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Policy Reforms of Informatics Education of Mongolia

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Abstract. As informatics has been accepted by countries around the world as the basic form of literacy education in the 21st century, it has become universally taught as a compulsory subject in primary education. School informatics is expanding in terms of content since students are needed to obtain not only ICT application knowledge and skills but also digital communication-collaboration, ethics, basic knowledge of computers, and programming. Children are definitely born into and develop in a society where ICT is widely used and their future careers are dependent on technology. Informatics education plays an important role in meeting the needs of young people. As a result, the policy of informatics education should be dramatically changed by considering the current needs and demands. This article introduces research findings with regard to how changes in informatics education have been made in Mongolia and how those changes have integrated with the reform policy of foreign countries. We conducted factual research using the policies, standards, curricula, and textbooks of informatics education as well as research papers of leading researchers. Methods such as comparison of documents on education and reflection have also been incorporated into our research.

Keywords: school informatics education, digital literacy education, education of computer science.

1. Introduction

School informatics education was first addressed at the World Conference on Computer Education which was held in August 1970 in Amsterdam, Netherlands. The conference was organized by the International Federation for Information Processing (Sheepmaker & Zinn, 1970). Subsequently, in 1971, the Conference on Computer Science Education in Secondary Schools was held in Paris, France and hosted by the Centre for Educational Research and Innovation (CERI-OCDE, 1971). (Baron, Drot-Delange, Grandbastien, & Tort, 2014). As a result, the foundation of teaching informatics in secondary education had been laid which led to informatics education being officially included in the system of primary education by the world's leading countries in the 1980s. (Carr & O'Brien, 2010). Informatics was viewed as significantly important in order to learn the methods of solving mathematics and algebra problems as well as to increase the development of new ideas and motivation. (Atchison, 1973).

Although only 40 years have passed since the computer science has been taught in countries around the world, ICT, as the basis of social development, has become the basic requirement for knowledge and skills that young people have to acquire. In terms of the informatics of secondary schools and informatics technology education, the policies and programs which had been accepted in the world hadn't been developed yet. (Dagienė & Stupurienė, 2016).

It is common for countries to implement informatics education using terms such as information communication technology or digital literacy education, (Guerra, 2012). Depending on the term, the subject content is different.

The book entitled "Rethinking Education: Towards a Global Common Good?", published by UNESCO in 2017, emphasized that in the technological era there is a challenge for our time which defines an illiterate person as someone who cannot use ICT, not someone who cannot read, write, and solve math problems. The amendments of two categories, "ICT Social and Ethic Issue" and "Career and ICT," to the application content of the Information and Communication Technology in Secondary Education approved by UNESCO in 2000 demonstrate that the proper use of ICT in all fields of society is significant. (UNESCO, 2000).

Many countries in the world are paying attention to the digital literacy education of young people. The digital literacy education covers a broad content of not only having ICT application knowledge and skills but also having an ability to reliably and responsibly collaborate with the public in social network or on the internet and make a contribution to the development of ICT. In addition to the ICT application, the issues of information ethics, digital citizen, and digital communication occupies an important position to the content of the digital literacy education. However, ICT with literacy is about ethically using the application knowledge and skills of ICT in creative activities, generating innovation, and applying for communication and collaboration. (Literacy with Information, Communication Technology. Across the Curriculum, 2012).

One of the impacts of ICT education is the use of ICT as a tool in the learning process. Although the policy of introducing ICT in training activities has been carried out in many countries, school children lack the knowledge and skills to use it as a learning tool in secondary education. This is due to the fact that the majority of countries have until ICT is taught as a compulsory subject in senior grades.

Regardless of whether school informatics education is implemented choosing one of the three previously mentioned forms, there is a universal principle that considers algorithm and basics of programming as its core concept. This is probably related to the history of informatics education starting with algorithm, programming, and codification. On the other hand, as students study algorithms and programming through contemporary informatics education, they are learning to acquire the basic skills of creating software based on mobile devices and web design. (Benaya, Dagiene & Gal-Ezer, 2015; Csernoch, Biro, Math, & Abari, 2015).

The Informatics Olympiad and competitions on computing and programming have been organized at regional, national, and international levels. It is one of the reasons why the subject of informatics has to be studied in secondary education.

2. Changes for the Policy of ICT Education

The tendency for changes in the policies of ICT education can be seen in international educational programs including "Public Informatics" which was developed by Common European Countries and "Common Computer Science" which was developed by Common Association for Computing Machinery-ACM.

