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Improved Yuanpei computer science teaching: For secured development of developing countries

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Abstract: This paper digs into the developmental strides achieved by some countries through the use of skill-oriented computer education. The involvement of the various governments through policy making, implementation, monitoring, funding, curriculum amendments, liberalization of computer science undergraduate program structure, the introduction of skill-oriented projects, is x-rayed. These parameters provide insight into the successful outcomes of these economies through investments in Computer education. The methodology adopted is a review of literature on various Computer Education Policies, Implementation methods adopted, as well as monitoring methods for sustainability. Our findings show that three reviewed Countries were able to develop skills through the researcher's computer education, that took over the technology world and helped advance their economies. While China focused on Hardware through task-free and funding of hardware-producing companies, the UK, through Raspberry Pi, focused on teacher and students' training in Software development. The United States on the other hand focused on Research and development and making ICT passing a prerequisite for college. The researcher recommends: Redesign of computer curriculum to teach coding to primary and secondary school students, training of teachers in specialized computer areas, and have them replicate the knowledge to other teachers, federal funding and monitoring of new computer education policies, including a minimum of a credit pass in computer subject as a prerequisite for studying computer science. Finally, the adoption of accelerated skill-based teaching of Computer science in core areas of beneficial disruptive Technology, through an intensive program such as "Yuanpei" would transform and cause desired sustainable development.

Keywords: Education, Computer Science, Economic development, Development, Developing Countries, disruptive technologies, Sustainable development, Skill-oriented teaching.

1. Introduction

Skill-based Computer Science teaching is the act of imparting computer skills into students from an early age (Nursery/Primary education), developing these skills in middle school, and finally advancing the skills through an intensive skill-based curriculum in disruptive technologies. This accelerated skill development nicknamed "Yuanpei" is a research program launched in 2001 in Peking university. The program was named after a Chinese philosopher who made laudable imparts in China's modern education system. This program allows the students to freely choose what field they want to be trained in while providing highly flexible funding methods. The project goal is to help develop a generation of skilled graduates in various disciplines. The following steps define the Yuanpei program in Computer Education:

1. Students with high Intelligence Quotient are selected from high schools and then taken through foundational Computer Science courses for one year.
2. The students are allowed to choose an area of interest from a list of core Computer Science courses considered impertinent to national development. Completing these courses qualifies the students to move into higher degrees and creative research.
3. Students receive intensive training for a shorter duration than the regular degree requires.

Improved Yuanpei, therefore, aims to introduce the accelerated course system with a specific specialization guide. Computer Science discipline has been found to contribute immensely to fast-tracking the development of nations. Successful economies have grown their information technology sector through such means as Research and Development hence the need for radically changing present non-fruitful methods of ICT consumption without production cannot be over-emphasized.

2. Literature review

For Greenwood and Holt (2014) economic development is measured in terms of a sustainable increase in the living standard of a people. For Schumpeter (1982), Economic development has to do with methods through which capital is transferred from known methods of production to new, innovative productivity-enhancing methods. In Nigeria, Universal Basic Education (UBE), made Computer education a core subject in her primary and junior secondary education. This new curriculum introduced in 2014, had the objective of creating an enabling environment for the subject, by providing computers in all schools (Igbokwe, 2015). Computer education at the secondary school level was implemented in the late 80s following the report of the National Committee on Computer Education (1988). The objective of creating a literate society, thereby closing the digital gap between Nigeria, and developed economies were to be implemented by: training of resource persons, provision and maintenance of required infrastructure, curriculum development, and software development and enhancement (Chukwuere, Mavetera & Mnkandla, 2016; Jegede & Owolabi, 2003).

Computer Science undergraduate office of the University of Maryland, USA, defined Computer Science as a study that focused on computers, computer components, and computational systems. Kanke (2017) described computer science as a discipline as the study of science that involves theory and practical development and application of computers and computing concepts like software, hardware, networking, and the internet. Nearly every industry is becoming reliant upon the various areas of computer science, especially in emerging disruptive technologies, such as which has hence disciplines included by the computer science degree spans through all possible areas of practical techniques for computer application.

