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The Development of High School Students ICT-related Competencies by Redesigning the Science and Technology Innovation Courses: A Case of a Mainland Chinese High School

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Abstract: The purpose of the current study is to explore the development of high school students' ICT-related competencies by redesigning a compulsory course for science and technology innovation. Results showed that the course has been implemented successfully. And the teachers teaching behaviors, students learning style, the classroom communication atmosphere, and the after-class evaluation have been positively changed.

Keywords: High school students, ICT-related competencies, science and technology innovation

1. Introduction

The Ministry of Education (MOE) of China released the Education Informatization 2.0 Action Plan on 13th April, 2018. In accordance with this document, the following development goals should be achieved by 2020 in China：The teaching applications should cover all teachers, the learning applications should cover all school-aged students and digital campus construction should cover all schools. The ICT-related competencies and information literacy of teachers and students should be highly developed, and the "Internet + education" platform should be established. The Education Informationization 2.0 Action Plan is an internal developmental requirement to realize new leap-forward based on historical and current achievements. It is an inevitable choice to adapt to the development of education in nowadays intelligent environment. It is also a key measure to fully stimulate the revolutionary impacts of information technologies, and an effective way to accelerate the modernization of education.

Traditional high school education pays too much attention to the results of college entrance examination, lays emphasis on knowledge transmission (Brooks, Normore, & Wilkinson, 2017), emphasizes too much on exam-oriented and exam-selected educational functions and curriculum management (Lim, & Khine, 2006). In high schools, the exam-oriented pressure brought by the college entrance examination forces teachers and students to blindly pursue the enrollment rate, and ignore the personalized development of students and the characteristic of schools (Zhou, Zhang, & Li, 2011). Consequently, the single and rigid school development strategies restrict students' creativity and imagination, students' independent exploration and cooperative learning. The characteristics of high schools are not obvious and the "exam-oriented education" is misunderstood (Wang & Shi, 2004). Therefore, in response to the educational problems brought about by this ICT-enabled era, it is vital for high schools to develop new ways to handle the relationship between students' comprehensive quality training and college entrance examination results, and further to promote the diversification of high school education (Chen & Xu, 2014).

2. Background of the Case Study

This study is located in the High School Affiliated to Guangxi Normal University (HSAGXNU), which is one of the top 10 key and exemplary high schools in Guangxi province, south-west China. In order to develop students' ICT-related competencies, the HSAGXNU started with the science and technology innovation curriculum construction, and research projects on the science and technology innovation curriculum integration practices in 2011. Meanwhile, the HSAGXNU focused on the development of the science and technology innovation core courses and established a comprehensive curriculum development framework, which included four major perspectives : administration, school culture, curriculum and activities (see figure 1). The core idea of the science and technology innovation education was project-based teaching. It should fully understand students' learning interests, integrate digital tools, advocate creation and sharing, cultivate students' interdisciplinary problem-solving ability and teamwork spirits. The effective integration of the science and technology innovation education and ICT should make full use of the advantages of resource database and serve for the teaching and learning (Zhu, 2011).

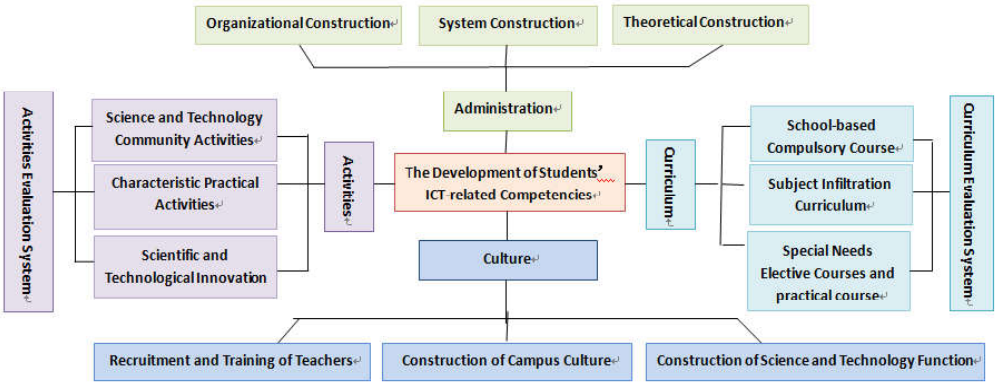

Figure 1. The Comprehensive Curriculum Development Framework for Developing Students' ICT-related Competencies in HSAGXNU.