According to the policy of "Public Informatics" developed by the European Union, each of the European countries are required to promote the growth of digital knowledge and skills in young people because of the basic changes of society. One of the ways of implementing the policy is to teach the subject of coding at all secondary schools in the European countries. (Caspersen, Gal-Ezer, McGettrick, & Nardelli, 2018, p.6). The strategy of the policy of "Common Computer Science" defines the objectives of developing informatics education as below.

- In the secondary education system, all students have the right to get continuous education on informatics. The subject of informatics is taught starting with primary education.
- Informatics curricula should reflect the scientific and constructive nature of the discipline, and be seen as fundamental to twenty-first century education by all stakeholders (including educators, pupils and their parents).
- Informatics courses must be compulsory and recognized by each country's educational system as being at least on a par with courses in STEM (Science, Technology, Engineering and Mathematics) disciplines. In particular they must attract equivalent credit, e.g. for the purposes of university entrance. (Caspersen, Gal-Ezer, McGettrick, & Nardelli, 2018, p. 8).

Computer science, the discipline that makes the use of computers possible, has driven innovation in every industry and field of study, from anthropology to zoology. Computer science is also powering approaches to many of our world's toughest challenges. Computer Science has become the foundation of creating new ideas and products in all fields of science as well as every industry to enable our world to conquer the tough challenges we are facing. The following research in the United States shows that the public demand for computer science education is high due to the fact that computing is an integral part of our world. (K-12 Computer Science Framework, 2016, p. 11).

- Most parents want their child's school to offer computer science. (Google & Gallup, 2015).
- Most Americans believe computer science is as important to learn as reading, writing, and math. (Horizon Media, 2015).
- Many of today's students will be using computer science in their future careers, not only in science, technology, engineering, and mathematics (STEM) fields but also in non-STEM fields. (Uddin, S., Imam, T. & Mozumdar, M., 2021).
- Not all young people in the United States have the opportunity to study computer science. The number of schools in the United States which teach computer science or programming effectively is fewer. (Google & Gallup, 2015). Although students in the United States have access to computers, the acquisition of knowl-

edge of computer science is often limited for marginalized students who are facing educational inequities. (Google & Gallup, 2015b)

Although ICT and computer skills are very important for the learning process of young people, in most countries, they have to wait until it is offered in high school. However, computer science has become an important tool for them to create world-renowned innovations. To address this issue, The Association for Computing Machinery (ACM) developed the educational program "Computer Science Education for All" in 2016. The K-12 Computer Science Framework illuminates the big ideas of computer science through a lens of concepts (i.e., what students should know) and practices (i.e., what students should do). The core concepts of the framework represent major content areas in the field of computer science. The core practices represent the behaviors that computationally literate students use to fully engage with the core concepts of computer science. (K-12 Computer Science Framework, 2016, p. 2–3).

K12: The Computer Science Framework is a powerful stimulus of knowledge and skills that creates equality and participation for every student, helps them to solve real-life problems, and discover many areas. The practice of computational thinking, such as summarizing, modeling, and analyzing, intersects with computer science concepts such as algorithm-programming, automation, and data representation. Computer science is more than just coding. It covers comprehensive aspects such as physical systems and networks, data collection, storage and analysis, and the social impact of computation. Students' programming knowledge and skills are valuable and contribute to important intellectual development. (Papert, 2000, p. 728).

Highly developed and developing countries around the world have recognized that basic education of computer science plays an important role in preparing the world's capable citizens to realize the nature of the information society, the fundamentals of social change, and to create changes and innovations in the future. (Fig. 1). Based on this, young people should have a computer literacy at high level.

- Have a computer literacy in primary education.
- Acquire application knowledge and skills of information technology in primary education.
- In secondary education, school informatics education has been planned and implemented to provide learners (or students) with an opportunity to acquire the basic skills of using ICT tools because there is a need for learners (or students)

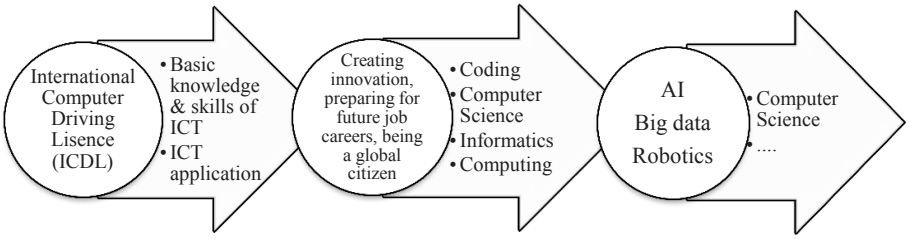

Fig. 1. Mapping on Informatics Education Policy Reforms.

to study computer science as an elective course in integration with their needs, interests, future job choices, and to have access to ongoing education. (Tsedevsuren, 2018, x. 53). How the educational content of computer science changes in the future is not clear in the same way it is impossible to foresee social development.

