The Impact of ICT Advances on Education: A Case Study

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***Abstract*—ICT advances in the pace of Moore's law as well as Gilder's Law. The introduction of ICT into education has resulted astounding effects in learning. This paper presents a case study of the establishment of National Engineering Research Center for E-learning, as part of education informationized effort in China. There are four stages of China's integration of ICT with education: start-up phase, application phase, integration phase, and innovation phase. The four phases are well in line with the ICT evolutions from standalone computer, to all IP network, to all cloud infrastructure, and to today's all AI, which utilizes full spectrum of ICT including emerging technology advances in big data and artificial intelligence. The role of ICT in education has gone far beyond as an assisting tool in learning; it led to re-consider the traditional classroom centric teaching architecturally, as well as represented a paradigm shift in education including the roles of classroom teaching, the way of learning, the learning period systematically. Interactive and exploratory learning have become the mantra and education as a service is inevitable. At the same time, like any other technologies, ICT used in education can backfire if not carefully planned. This paper proposes a systematical engineering approach that integrates multiple tooling and activities around the learning of a particular subject with the purpose that engages learners through an intuitive, game-like environment where students learn through exploration and discovery.**

Keywords-PhET; MOOC; classroom; open source; cloud computing

I. INTRODUCTION

Nowadays it has been quite normal for teachers and students to get access to online educational resources on campuses in China. China is accelerating the innovative application of information technology in education and teaching. This can be seen from the substantial progress in the three links and two platforms, the increase of China's influence in education informatization globally, and the improvement of teachers' capabilities to utilize information technology. In 2018, the Ministry of Education of China issued the "Action Plan for Education Informatization 2.0"[1], which clarifies the specific implementation actions of Education Informatization 2.0, including eight aspects: digital resource service popularization action, e-learning space coverage action, network intelligence support project action, education governance capability optimization action, digital campus norm construction action, smart education Innovative development actions and comprehensive improvement of information literacy. In 2019, the Ministry of Education released the "Statistical Bulletin for the Development of National Education in 2018". In 2018, there were 518,800 schools at all levels and all types, with 276 million students enrolled in various levels of education, and 16.7285 million full-time teachers[2]. At present, education in China is mainly exam-oriented. The result of the college entrance examination has a significant impact on the future development of a student as the exam is a must for almost anyone who wants to pursue higher education.

Extensive use of digital technology for educational practice seems to be a top priority for contemporary school education. Developing economy has rapidly accelerated the spread of ICT in schools, quickly matching the level of coutries that adopted ICT early like the United Kingdom and the United States[3]. However, this expansion has caused some critics to question the "return on investment" of the new technology. After all, there are studies that challenge whether the level of learning matches the level of resource acquisition[4,5]. Although these conclusions are often questioned, these doubts may trigger more critical reflection on the role of new media in education[6,7]. On the other hand, many people believe that any disappointment is related to the quality of the "task" rather than the quantity of resources[3,8,9,10]. Such comments are often regarded as simply ignoring resources and claiming that schools and their staff are slow to use new technologies[8,11,12,13]. Sometimes this is related to teachers' beliefs and attitudes-although it turns out that these are not reliably related to actual teaching practices[14]. These considerations together form a tension, known as good learning opportunities / moderate acceptance. Some researchers try to

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understand this situation through the so-called "factor approach"[15]. David Valiente et al. studied the electronic courses of the bachelor of engineering degree program at the official Spanish university and analyzed the achievements of students in using ICT (information, communication and technology) resources in the learning process[16].

This article explores and practices the integration of education and ICT through a key comprehensive normal university directly under the Ministry of Education of China. By reviewing the development process of the National Digital Learning Engineering Technology Research Center, it shows that managers recognize the rapid development of ICT Application platform for rapid deployment in education. The motivation for software development, functional characteristics, and application practices of the teaching platform starC reflect the stage development characteristics of ICT in education. Finally, a case study of the "linear algebra" course, which is closely coordinated by the teacher and the students of Central China Normal University, is closely combined with ICT. This study will analyze the widely used starC teaching software and its application cases to explore the characteristics and development laws of China's ICT on education.

The rest of the article is organized as follows. In the second part, the development process of education and the development process of ICT are reviewed. The third part shows the practice of combining ICT and education. The fourth part deeply analyzes the starC software platform and the course practice of "Linear Algebra". Finally, the fifth part analyzes the advantages and disadvantages of combining ICT and education and summarizes the full text.

II. Related work

In this section, we first review the development process of education, and then the development process of ICT.