The author outlined some of these areas are: Microprogramming, Data Management, Memory systems, Artificial Intelligence, Operating Systems, Cyber Security, Bioinformatics, Software Development, Networks and Administration, Computational physics, Digital image/sound, Computer Graphics, Computer programming, Web Development, Cryptography, iOS Development, Simulation, and Modeling, Computer Architecture Networks, Mobile development, Software systems, Parallel Programming, Database Design, and, Computer Engineering. Having a degree in Computer Science should qualify one to pursue a career in any of the areas of specialization outlined above. Below is a table showing the expected starting salary on some Computer Science careers:

Table 1: Starting salary on some computer science careers

S/N	CAREER	EXPECTED SALARY/Yr($)
1.	Software Developer	80,500
2	Software Test Engineer	84,000
3	Senior Software Engineer	98,000
4	Software Development Manager	115,000
5	Software Architect	116,000
6	Programmer Analyst	74,800
7	Systems Developer	93,800
8	Web Developer	58,000
9	Software Development Engineer, Test	82,000
10	Application Support Analyst	69,800
11	Computer System Analyst	68,300
12	Database Administrator (DBA)	85,100
13	System Administrator	62,900
14	Systems Engineer (IT)	83,300
15	Systems Analyst	81,900
16	Network Administrator	59000
17	Network Engineer	83,900
18	Business Analyst	81,500
19	Program Manager, IT	111,000
20	Information Technology Specialist	64,200

Source: Careers in Computer Science. www.internationalstudent.com

Report from "careers in Computer Science blog state that Computer science jobs are stable and that recent studies suggest that 6 out of 10 occupations with most new jobs are in the field of Computer Science. Garba, Adepoju and Alhassan (2015) and Muhammad, Tumburku, Muza and Gwandu (2019) Identified factors mitigating against the successful application of Computer studies across Universal Basic Education in Nigeria. The UBE oversees curriculum for students in primary 1 to 6, and junior secondary 1 to 3, making it a 9 years foundation plan.

Some of the factors identified are:

1. Lack/insufficient Computer laboratory
2. Lack textbooks in the schools
3. Lack of motivation
4. Poor school environment
5. Lack of steady power supply
6. Unqualified teachers
7. Lack of commitment by school managers
8. Complex and wide syllabus of curriculum for students at a level under study.

Jegede and Owolabi (2003) compare Nigerian National Computer policy (1988) with presently practiced Computer education. The authors collected information from 20 secondary schools (10 each of public and 10 private schools) located in 6 different states in Nigeria. They found that:

1. Computer education infrastructure is provided only for Federal Unity secondary schools and is scarcely available in state schools which constitute 80% of Nigerian schools.

2. The computer education policy stipulates 8 personal computers per school, calculated on the assumption of 40 students per class, or a ratio of 5:1.

In practice, they found that 80% of schools have 5 computers and not stipulated 8 and that the average number of students per class is 50, giving a ratio of 10:1. On competence of teachers, the policy dictates training for three teachers from the fields of Mathematics, Physics, or Chemistry. However, there were no teachers' training programmes given. Policy statements for maintenance of hardware and peripherals, provision of software, and customized computer education curriculum were not yet in place.

3. Methodology

The methodology adopted is a review of literature on Computer Education Policies of three Developed Countries, Curriculum, and Modes of Implementation (China, the USA, and the UK). In this section, a review of computer education policies and implementation strategies adopted by some countries that have used computer technology to advance their economy is carried out.

4. Computer education policies of three developed countries

4.1. Chinese computer education policy, policy monitoring and implementation

Chinese Informatics Policy stresses the importance of linking education, economic development, and Science and Technology using New Information Technology (NIT), accompanied by a rise in the level of computer literacy (Makrakis & Yuan-tu, 1993). Chinese national policy on computers in education includes areas such as: 1) Priorities, procedures, 2) Hardware and software, 3) Teacher training, 4) Research and development, and 5) Institutionalization.

Chinese policy emphasized the production of large-scale Integrated Circuits and peripheral equipment and Software. Measures were adopted to facilitate the introduction and use of new technologies as well as to promote research and development. The measures adopted were monitored by the Bureau For the Management of Computer Industry which falls under the Ministry of Electronics Industry (Makrakis & Yuan-tu, 1993). By 1990, China was the world's largest television manufacturer with exports of about 2million units in the first half of that year. The success came as a result of China's open-door policy, which had Japan and the USA invest in technology (Makrakis & Yuan-tu, 1993). China also developed an experimental zone for electronics production and by 1990, almost 160 high-tech enterprises had been established in Beijing's Silicon street with about 70% specializing in computers. The area also had more than 100 scientific research institutes. Also, the state introduced incentives such as three years exemption from taxes and another three years of reduced tax for investors in the zone.