The questions "*How has computer science been taught in our country?*" and "*How are the global trends in ICT for education and educational principals and approaches to ICT reflected in Informatics Education Policy Reforms?*" have been main concerns. The solutions to these questions have been taken into consideration in this article.

3. Research Methodology

Based on legal documents, we utilized main research methodologies, such as observation, comparison of documents on education, and reflection in this study. The study of Informatics Education Policy Reforms in Mongolia has been conducted using the major documents of informatics education and other sources listed below.

- Curriculum on Informatics and Computing Technique Basis, 1988.
- Standard of Informatics Education (Primary and Secondary Education), 2004.
- National Program on Informatics Education of Primary and Secondary Education, 2004.
- Core Curriculum on Informatics Technology of Primary and Secondary Education, 2014–2015.
- Core Curriculum on Informatics Technology of Primary and Secondary Education, 2015.

4. Research Outcome

Starting in 1988, an informatics course titled "Informatics and Computer Basics" was taught in the 9th and 10th grades at secondary schools. Written by Russian textbook writers led by A.P. Ershov and translated by Ts. Amarsanaa, B. Narankhuu, D. Garmaa, and Ya. Senemeder into Mongolian, this computer science textbook was used in secondary schools. Additionally, in 1988, a methodological guideline of the textbook "Informatics and Computer Basics – 9," translated by B. Jargal, Yu, Namsrai (should this be Yu Namsrai without the comma in between), and L. Choijoovanchig, provided methods for carrying out programs for secondary school teachers. The importance of studying "Informatics and Computer Basics" in the senior grades of secondary schools was defined as "Discovering the actual capacity of the computer for learners is considerably important to extend not only human recognition of the world view but also their intellectual and cognitive skills. The study of informatics is the scientific background for developing students' perceptions of the possibility of automating various human activities based on algorithms."

The objective of the subject was defined by the followings: (Myagmar, 1987, p. 4):

- Systematize distinct areas of study of algorithm within the subject of algebra offered in an eight-year schooling system.
- Have students acquire basic skills of algorithm.
- Give students an imagination on automated performance of algorithm.
- Solve mathematics problems using modern computers.
- Introduce the applications and features algorithm, programming, computer and
- automation to provide an orientation to technical jobs.
- Introduce the basis of modern computing techniques based on examples of general principles of micro-computer.
- Introduce basic concepts and methods of developing programs using a language for programming.
- Give students an understanding of the stages of solving math problems using a computer.
- Introduce the main framework of using computing technique and its role in social development.

The informatics course was very important in order to realize the impact and development of electronic computing machines in future society and give children and young people an understanding of computer development and its use as well as algorithm programming at an early age. (Myagmar, 1987, p. 4)

The objective of the subject "Informatics and Computer Basics" which was defined as "to demonstrate the importance of algorithms, programming, and computers in industries of modern society" (Myagmar, 1987, p. 3) is still viewed as an important concept because it was the first to recognize the nature of the information society. Computer science plays an important role in improving the subject quality of natural sciences including mathematics, algebra, and geometry. Therefore, the curriculum and textbook content provided not only examples of how to solve the problems with those subjects but also examples of the algorithm.

The next major change in information education was made in 2004. The name of the subject was changed to "Informatics" and the content standards were implemented at the primary and secondary education.

The standard defined not only the basis of informatics science but also the role it plays in the development of other sciences and life of modern society. The objective of informatics education was defined in the standard as " … to prepare citizens with competency who can meet the needs of informatics education and who have acquired the skill and ethics using the knowledge and information needed for citizens living and working in a knowledge-based society". The standard demonstrates that informatics education has significance theoretically and practically.

To develop the theoretical and practical skills student need to acquire through the subject of computer science, the content of the standard is designed with following five areas: "Information", "Computer", "Algorithm", "Model", and "Information Technology". (Uyanga, Tsogtbaatar, & Choijoovanchig, 2005, p. 5). Since textbooks for all lev-

els of secondary education had been developed in accordance with the requirements of ICT education standards and used in secondary schools, ICT education has become an integral part of the education system.