A. Review the development of education

The original individual education started from the knot-knots of the primitive society, mainly through word-of-mouth transmission of knowledge, and after the agricultural society, personalized farming education appeared, mainly by handwriting text to transfer knowledge. In the second industrial revolution, in order to train workers on a large scale, there was large-scale education in class teaching style, and the printing of paper was applied on a large scale. In the era of the third industrial revolution, personalized education of ecologicalization, networking, decentralization, and life became a new demand, changing from electronic transmission to digital transmission [17].

The changes in new technologies with information technology as the core in the new era have spurred the transformation of education. The development of education depends on the corresponding social environment, from the individualized education in the primitive society to the cloud computing personalized education supported by new technologies such as data and artificial intelligence. Education always pursues the education of Confucius and the ability to teach students according to their aptitude, so as to realize the individual development of each student.

B. Review the development process of ICT

In the information age, Moore ’s Law believes that when the price is unchanged, the number of components that can be accommodated on the integrated circuit will double every 18-24 months, and the performance will also double. This law reveals the speed of information technological progress [18]. Gilder's law is described as: In the next 25 years, the bandwidth of the backbone network will double every 6 months, and its growth rate will be three times the growth rate of CPU predicted by Moore's Law [19]. The history of the development of information technology can be divided into three stages. These are the all IP 1.0 stage, all cloud 2.0 stage, and all AI 3.0 stage. The all IP 1.0 stage is mainly static digital resources. By digitizing paper resources, from flipping through books to looking at digital resources on computers, graphics and images are more colorful, and various related resources are linked together through hyperlinks and other technologies. The rapid development of retrieval technology makes it very convenient and efficient to find related resources among massive resources. The all cloud 2.0 stage is mainly an interactive interface. Large-scale network teaching has begun to explode, such as Coursera, Udacity, edX. The physical classroom can be completely transferred to the network, making it possible for anyone to learn at any place and in any time. all AI 3.0 stage is to customize personalized resources according to the needs of learners through knowledge maps and teach according to their aptitudes. Through data collection, researchers get learners’ profile, and they understand the weakness in a student’s learning through data analysis, thus providing precise guidance for students so as to help improve their abilities to solve specific problems. In other words, it is to record the trajectory of students’ learning process, and then give automatic analysis on their learning, and predict possible difficulties they may meet in their learning. In this way, teachers and parents can provide more targeted guidance, which correspondingly increases the requirements for teachers.

III. The integrate of ICT and education

The great role that information technology plays in social development led developed countries around the world to take measures to combine information technology with education. Since the 1990s, developed countries have successively issued various policy plans, under whose guidance they have adopted a phased and progressive strategy to promote the integration of ICT and education. The United States released the "Connected Education" (Connect ED) program in 2013, which was to create a new ICT-based education ecosystem and realize the US education transition to digitalization within five years. NETP2016 focuses on the improvement of students' cognitive and non-cognitive ability, lifelong learning ability and leadership training[20]. Since 2011, the UK has attached importance to the development of a "digital confidence system", which focuses on providing students with learning resources and support that can be accessed anytime, anywhere, helping students build high-level skills, so that all students can increase learning income. In 2016, the British government planned to

invest 1.3 billion pounds to improve the network, aiming to provide an online learning environment for all students anytime, anywhere[21]. South Korea 's education informatization has been constructed in five stages since 1996, establishing a national education backbone network in the first stage, establishing a campus network and hardware infrastructure in the second stage, establishing an e-learning support environment in the third stage, establishing u- Learning support environment in the fourth stage, and establishing SMART education support environment in the fifth stage[22]. Japan has implemented the "e-Japan", "u-Japan", and "i-Japan" strategies to promote the integration of ICT and education in the country. In 2010, Japan implemented the Future Campus Project, which aims to complete the nationwide popularization and application of e-books by 2020. In 2016, Japan formulated the "Acceleration of Education Informatization Plan", which proposed to build a "smart school" and redefine the information application capabilities required by the next generation of citizens[23].In 2005, Singapore implemented the Information Technology Demonstration School (LEADICT @ Schools) project [24]. This project selected 15% of the schools as pilot projects to encourage them to apply information technology in teaching and form a typical information technology teaching application model, which has been actively promoted nationwide.