Policy monitoring

Chinese Computer education prioritized teaching computers in Chinese lower-level schools by inviting university teachers to offer simple programming courses in BASIC (Makrakis & Yuan-tu, 1993). According to Zhang and Lo (2010) in their paper titled "Undergraduate Computer Science Education in China" described computer science programs for undergraduate Computer Science majors (core program) and fundamental education offered to non-computer science (non-majors), using the Peking University as a yardstick for measurement. At this University, the computing discipline is "Computer Science and Technology". The discipline curriculum was modeled after Association For Computing Machinery (ACM) computing curricula in 1991. Zhang and Lo (2010) reported that the Chinese Advisory Committee, a body with the responsibility of Computer education policy making, outlined four challenges faced by Computing professionals. These include:

1. Widening of discipline's intention
2. Making sub-disciplines within Computer discipline to be independent
3. Taking cognizant of non-uniformity of information technology needs of different societies.

Following the report, the Chinese Education Ministry developed precise categories for training the Chinese high-tech workforce in University education. The categories are:

1. Science Oriented

2. Technology-oriented.
3. Engineering–oriented

This is presented in the graph below:

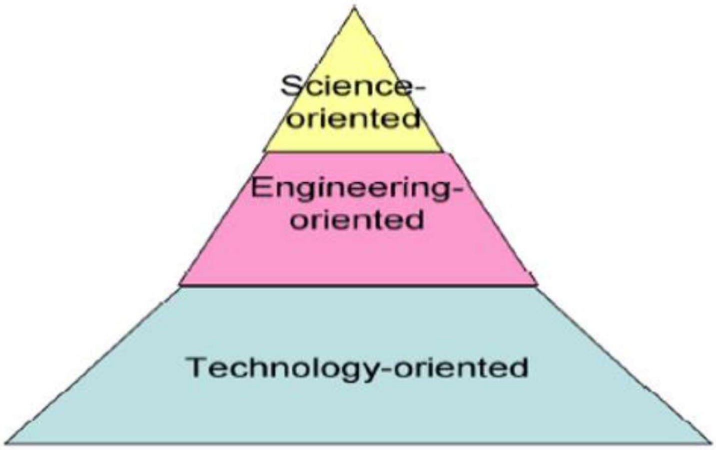

Figure 1: Pyramid model of computing education. Adopted from Zhang and Lo (2010)

Science-oriented skill is concerned with identifying and automating information through scientific research. Engineering–oriented skill involves theory and design using engineering solutions and at a low cost. In Technology-oriented skill, the act system theories and construction, as well as fundamental methods of problem solving are acquired.

Implementation the strategies followed by the ministry of education in China are:

a) Allow Universities to follow a specialty under the Computer Science and Technology in higher education. Computer Science and Technology major must fulfill required curriculum, as well as specialize in either Theoretical Computer science, Computer Architecture, Database and Data Management, Software Engineering, Digital Media and HCI, Computer Networking, Artificial Intelligence, Knowledge discovery, Natural language processing, and Intelligent perceptiveness.

b) Provided opportunities for enhancing academic capabilities of teachers such as free online courses at www.enetedu.com and other MOE-sponsored training and forums.

c) Enhance practical hands-on ability of students. Dedicating more time to Engineering and technological education ensures more experiment-based teaching.

The second strategy is the introduction of the Yuanpei project. The program was designed to select high school students with high IQ and provide accelerated IT training for this group, in areas considered as critical to the nation's developmental plans. Yuanpei is an accelerated course plan which originated in Peking University and is geared towards helping the nation to develop a generation of skilled graduates. It takes the students through foundational courses in the first year, after which Computer Science and Tech majors take only eight courses within a duration of three years. The core courses offered here are: Advanced Introduction to Computer Science, Advanced Database System, Advanced Computer Architecture, Advanced Operating System, Advance Programming Practice, Advanced Software Engineering, Advanced Data Structure and Algorithms, and Advanced Compiler Theory (Ntseme, Jokonya & Chukwuere, 2020; Zhang & Lo, 2010).

The third strategy implemented by China's ministry of education is an innovation that allows academic-industry collaboration, where researchers from discipline's related industries, for example, IBM teach students courses like Advanced IT Technology, Parallel Computing in Multicore Architectures which is handled by Intel engineers, Fundamental Storage Technology and Electromagnetic compatibility Engineers (Zhang & Lo, 2010).