3. Participants

In 2014, the HSAGXNU established the overall goal----"to establish a scientific curriculum system, stimulate every student's innovation potential". Meanwhile the HSAGXNU also developed the curriculum integration mode----"science and technology innovation talent training strategies", to educate the innovative quality of outstanding talents. Since the summer of 2014, the HSAGXNU has integrated information technology courses, comprehensive practice courses and general courses into science and technology innovation courses, teaching 3 class hours per week. During the following three years, totally 49 teachers and 1670 students have participated in these courses. The teaching team was selected from different specialization, English, Physics, Mathematics, ICT, Chemistry, Science, and Engineering. And all the participants were higher school students from Grade one and two, aged from 15-17 years old. Each student has received a total of 160 class hours of science and technology innovation training. In the spring of 2020, these courses have been taught to 1798 students, and 54 teachers have involved in these courses. The HSAGXNU invited five experts from the faculty of education, Guangxi Normal University (GXNU) to work with the teaching team to design the course contents. After five consultation meetings, the course contents were determined as shown in the following table 1. These courses have almost realized the transformation from the "elite students' innovation ability training" into "innovation literacy training for all students". The implementation of the science and technology innovation compulsory courses has ensured

sufficient time to develop students' scientific and technological innovation ability and ICT-related competencies in the high school.

Table 1. *The contents of the science and technology innovation courses in HSAGXNU*

Course No.	Contents	Categories
1	Creative electronic musical instrument based on Arduino	ICT-related Competencies
2	Design and manufacture of intelligent small lamp based on Arduino	ICT-related Competencies
3	3D Printing Course	Technological Design
4	Simple motor design and manufacture	Inquiry-based Instruction
5	The exploration of drinking birds	Inquiry-based Instruction
6	Design and manufacture of wire gyro	Inquiry-based Instruction
7	Design and manufacture of falling body	Inquiry-based Instruction

4. Results

4.1 Teaching and Learning Achievements

4.1.1 Teachers

Teachers' enthusiasm on teaching and research has been greatly encouraged. Teachers have won a series of awards for science and technology (See table 2). For instance, two research projects won the first prize in Guangxi Provincial Based Education Achievement Competitions in 2018. Mr. Yu-Hua LI was rated as "the National Top 10 Science and Technology Counselors in China" by Chinese Association for Science and Technology. Mr. Yu-Qiao Ma and Mr. Rui-Hua Mao have won several national and provincial level awards and outstanding science and technology instructors.

Table 2. *Teachers' Science and Technology Competition Awards in HSAGXNU*

Teachers' Science and Technology Competition Awards (2014-2019)			
Category	National level	Provincial level	Municipal level
Item	4	20	20

4.1.2 Students

Through the implementation of the science and technology innovation courses and the in-depth promotion of project-based teaching, the HSAGXNU students' innovation consciousness and competencies have been significantly enhanced, and their scientific and technological literacy has been generally improved. From 2014 to 2019, the HSAGXNU students have won more than 20 national invention patents and hundreds of national and provincial science and technology competition prizes (See table 3).

Table 3. *Students' Science and Technology Competition Awards in HSAGXNU*

Students' Science and Technology Competition Awards (2014-2019)					
Category	National level	Provincial level	Municipal level	Student Patents	Students' Invention and Creation Achievement Awards
Item	16	90	120	8	11

4.2 Feedback and Reflection from Teachers

Teacher A: With strong interests in science and technology innovation, my students have carried out continuous innovation and production through project-based learning, participated in series of competitions, presented their scientific and technological literacy and gained great growth and harvest, which made me more determined on the development path of science and technology innovation.

Teacher B: *Through project-based teaching, STEAM education has been carried out in a real way in the classroom. My students actively participated and explored in classroom activities. They began to question, to challenge, and place more emphasis on practice.*

Teacher C: *On the way of science and technology innovation education, there are many surprises and gains. My graduates of previous years had highly approved the scientific foundation of what they had learned in our high school and found their own future career interests.*

5. Discussion and Conclusion

Considering the educational context in China, this study was conducted to provide a basis for holistic understanding of developing high school students' ICT-related competencies by redesigning the science and technology innovation curriculum. The HSAGXNU have made a bold attempt to integrate ICT and curriculum in the process of educational information technology reform, and made careful arrangements and systematic plans in terms of school organization, educational theory, culture and evaluation and so on. The contribution of the study is discussed the sustained changes with respect to the following perspectives.

Teachers' teaching behaviors and students' learning style have been changed. The teachers' teaching behaviors have been changed. They returned the class to the students, and the students learning style has changed from passive to active. They could have learning space for independent thinking, and carry out group cooperation to achieve learning effects.

The classroom communication atmosphere has been changed. The reform of educational information technology has brought students a platform to show themselves, and students have more opportunities to participate in classroom instructional discussions. The classroom has been changed from lecture to discussion or cooperative learning in a harmonious atmosphere.

The after-class evaluation has been changed. In the science and technology innovation curriculum, the evaluation method was no longer the single evaluation method based on academic achievement, instead, it had established the evaluation system through teaching and learning process and credit system, and evaluated students' learning outcomes from more scientific, objective and comprehensive perspectives.

The development of high school students' ICT-related competencies is a systematical project and an important symbol of modernization of education. Therefore, it requires principals, teachers, educational administrators and researchers to collaboratively make efforts in terms of school organization, teaching process, teaching modes, teaching quality, and evaluation.

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