Education informatization in China is keeping pace of developed countries in the world. In January 1999, the Opinions on Developing Modern Remote Education was formulated; in May 2011, Guidelines for National Medium and Long-term Education Reform and Development Plan (2010-2020) was formulated; and in 2012, Development Plan for Education Informatization Decade (2011-2020) was issued. These official documents all pointed out that information technology has a revolutionary impact on education. In September 2012, education informatization TV and telephone work was held nationwide. The conference held that education informatization is a profound reform of education concept and teaching mode, an effective means to promote education fairness and improve education quality, and the only way to realize education and build a learning society. The inclusion of network education in the the 19th National Congress of the Communist Party of China (19th report) means that education informatization has begun a new era in China. The inclusion of network education in the 19th reports means that education informatization has begun a new era in China. The new era should have a new look, and more importantly, new achievements. In the next step, education informatization in China will enter the 2.0 era, truly stepping to an education informatization development road with Chinese characteristics, which changes from integration application to innovation development stage [25].

National Engineering Research Center for E-Learning (NERCL) relies on central China normal university, and it is a specialized research and development institution engaged in education technology research and the transformation of scientific research achievements in China. In 2004, it was approved by the development and reform commission of Hubei province as the engineering research center of Hubei province; in 2006, it was approved by the ministry of education as the engineering research center of the ministry of education; and in 2007, the national education digital media and visualization discipline innovation and introduction base. In 2009, it was approved by the State Ministry of Science and Technology, and entered into the constructional sequence of national engineering technology research center. Then it became the only one domestic education informationization in the field of national engineering technology research center, and had Chinese education information technology research and development, product promotion and important industry demonstration base. This represents the domestic first-class technology development and engineering practice in the field of education informatization level. In 2011, the Education Informatization Strategy Research Base of the Ministry of Education was settled in Central China Normal University. In 2012, Central China Normal University and Beijing Normal University established Education Information Collaborative Innovation Center. In 2013, the NERCL passed the acceptance inspection with excellent results. In 2014, education department settled the basic education Future Classroom Equipment Research Center into the engineering center, increased the research and development of education equipment, and improved the research level of education equipment in China.

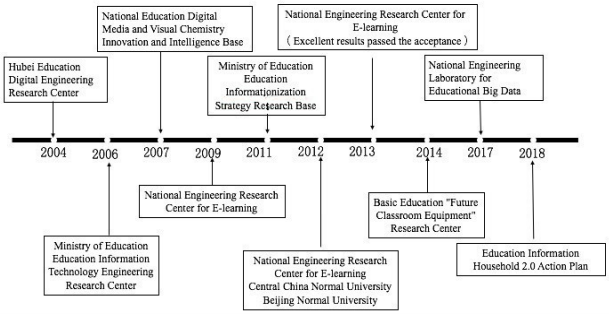

Figure 1. Development Path of National Engineering Research Center for E-Learning

In 2017, Central China Normal University was granted to build the National Engineering Laboratory of Education Big Data Application Technology (NELEBA)[26]. This is the first national engineering laboratory for education industry in China, specializing in education big data research and application innovation. The goal of NELEBA is to become a leading domestic, international first-class education theory research, engineering experiment data, achievements transformation and high-end talent training platform. Then it wants to improve the quality of education in our country, promote the education fair and education play a key role in the revolutionary development of governance ability, support national education modernization development goals, and restore to intelligent education as the core of the future. In order to accomplish the NELEBA construction and conquer education big data key technologies, we will focus on laboratory construction by the form of "1 data center + 5 platforms + 7 major research centers", then form education big data applications technology research and development platform and innovation application research center, or the education innovation application demonstration of network data. In 2018, the Ministry of

Education issued the Education Informatization 2.0 Action Plan, which clarified the direction for the future of education informatization in China. In 2020, it starts to formulate the next 10-year development plan for education informatization and the medium- and long-term plan for education informatization (2021-2035).

IV. CASE STUDY

In this section, we deeply analyzed two real cases of combining ICT and education. The first is a smart classroom based on the starC platform, and the other is a course practice combined with ICT.

A. Smart classroom based on starC platform.

The National Medium- and Long-Term Education Reform and Development Plan (2010-2020) clearly states that "focusing on improving students' learning ability, practical ability, and innovation ability... to promote students to actively adapt to society and create a better future". Cultivating students' key academic abilities has always been an important goal in basic education teaching. Focusing on this goal, the National Engineering Research Center For E-Learning developed the starC platform, the starC platform developed the electronic double-board classroom teaching system using electronic double-board technology. The system is aimed at the characteristics of the subject, and the "student-centered" classroom teaching platform. Emphasise on the modernization of educational content, teaching methods and methods, highlighting the role of classroom teaching design and organization, reflecting and adapting to the individualized needs of teaching, focusing on improving the application level of teachers' information technology, updating teaching concepts, and inspiring students' interest and initiative in learning Sex, improve the efficiency and effectiveness of classroom teaching, and promote the transformation and innovation of classroom teaching.

