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# COMPUTER EDUCATION REFORM IN TAIWAN

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## Abstract

*This article discusses the evolution of computer education curricula in primary and high schools worldwide, highlighting the significance of adapting to the rapid advancements in information technology. It addresses the varying perspectives on the content and timing of computer courses and analyzes literature on pre-university computer curricula across different countries. These differences reflect the unique societal and economic conditions of each country. Taiwan's computer education reform, initiated in 2019 with the 12-Year Curriculum Guidelines, is explained. The reform significantly emphasizes computational thinking, a recent shift in curriculum orientation incorporating problem-solving skills to address real-world issues. The discussion also notes the difficulties in promoting new computer curricula, emphasizing the need to understand these challenges to prevent potential conflicts.*
**Keywords**: *ICT in education, computer science education, computational thinking, computer education reform*

## Introduction

Because of the importance and rapid development of information technology, countries around the world are actively updating the curriculum and implementing strategies for their computer education courses, particularly in primary and high schools, hoping to strengthen students' literacy and lead students to acquire the necessary competencies for learning and career development. However, diverse views on computer education still exist among experts and citizens in various countries. The main questions are what subject content computer courses teach and which school years schedule these classes. This article compiles and analyzes relevant literature on computer curricula before university education in several countries. From the experience of various countries engaging in computer curriculum reform, discussion and suggestions are put forward for future computer curriculum updating and implementation.

### *Background: The Orientation of Computer Education*

The computer curriculum of primary and high schools in various countries can be divided into two types of orientation, namely ICT (Information and Communication Technology) courses based on computer literacy and CSE (Computer Science Education) based on computer science discipline.

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ICT courses focus on improving students' general ability to use computers. Courses include Internet use, software operation, and word processing. Comparable terms include information literacy, digital literacy, and computer literacy. The UK has achieved exemplary status among the countries that have adopted ICT as a computer curriculum due to its extensive experience in curriculum planning and implementation. ICT was added to the 1988 Central Government Curriculum in the United Kingdom, emphasizing computer and software usage. Students are required to take ICT courses focusing on IT applications. After acquiring basic competencies, students aged 16 to 18 are also provided opportunities for advanced computer courses at the A-level stage (Brown et al., 2014). Similarly, after the 1980s, computer courses in France have been ICT-based. Based on the concept of "learning by doing," teachers guide students to be familiar with software tools and teach students to apply what they have learned in the learning process of different subjects, and simultaneously familiarize themselves with the use of software tools, and enrich and deepen the learning effectiveness of other disciplines (Baron et al., 2014)

In contrast to ICT's emphasis on the use of computers, the CSE curriculum treats computer science as a separate and complete scientific subject. The content is mainly based on an introduction to computer science, including algorithms, data structures, programming, system structure, and problem-solving. This orientation is sometimes referred to as computer technology education. Among the many countries that adopted CSE as the content of the computer curriculum, Israel was the first to implement it and Lithuania followed a decade later. Computer courses were first included in the high school curriculum in the 1970s, requiring students in grades 10 or 11 to take classes that focused on computer science courses. Israel's education system uses the same curriculum norms throughout the country, and the computer curriculum includes introductory computer science courses, two different paradigms of programming, data structures, and theory (Benaya et al., 2017). Since 2011, computer courses have been included in the grades 7 to 9 secondary curriculum, including logical thinking and programming (Gal-Ezer & Stephenson, 2014). In addition to Israel, the CSE curriculum orientation is also adopted by the United States. The ACM Model High School Curriculum was first released in 1993, followed by a Model Curriculum for K–12 Computer Science in 2003 (Tucker, 2003). The course emphasizes IT fluency, which means that students have the concept of computers and networks, the ability to use computers to solve problems, and the skills to use computers in the workplace.

