features were praised by the guests and other members of the participating primary and secondary schools. This shows that interdisciplinary integration and teamwork can further enhance the depth and breadth of interactive media production.

IV. CONCLUSION

With the open source, lower-level packaging and thresholds of cutting-edge digital technologies, more and more primary and middle school information technology teachers have started a journey to make passenger education. They have led a group of primary and secondary school students and started to face real-life challenges, actual needs, or the pursuit of For the beautification of life and the cultivation of sentiments, Attempts are made to break through the limitations of the human-machine interaction of traditional keyboards and mice, and to design and produce interactive media works with unique human-computer interaction methods with diverse input, fast, accurate processing, and diverse outputs. From fun programming to fun creation[16], interactive media created by teachers and students in China has tapped more and more innovative practice potential in scientific experiments, mathematical modeling, simulation, artistic expression, creative design, etc.[17]. Leading education based on cutting-edge technologies such as physical computing platforms and 3D printing technologies has a deep theoretical foundation - constructionism. It is a new education mode that adapts to the age of digital information and cultivates students' STEM literacy and innovative practical ability. Facing turbulent wave of technological changes and new educational concepts, educators need to consider the significance and value of their reforms in information technology education, general technical education reform, and comprehensive practical curriculum reform of primary and secondary schools and universities., . In the practice of maker education for STEM education, new ideas and experiences have been continuously accumulated to deepen education reform and improve the quality of education. There is a long way to go from made in China to created in China. Maker education for STEM education may open the way for more students to participate in innovation and to cultivate students' innovative practical abilities and STEM comprehensive literacy since childhood.

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