From system design to subject tools to subject teaching resources to cloud classrooms to digital curriculum resources to digital curriculum resources, to the establishment of the final disciplinary ability evaluation and analysis system, the "student-centered" teaching system is truly embodied. While providing students with a full range of resources, the informatization data collection and analysis system starts from the actual typical needs of student ability data collection and analysis, explores the operation mechanism and application model of informatization data collection and analysis, Data, artificial intelligence and other information technologies, through information-based data collection and analysis platform, dynamically collect students' key ability data, and analyze through deep learning technology, can maximize the evaluation of students' true ability level, this subject-oriented Capability evaluation and analysis has a perfect subject capability index system, a scientific and reasonable capability evaluation model, strong cloud computing storage technology support, and subject-oriented capability evaluation application innovation.

The National Digital Learning Engineering Technology Research Center aims at the huge deficiencies of current multimedia classrooms in terms of interactivity, networking, virtualization, intelligence, etc., based on the relevant theories of education and learning, adapting to the current development of science and technology, the transformation of learning models, and applying technology Innovative education, integrating the core hardware and software equipment of smart classrooms to meet the needs of current and future smart classroom construction and learning, and provide standards, core software and hardware equipment and overall solutions for smart classroom construction. A series of smart classroom standards have been formed to standardize and guide the construction of different types of smart classrooms, and explore innovative classroom teaching models. Based on the self-developed starC classroom teaching platform of the Engineering Center, with the support of information technology, the new educational teaching concept of the information age is integrated, and the future classroom solutions adapting to the school are actively explored, integrating dual-screen teaching, intelligent interactive teaching, high-definition direct recording, remote interaction, classroom with internet of things and many other functional systems. The Engineering Center will productize relevant research results and build more than 5,000 smart classrooms in more than 10 provinces and cities including Beijing, Guangdong, Xinjiang, Hunan, Hubei, Jiangsu, Fujian and Yunnan[27].

B. Practice of a course combined with ICT

In the second phase of smart classroom of No. 8 teaching building of Central China Normal University, advanced mathematics class of acting Jinjun Dai was taught in 9 smart classrooms at the same time. Each classroom has about 40 students, who are divided into six groups, sitting around six screens, sometimes staring at the screen to listen to a lecture, and sometimes clicking on their mobile phones to answer questions. Jinjun Dai, the winner of the university's Teaching Festival Award for undergraduate teaching innovation, had previously set a record of holding eight classes at the same time, and the average score of students was 20 points higher than that of other classes. In the class of Jinjun Dai, the 90-minute class is divided into three stages: first, according to the preview of students, focus on the key points and difficulties to teach knowledge, then students discuss in groups, accompanied by online tests, and finally the teacher answers the remaining questions. Each classroom is equipped with two senior teaching assistants, who are ready to be mentored if they have any questions. In class, instead of chalk and chalkboard, the electronic stylus and computer screens of the Jinjun Dai replaced the chalk and blackboard. The content of the blackboard is sent to students online, so that they can "review the past and learn new things" at any time. This new class has new requirements on students' learning habits: before class, students must prepare by the "cloud classroom platform" independently developed by the school and enter the class with questions. In class, participate in discussion and show to each other; after class, I will submit my homework online, and I will be able to speak at any time in BBS section of "cloud classroom platform", and the teacher will make comments and answer questions online.

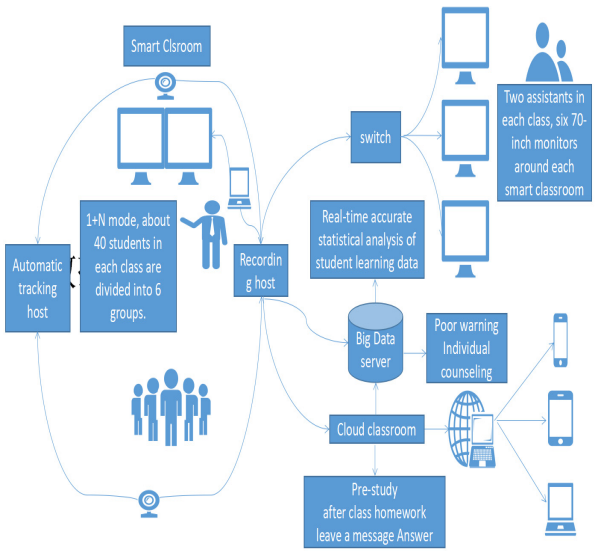

Figure 2. Smart classroom 1+N mode

Through the all cloud technology, students can enter the Normal University Cloud Classroom for learning through various terminal devices such as mobile phones, tablets, PCs, etc. Before the class, they have to make full preparations through the "cloud classroom platform" independently developed by the school. Students enter the class with questions, participate in class discussions and make presentations in front of classmates. After the class, they have to complete and submit the online assignment and they talk at any time in the "cloud classroom platform" forums, to which teachers and teaching assistants can respond with comments or explanations.