Today, the prevailing application of information technology has influenced people's lives and career choices. Thus, the content and delivery of computer education urgently need to catch up to the speed of information technology development. In the United Kingdom, for example, ICT courses are so simple that students are not interested, resulting in low numbers of year 11 students taking advanced computer courses (Brown et al., 2014). The United Kingdom is not a single case; this phenomenon also exists in the education system of many countries. Also, the education committee members of the international organization IFIP

(International Federation of Information Processing) have discussed many times and hope to establish a recommended computer curriculum guideline for primary and high schools. Although experts from various countries differ in details, there is a consensus that computer courses must be deepened (Northrup et al., 2022; Webb et al., 2017).

## The Reform Challenges: Lessons Learned From Other Countries

In spite of the trend of deepening content, the early implementation of computer science courses, such as computer programming, has become a critical issue. People's attitudes toward which educational stage to teach computer programming are different. Countries with higher demand for computer talent tend to arrange programming courses earlier. Estonia and Israel, for example, require learning to program at the primary school level, while Austria and Ireland introduce programming at the secondary school level. In the Czech Republic, students do not learn programming until vocational education (Moreno-Leon et al., 2016). Therefore, countries reacted differently toward computer education reform because of the diversified situations in society and the economy. Likewise, those countries face various difficulties when promoting the new computer curriculum. These experiences during the computer education reform are important information to understand the causes and avoid potential conflicts.

### *Objection to Deepen Content: South Korea and India*

Although South Korean schools have had good information facilities and educational foundations for a long time, the promotion of secondary school computer education has yet to be smooth. Since 1992, South Korea has added a separate ICT literacy curriculum to the curriculum of grades 6 and 7, focusing on the use of computers. Since 2007, the course name and content have been changed to informatics, focusing on the principles and concepts of computer science (Choi et al., 2015). However, these courses were rarely opened because of low registration. Looking back at South Korea's process of promoting a new computer curriculum, we can find that the biggest obstacle is the public's disapproval of the orientation of the curriculum. In the highly competitive environment of further education, parents are worried that computer courses will affect students' concentration on coursework. They believe the computer literacy curriculum is sufficient for daily use and does not need to include professional computer content in the secondary school curriculum. Although a new software education program was piloted in 2018 after the prior reform failure, the shortage of professional faculty, the policy of university admission standards, and the recognition and support of the public may be critical factors affecting the sustainability of the new computer curriculum (Kim et al., 2015).

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A similar situation exists in India. Although India's universities have cultivated many excellent computer talents, computer education in primary and secondary schools is not popularized. In addition to the general lack of information equipment and qualified teachers in primary and secondary schools, the most crucial factor is that the public must agree with the need for primary and secondary schools to set up computer courses. People believe that information technology can be learned through daily life or existing courses, and there is no need to add new courses. In contrast, advanced computer courses can be left to study at the university level. Therefore, although some scholars have proposed planning, it is still in the research stage of individual schools and has yet to receive attention from the government (Raman et al., 2015).

*Distributed Control of Curriculum: Finland and USA*

Finland ranks among the ICT powerhouses, but its ICT development lags behind other advanced EU countries, with only 2% of secondary school students in grades 10 and 12 studying computer programming (Kurhila & Viehavainen, 2015). The reason for this phenomenon should be the elevation of course autonomy. Under the Finnish education system, schools and teachers are often given full power and freedom to arrange their lessons, so there is no mandatory computer curriculum, in other words, each school determines the content and allocation of hours for computer courses. In this context, computer courses vary significantly between schools. Suppose the teachers in the school have programming expertise. In that case, the school may offer relevant courses, but if there are no teachers in the school who are neither enthusiastic about teaching programming nor are willing to engage in relevant teaching, the possibility of the school offering related courses plummets. In other words, teachers' computer expertise affects whether the school offers courses and students' learning opportunities. In this case, students mainly acquire computer science content through self-learning. Opportunities for taking courses also lead to the lack of opportunities for secondary school students to explore subjects and interests early and know whether they are suitable for university computer majors (Kurhila & Viehavainen, 2015).