To support the standard implementation of informatics in training, the "National Program for Informatics Education" was developed in 2009–2012 (Appendix 2, the Order No. 301 of the Minister of Education, Culture and Science, 2009). The national curriculum is based on the concept of the International Computer Driving License (ICDL), which laid the foundation for making informatics subject usage-based. "National Program for Informatics Education" was developed with the following contents "A1. Basic Concepts of Information and Communication Technology (ICT)", A2. Using a computer and working with files", "A3. Text information processing", "A4. Spreadsheet data processing", "A5. Image processing", "A6. Demonstration and processing of audio and video information", "A7. Working with databases", "A8. Use of website and internet" based on the approach that "Not every student becomes a computer scientist, but every student should become an citizen with information technology education in the future." (Otgonnaran, Tsogtbaatar, Altantuya, & Tsedevsuren, 2009, pp. 14–18). The application-based content, which was implemented with the national program, is fully reflected in the core curriculum developed in 2015. Name of the subject was changed to "Information Technology" because of the changes in core curriculum based on the principles of application knowledge and skills to be used in other ICT subjects and solving life issues (Core Curriculum Handbook for Basic Education, 2015, pp. 48–49). As a result, the content of algorithms, programming, and modeling, which is the basics of computer science, has been dramatically reduced and the content of ICT applications has been increased. (Tsedevsuren, 2016, pp. 72–73). The focus on providing students with the opportunity to learn through practical examples of how ICT can be used to solve other academic and life problems was the important change to increase practical aspects of the subject.

In high school, however, informatics has been included in the compulsory elective section of the curriculum. Consequently, students have had an opportunity to choose one of three areas, such as "Software," "Hardware," and "Multimedia," but local schools, located in rural areas and, especially, in counties, are facing difficulties implementing the program because of the insufficient ICT learning environment. Local schools have common issues such as teacher knowledge and skills, computer laboratory equipment capacity, networking, and Internet availability (Tsedevsuren, 2018a, p. 78). According to the changes in informatics education, the elective subject "Information Technology" consists of two selective areas such as "Information and Communication Technology" and "Programming" to be studied in 10th grade for 1 hour, 11th grade for 3 hours, and 12th grade for 5 hours a week, respectively. (Core Curriculum for Upper Secondary Education. Information Technology, 2016, p. 25). These elective subjects had been offered to a few schools in Khentii, Khuvsgul provinces and the city of Ulaanbaatar due to the lack of teacher skills, learning environment, inadequate laboratories, and lack of interest in elective subjects because informatics is not taken as general entrance examinations (Tsedevsuren, 2018a, pp. 77–78).

Because of the latest curriculum refinement, information technology has been redeveloped into a compulsory subject to study in senior grades of secondary schools and it is being implemented from the 2018–2019 academic year. The revised curriculum was developed on the basis of the principle that "ICT literacy has to be studied in primary education (Primary Education Curriculum, 2019, pp. 49–50), while a basic knowledge of computer science, all types of information processing including school subjects and useful information, problem-solving skills, and consumer culture and ethics in information society has to be acquired in upper secondary education". (Curriculum for Secondary Education, 2019, p. 44).

Table 1 shows the chronology of Informatics Education Policy Reforms of Mongolia.

Table 1

Policy Reforms and Features of Informatics Education (Computer Science)

Policy documents, years published	Principle			Features and explanations
	Content	Methodology	Assessment	
Curriculum on Informatics, Computer Basics, 1988	Based on knowledge and understanding: Information processing, Computer and algorithm, algorithm design, composing algorithm, basics of programming, computer development	The teacher should introduce and explain the main concepts and approaches in detail, recognize the main ideas, and focus on them.	The knowledge and skills to be acquired by students was defined in the curriculum. Students will be assessed by doing exercises, such as solving mathematics and algorithm problems.	Informatics was studied in 9–10th grades for 34 hours of classes per semester respectively. It was available to study 68 hours of classes in 10th grade at a school equipped with computers.
Standard on Informatics Education, 2004	Knowledge and skills necessary for students to acquire were divided into five categories: "Information," "Computer," "Algorithm," "Model," and "Information Technology." The categories were based on the development of students' talents and abilities in addition to features of their ages, thinking, interests, and needs. (Chimedlkham, Uyanga, Tsogtbaatar, & Choijoovanchig, 2005, p. 5).	By considering students' ages, personalities, health situations, and learning abilities, a methodology for supporting their participation and development as well as preparing them to become well-balanced and responsible citizens will be used adhering to flexible, humanitarian, usage based principles.	Students' progress is assessed according to the children's personalities and features of their ages and thinking. *Features:* self and collective assessment. Principle: Assessment should be open and fair. A variety of assessment methods were used.	Informatics will be studied at all levels of education: 35 hours of classes in primary education, 140 hours of classes in secondary education, 175 hours of classes in high school.