4.2. United States of America computer education policy and implementation

The United States of America has a decentralized education system. The states and local governments make major contributions, while the Federal role is about 8% (Zucker, 1982). In 2018, Code Advocacy Coalition on the status of Computer Science education, policy, and Implementation across the USA came up with a report (State of Computer Science Education, 2018). The following policies were proposed (State of Computer Science Education, 2018):

1. Allocate funding for rigorous computer science teacher professional learning and course support.
2. Allow computer science to satisfy a core graduation requirement.
3. Allow computer science to satisfy core high school graduation conditions as well as satisfy an admission requirement at higher education.
4. Create a state plan for K-12 Computer Science.
5. Create programs at institutions of higher education to offer computer science to pre-service teachers.
6. Define Computer Science and establish rigorous K-12 computer science standards.
7. Establish dedicated computer science positions in the state and local Education Agencies.
8. Implement clear certification pathways for computer science teachers
9. Require that all secondary schools offer computer science with appropriate implementation timelines.

Considering the decentralized nature of the United States education system, the report stated that, about 44 states out of the 50 states in the USA have implemented one or more of these national policies. It also noted that a higher percentage of computer-teaching high schools are located within states who have implemented more of the nine outlined policies (State of Computer Science Education, 2018). On the effects of funding, the states which provide teacher training have a 1.7 times implementation rate than those where teacher training funding is not provided for (State of Computer Science Education, 2018).

Implementation strategy adopted by the USA

Each State provides centralized leadership whose task is to oversee statewide initiatives and monitor the implementation of adopted policies. Computer Science Supervisor at the state level is to ensure the project receives state-wide support and sharing of best practices with school districts (State of Computer Science Education, 2018). The United States at the Federal level funds Computer research and has made laudable technological advancements through Federal Government-funded research. At the tertiary level, a study of Maryland University Computer Science will be used as a measuring yardstick. This University has a curriculum designed with input from employers, industry experts, and scholars. The curriculum aims at equipping the students with skills to face and overcome challenges in their area of specialization (CS undergraduate office, Maryland).

Furthermore, teachers are changing teaching tactics to encourage more students who chose the discipline as a major. Instead of teaching a coding language that may be outdated by the time the student graduates, they rely on visual or "drag and drop" programming languages that allow students to see the output in real-time (Alexandra & Chris, 2019). Most boot camps succeed by contextualizing the theory. They teach a practical approach to problem-solving. The instructors used at most boot camps are practitioners, working with tech companies instead of academics.

4.3. Computer science education policies and implementation strategy in the United Kingdom

The United Kingdom, computer manufacturer, Raspberry Pi leads in a £78m project which targets the training of 40000 teachers in computer science. The Raspberry I team along with its partners, STEM Learning, and the British Computer Society, will deliver a program for primary and secondary school teachers, including free educational resources, national training, and certification. Over four years from project inception, they will deliver face-to-face workshops across 40 schools in well-performing areas, the schools which receive the teaching will then be paid to deliver training to neighboring schools. The teachers are to attend a code club, an after-school group run by Raspberry Pi.

The project is a combination of emphasis on teacher training, commitment to the subject, and making resources available to teachers. The project also pays the bursary of teachers' schools for the time teachers spend outside the classroom (Madhumita, 2018). Before the project, students at the primary and secondary school level were only taught the computer fundamentals such as Powerpoint. Google's former CEO frowned at this, hence collaboration between Google, Arm, Cisco, and Raspberry Pi. This collaboration led to the design of credit card-sized computers that can be easily programmed, Google Home voice System, Space experiments, and chatbots (Madhumita, 2018).

At the tertiary level, a look at the computer science and technology department of Cambridge University showed the skill-oriented course plan (Computer Science at Cambridge). The department states that her discipline is vast and skill-based and that the students learn skills that prepare them for future technology. Foundational and modern computer courses are taught, as well as theory, and foundation in law, economics, and business. The students also develop practical and hand-on-learning skills in programming and hardware systems.

The statutory requirements for class attendance are a Scientific calculator, a laptop with half of its main drive dedicated to a bootable Linux system such as Ubuntu. From Year 1 to year 4: Copies of the student's textbook must be presented or a fee ranging between £150-£250 covering the textbook cost.

Usually, about half of the graduates from this school pursue a career in Computer science, one some of them follow a career part in teaching and research. In the first year, the students take seven papers such as Computer foundations, Java, Operating systems, Digital electronics, graphics, OOProgramming, and Interactions.

In the second year, 4 core technologies, and theory courses are taken. These are: Theory, systems, programming and applications, and professionalism.

In Theory, courses studied are: Logic, Proof, computational theory.

The Systems course is broken down into computer networking and computer design.

In the Programming course, advanced algorithms and compiler construction are taught.

In applications and professionalism courses, Graphics, Artificial intelligence, and Security are taught.

In year 3(Part 1), the students select specialization areas from a large selection of topics like bioinformatics and language processing, computer architecture, data science, and robotics. All students demonstrate skill and write 12000 worded dissertation to it.