Similar factors also affect the promotion of computer courses in the United States. Since the curriculum is determined by each state individually, the content and number of hours of computer courses in each state are not the same. Overall, computer courses in American high schools are elective and not valued. According to the CSTA survey, most of the computer courses in junior high schools are conducted in the form of extracurricular activities. In the high school segment, about 74% of high schools offered introductory computer courses in 2013, up from 65% in 2009 and 69% in 2011, only at a slow pace (Gal-Ezer & Stephenson, 2014).

### *Shortage of Qualified Computer Teachers: UK and USA*

Dramatic transformations have driven the British new computer curriculum. The multiple struggles from the industry and lobby groups led to the change of computer curriculum content several times. In the 1988 Central Government Curriculum, ICT was included in the curriculum, focusing on applied technology and software. In the new curriculum of the year 2007, the computer curriculum remained ICT-based. After lobbying from the industry and teachers, the ICT curriculum changed to 'Computing' in 2012, designed to cultivate students' programming capability before age 11. Moreover, the promotion schedule of the new curriculum was hasty, resulting in a short response time for the education site and many problems in preparing for the new curriculum. One of the biggest problems is the need for more teachers. The existing computer teachers in primary and secondary schools in the UK are all ICT teachers, and most have no professional computer training. When the new curriculum is promoted for a year or two, they are demanded to learn professional skills such as programming and improve their teaching knowledge of how to promote computational thinking (Sentance & Csizmadia, 2017). Similarly, the United States faces the problem of a computer teacher shortage because of the salary gap. To solve the problem of insufficient computer teachers, the CS 10K Project, supported by NSF, planned to train 10,000 teachers nationwide (Cuny, 2011). Nevertheless, the accomplishments of this initiative are not yet widely published in academic reports.

## The Computer Education Reform in Taiwan

In 2019, the Taiwanese government launched a new national curriculum, namely the 12-Year Curriculum Guidelines, redefining the progression of learning by emphasizing the core competencies at each stage of learning. Drawing inspiration from international trends in basic education, the new curriculum guidelines promoted the holistic development of each child with opportunities to cultivate their individual aptitudes to reflect international best practices (Coudenys et al., 2022). Computer curriculum, part of the technology curriculum, is a significantly changed discipline.

### *Computational Thinking as the Curriculum Orientation*

In the recent years of computer curriculum reform, computational thinking has gradually attracted attention (Wing, 2006). Compared with the ICT and CSE courses mentioned above, computational thinking belongs to the recent rise of curriculum orientation. In addition to adopting the course content of CSE, computational thinking also emphasizes using this knowledge and skills to understand and solve real-world problems. Nevertheless, different views among scholars exist on implementing computer curricula based on computational thinking. Some scholars

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believe computational thinking is about cultivating problem-solving knowledge and skills and, more importantly, practice (Patton et al., 2019). Lye and Koh (2014) offer a more in-depth commentary, agreeing with Brennan and Resnick (2012) that digital creators' computational thinking, including computational concepts, practices, and perspectives, is more appropriate.

In 2003, the ACM released the Primary and Secondary School Information Model Course, which divided the K-12 curriculum into four levels, the first of which was K-8, and suggested that algorithmic thinking should be integrated into the curriculum at this stage. Similarly, in 2011, the CSTA K–12 Computer Science, a curriculum standard published by the Computer Science Teachers Association of the International Organization (CSTA), adopted computational thinking as its design concept. By definition, ISTA and CSTA view computational thinking as a problem-solving process, so the focus of learning includes asking questions, logically organizing and analyzing data, abstractly presenting data, automating solutions, finding the most efficient solutions, and the ability to transfer solutions to other problems (ISTA & CSTA, 2011). Nevertheless, the design concept is still too vague for teachers to implement into practice with computation. In other words, how to design instruction activities to promote students' computational thinking becomes a problem.