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Table 1 – continued from previous page

Policy documents, years published	Principle			Features and explanations
	Content	Methodology	Assessment	
Curriculum for the National Program for Informatics Education, 2009–2012	Usage-based: "A1. Basic Concepts of ICT," "A2. Using a Computer and Working with Files," "A3. Text Information Processing," "A4. Spreadsheet Data Processing," "A5. Image Processing," "A6. Demonstration and Processing of Audio and Video Information," "A7. Working with Databases," "A8. Use of Websites and the Internet."	The methodology is based on learning to obtain information through research, collect the information, process it using technology, solve problems and make decisions as to how to find and collect information, process it using technology, and determine the ways in which information came to be, can be improved, and used. Methodology: Knowledge and understanding, activities of creation of knowledge, communication skills, and creative skills, critical thinking skills, decision making, and problem-solving skills.	Understanding of basic and application knowledge will be equally assessed throughout education. As students advance into senior grades, especially high school, individual and teamwork will be evaluated according to certain criteria. (based on Bloom's taxonomy).	
Core Curriculum on Informatics Education, 2015–2016	Primary: Content based on ICT literacy and its use. Senior: The elective course is based on the principles of applying the application knowledge and skills needed to solve other areas of ICT and life problems. The content includes 5 sections: - Software, - Hardware, - Multimedia, - Information and Communication Technology, - Programming. (Curriculum on Information Technology, 2016, pp. 48–49).	Methodology, such as acquiring application skills and knowledge by applying ICT as a means of communication and using it independently and collaboratively as a learning tool for other subjects to process information and solve the problems, will be used.	Basic knowledge of ICT and computer science. Knowledge and skills of processing information and solving the problems using ICT will be assessed.	Informatics is not studied at an elementary school. The basic content is studied at secondary school for 140 hours of classes while the senior graders of high school study it as an elective course for 105 hours choosing one of the three areas "Software", "Hardware", and "Multimedia". It is available to study 35 hours in 10th grade, 105 hours in 11th grade, 175 hours in 12th grade in the fields of "Information and Communication Technology" and "Programming".

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Policy documents, years published	Principle			Features and explanations
	Content	Methodology	Assessment	
Curriculum on Information Technology, 2019	Intermediate: By studying the application- based content, students will acquire ICT literacy and information processing skills. Senior: The content aims to enable students to have basic knowledge of computer science, process useful information (including information on other subjects), acquire problem-solving skills, and instill in consumers' culture and the ethics to properly use the information in society. (Information Technology Program, 2019, pp. 49–50).	Creative methods will be used to allow students to learn a computer language and how to use ICT as a tool for information processing, problem-solving, and continuing learning.	The following knowledge and skills will be assessed: - process the information using ICT, problem solving; - understand ICT and computer science terminology, use information in an ethical and cultural manner, create, interpret, share and collaborate with others depending on their circumstances and needs.	Informatics is not studied in elementary school, however, the basic content is studied in secondary school for 140 class hours. Informatics is available to 10th graders for 35 hours, 11th graders for 105 hours, and 175 hours for 12th graders in the fields of "Information and Communication Technology" and "Programming." Seniors in high school can also take Informatics as an elective course for 105 hours, choosing one of three areas: "Software," "Hardware," or "Multimedia."

5. Conclusion

Informatics education plays an important role in acquiring basic knowledge and skills for citizens living and working in the information society. Therefore, many countries around the world have included the subject of informatics in secondary education. The content of this subject has been shifted from the use of information technology to the basic content of computer science, which is foundation of technological society since computer science is crucial for preparing future citizens who have realized the nature of social changes, can create innovations, and have an ethical use of communication.

In 1988, Mongolia introduced Informatics into secondary education. It was the right decision at the right time. Informatics has been taught in secondary education for 30 years which is a relatively short period. However, its content and methodology has been changed five times and the subject has been renamed as "Information Technology" based on content application.

The renaming of the subject and the reduction of the basic content of computer science was a step backwards from the reform of the content of global informatics education. Despite the shortcomings, Mongolia is one of the few countries with experience in teaching informatics as an independent subject in secondary education, starting from primary education.

Depending on the changes in the information society and the needs of future citizens who will be living and working in the 21st century, the following policy changes need to be made:

- Change the name "Information Technology" to "Informatics" or "Computer Science.
- Include the basic content of computer science that supports the skills needed in the 21st century, such as understanding the basics of uncertain social development and helping to create innovation in the subject content.
- Increase the teaching hours of informatics.

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