Through all AI technology, the data of students before, during, and after class are collected on the classroom and cloud classroom platform, and the data analysis engine is used to quickly understand the learning effect of students and adjust teaching strategies in time. Teachers can understand the problems of students with learning difficulties by establishing a set of early learning warning mechanisms, and provide timely individual counseling to help the students with problems. Through individual counseling, teachers can get better understanding of the difficulties that disturb their students, thus providing more specific and targeted help to individuals. Teachers solve the actual problems faced by students in a timely manner through online Q & A. As the winner of the Undergraduate Teaching Innovation Award commended by the school's "Teaching Festival", Dai Jinjun had previously set a record that the 8 classes led by him at the same time all got an average score of 20 points higher than other classes.

Education informatization development generally goes through four typical stages: start-up, application, integration and innovation. Since the publish of the Planning of the Decade, education informationization 1.0 stage progress, implement the “three big breakthrough”, “three links two platform” major progress was made in construction and application. Over the past five years, the main indicators of education informatization in China have more than doubled. The Internet access rate of primary and middle schools has increased from 25% to 90%, the proportion of multimedia classrooms has increased from less than 40% to 83%, and the number of online learning spaces for teachers and students has surged from 600,000 to over 63 million[28]. Under the guidance of education informationization 2.0 at present stage, it is necessary to expand the education resources. We need to do somethings from dedicated resources to expand to the common resources, from the application skills in information literacy, from the drive to lead innovation, need to shift the focus, from pay attention to the speed to improve the quality, and from experience management to precise management[1].

V. Discussion & Conclusion

Although the combination of education and ICT has brought forth many new teaching models and teaching methods, and also greatly improved the quality of teaching and learning efficiency, it also brings many drawbacks to be dealt with. For example, the rapid application of new ICT technology in education will inevitably make outdated products and services obsolete. Such replacement will bring great burden to teachers and students. Another example is the increased access to knowledge for students, which in some ways is likely to make the students surpass the teacher, so that it is difficult for the teacher to give an in-depth answer to the student's question immediately. The Internet is rich in resources, and students have a strong dependence on it, but prolonged use of various electronic devices is prone to cause short-sightedness, which is not conducive to students’ physical health, and uneven network information can also easily challenge students' mental health.

The aim of education is to make people successful. There are various definitions of success, which can be defined as that students have gained abundant knowledge, mastered necessary skills and formed a positive attitude during university. Or it can be defined as students who have obtained good grades, maintained their studies and obtained degrees during their college years. It can also be defined as student's achievements after graduation, such as entering graduate school, passing the professional qualification examination, obtaining satisfactory positions and ideal income. After studying the many definitions of student's success, George Ku gave a broad definition of student's success: academic achievement, active participation in educational activities, satisfaction with university experience, the knowledge wants to learn, academic continuity, achievement of educational goals (such as graduation, degree), and achievements after graduation. It can be seen that student's success can be divided into success during school and success after graduation[29]. Newton said, “if you ask a good skater what success is, he will tell you get up when you fall down, that is success. ”Maslow's hierarchy of needs theory is one of the theories of humanistic science. Its theory divides human needs into five kinds according to the hierarchy from low to high, which are physiological needs, security needs, emotions and attribution, respect for needs and self-fulfillment needs[30]. One of the basic attributes of modern education is humanity, and the fundamental of humanity is that education must respect individual differences. In other words, the ultimate goal of education is to enable everyone to achieve success within the individual's cognitive system, to enable everyone to achieve his self-worth in his own self-consistent system. As China attaches

more and more importance to education, the scope of education has become more and more widespread, and the number of educated people has increased. In this context, only the support of information technology can make the difference of respect possible. It is the continuous development of educational informatization that provides an opportunity to truly realize personalized education. At present, education informatization enters the 2.0 stage. On the one hand, it is the inevitable result of the continuous development of "Internet + education". On the other hand, it is also an important embodiment of "information technology to promote educational progress".

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