Year 4 (Part III Optional Integrated Masters)

The fourth-year programme is designed for students who want to consider a career in industry or academic research. To progress to part III depends on the Part II examination record and achievement. A successful student's completion of part III earns an MEng degree as well as a BA degree attained at the end of part II.

5. Result

In this section, comparative analysis of policies and plans for computer science education and implementation strategies deployed.

Table 2: Primary/secondary school computer education plan

CHINA	USA	UK	NIGERIA
Invites teachers in tertiary institutions to teach.	Computer science satisfies a requirement for graduation from high school as well as satisfy admission requirement to higher institution	Government-funded training for 40000 teachers in selected schools, who will be paid to replicate the training in neighboring schools.	Computer Science education policy states that teachers from some science departments be trained in computers to support the computer major teachers. However, no government-funded training is available for teachers.

Table 3: Government support for local production of CS hardware

CHINA	USA	UK	NIGERIA
China developed an experimental zone for electronics production, and by 1990, there were almost 160	Provides Federal research funding. Some examples are: The US Air Force Semi-Automatic Ground Environment (SAGE) project. SAGE pioneered	Government-funded Raspberry Pi to develop easily programmable Computers, train school teachers in coding,	Nigeria depends on the importation of cheap hardware from China. It is also a dumping point for used computing and electronics. Compromised/stolen

high-tech enterprises established in Beijing's Silicon street. The state also introduced incentives such as three years tax-free and another three years of reduced tax for investors in the zone leading to the establishment of over 100 scientific research institutes.	development in real-time digital computing and core memory.	collaborate with other IT companies software and hardware development.	phones find their way into the Nigerian marketplace. Nigerian software developers also complain of low patronage by companies in the country.

Table 4: Tertiary level computer science education strategies

CHINA	USA	UK	NIGERIA
Accelerated Course Plan(Yuanpei Project) enable the skill based education of the brightest student high school (2) Teaching undergraduates by researchers from Technological companies like IBM, Dell, EMC 3. Computer Science majors specialize in a field under the discipline.	Computer science curriculum is designed with inputs from employers, industry experts, and scholars, hence the skills required for immediate employments are given. 2. Specialization in a particular area of the discipline is a prerequisite for becoming a graduate.	Students are introduced to foundation and core courses in the first 2 years. They specialize in an area in the third year, then acquire Masters degree in the fourth year.	A generalized curriculum that has the students studying various non-computer core courses for the first 2 years. No specialization emphasis, hence the students are left with little or no skills.

Table 5: Support and requirements

CHINA	USA	UK	NIGERIA
Resources are made available for the teachers and students and in Chinese language Enetedu.com 2. Core course textbooks are mandatory	Resources are made available for teachers at code.org. 2. Financial support is provided for US citizens and textbooks and course tools are mandatory.	Core textbooks, scientific calculator, Laptop are prerequisite to study this course.	It is not mandatory for students to have textbooks, laptops, or other tools required in this field of study.

6. Recommendations

6.1. Long term

1. Redesign of computer curriculum to teach coding to primary and secondary school students.
2. Train teachers in specialized computer areas, and have them replicate the knowledge to other teachers.
3. Federal funding and monitoring of new computer education policies.
4. Including a minimum of a credit pass in computer subjects as a prerequisite for studying computer science.
5. Making it compulsory for the first-year computer science major students to own laptops.
6. Allocating higher credit load to practical courses and ensuring students turn up for each semester with required tools and course materials.

6.2. Short term solution

1. Introducing an "Improved Yuanpei project" where students with high intelligence quotients are selected from secondary schools across the country, for an intensive computer science and Technology short-term undergraduate program that directly prepares them for taking over all outsourced tech jobs in the country's system.
2. Training of existing computer science teachers in the area of course contextualization.

3. Establishing a ripple effect project where trained Yuanpei graduates can engage primary/secondary school teachers, and the trained can be paid to train teachers in other schools.
4. Pilot Improved Yuanpei Computer Science and Tech majors can be selected from students who score 250 and above in JAMB and confirmed intelligence by their schools.

7. Conclusion

1. There have been Computer Education policies in Nigeria, however, implementation has neither been enforced nor monitored.
2. The existing curriculum for computer education does not promote skill acquisition.
3. Lack of teacher training for computer teachers at all levels makes it impossible for the course content of the available curriculum to be fully imparted.
4. Nigerian students are not mandated to buy course textbooks and related learning tools. Finally, the available curriculum is loaded with courses outside core computer science courses for the first two years of a four-year course.

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