In fact, the 12-Year Guidelines of Taiwan aim to promote innovation and adaptive pedagogy among teachers, encouraging student-driven learning in the classroom to facilitate competency development (Coudenys et al., 2022). Granting autonomy to increase student adaptive support, teachers are encouraged to use different tools or strategies to develop student competency. For example, computer teachers can freely select a coding language to teach programming. Prior studies indicated that teachers need more training and appropriate curriculum design paradigms when the new computer curriculum design combines computer technology and problem-based learning (Ozturk et al., 2018). Therefore, sufficient professional support, teacher buy-in, and self-motivated interest to adapt pedagogical techniques are vital to the success of guideline implementation. In addition to workshops that teach directly about the new curriculum and its pedagogical approaches, the Ministry of Education funds school teams to submit proposals to promote integrating ICT in education and design innovative teaching.

### *Integrated and Independent Computer Courses*

Computer curriculum planning has been derived for different stages of education: in primary school, the concept of computer science is aimed at imparting the concept, and at the high school level, it is taught in independent science courses, and schools are also encouraged to provide more in-depth computer courses as preparation for employment or university (Knobelsdorf & Vahrenhold, 2013; Nelson et al., 2016; CSTA, 2017). While discussing the early introduction of programming course content, how to provide appropriate curriculum planning according to

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students' physical and mental development stages has also become a problem that must be faced in reforming computer curriculum. Based on learners' cognitive development and motivation to learn, many studies suggest that programming should be integrated into primary school ICT curricula or other subjects. At the secondary level, it is included in independent computer courses (Lye & Koh, 2014; Moreno-Leon et al., 2016; Repenning et al., 2015). In the new Taiwanese curriculum, computer courses are integrated with other subject courses at primary schools and the computer courses are independent at high schools.

*Seeking Support from the Society*

The 12-Year Basic Education Curriculum Guidelines were researched and drafted in 2008 and published in 2014. Like the challenges preceding the previous curriculum reform, the government explicitly called for the involvement of multiple stakeholders, including teachers, administrators, parents, and NGOs, to reduce resistance.

Another challenge facing the reform's future is disseminating information to the public to create awareness of the goals and processes. A public concern is the lack of confidence in how the new guidelines will equip students with the knowledge and skills they need to master the content. Before the new curriculum was launched, the Taiwanese government started to strengthen the advocacy of the new curriculum content and obtain the support of teachers, parents, and the public. Public hearings and workshops were held for teachers and parents who felt nervous and skeptical about the changes.

*Training Computer Teachers*

The new computer curriculum beyond primary school is expanded and deepened and thus increases the hours of computer courses. Accordingly, the number of computer teachers needed to be increased after starting the new computer curriculum. However, the salary gap between teaching and IT professionals hinders teacher recruitment. The Ministry of Education has taken many remedial and supporting measures to solve the shortage problems, such as recruiting part-time teachers and providing in-service computer training for existing teachers.

## Conclusions

Both innovations in computing and innovations using computing are fundamental to national competitiveness and societal progress. Building a talent pool to sustain that innovation should start with K-12 education. The Taiwanese government has long invested considerable resources in promoting computer education in primary and secondary schools. However, many challenges occurred when the computer education reform was launched.

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An analysis of reform experience in South Korea and India shows that the public's stereotype of the schedule and content of computer education has also led to the delay in completing the government's reform plan. The opposition to the reform of computer curriculum based on the deep-rooted education in the culture not only hinders the promotion of new computer courses but also triggers students' willingness to choose courses and ultimately drags down the arrangement of courses and the cultivation of teachers. Thus, the impact of public recognition must be considered. Striving for recognition should be an essential strategy to promote the new computer curriculum in the future.

For countries based on the framework of national uniformity and standardization, computer education reform should be designed by the government and openly discussed with the stakeholders long before launching. Other supporting measures, such as teacher training and information equipment factors, have been considered while planning the curriculum, so only a tiny part of the adjustment has been made in the promotion process, and the implementation will be relatively smooth.

When countries like Finland and the United States offer a high degree of curriculum autonomy or when the implementation of computer syllabuses is loose, school commitment becomes a critical factor in promoting computer curriculum. Furthermore, when schools fail to engage in computer education, society or professional organizations can actively step forward and create a different picture to promote the effectiveness of computer courses.

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