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정보영재아동의 학년별 차이 비교 분석에 관한 연구☆

A Study on Grade Comparison Difference Analysis of the Gifted Children in IT

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요 약

현대 지식정보사회에서 한 나라의 경제력은 IT 산업과 기술에 크게 의존하고 있다. 이러한 관점에서 대부분의 국가들은 새롭고 혁신적인 IT 기술을 개발함으로써 IT 산업을 부흥시키려고 노력하고 있다. 전통적으로 IT 산업에 있어서는 단지 소수의 뛰어난 인재가 전체 산업을 주도하고 있다. 따라서, 조기에 정보영재를 판별하고 양성하는 것은 IT산업의 육성에 있어서 매우 중요하며 필요하다.

본 논문의 목적은 정보영재아동의 학년별 학업능력을 조사하는 것이다. 이러한 목적을 위해 본 연구는 초등학교 4학년, 5학년 및 6학년 정보영재아동에 초점을 두고 있다. 본 연구에서는 정보영재의 다양한 능력 가운데서 프로그래밍 능력과 논리적 사고력에 중점을 두었다. 현재까지 정보영재아동의 학년별 차이를 비교하고 분석한 연구는 없었다.

이러한 연구목적을 위해 서울시의 한 대학부설 과학영재교육원에 재학한 정보영재아동들을 대상으로 연구하였으며, 8년 동안의 성적이 분석되었다. 통계처리결과로부터 정보영재아동의 프로그래밍 능력과 논리적 사고력에 있어서 4학년, 5학년 및 6학년 간에 유의미한 차이는 없다고 결론을 내릴 수 있다. 이 연구결과는 향후 정보영재교육에 있어서 교육내용, 교육과정 및 법과 제도를 제안하는 데 있어서 도움이 될 것으로 기대한다.

☞ 주제어 : 정보영재, 학년별 차이, 프로그래밍 능력, 논리적 사고력

ABSTRACT

IIn the current information and knowledge-based society, a nation's economy power heavily depends on IT-related industry and technology. In this sense, most countries are trying to foster IT industry by developing new and innovative IT technologies. Traditionally, only a few talented persons have been leading the whole IT industry. Thus, it is very important and necessary to identify and support the gifted children in IT in early ages for development of IT industry.

The purpose of this paper is to investigate study performance of the gifted children in IT for different grades. Our research is focused on especially 4th grade students, 5th grade students, and 6th grade students in elementary schools. Among various abilities of the gifted children in IT, in this paper, we are interested in programming ability and logical thinking ability. To our best knowledge, there is no research work on study performance depending on different grades of the gifted children in IT.

For this purpose, the gifted students in gifted science education center attached in a university at Seoul Metropolitan Area are selected and their test scores for 8 years were collected and analyzed. The statistical analysis results show that there is no significant difference among 4th grade students, 5th grade students, and 6th grade students for programming ability and logical thinking ability. We hope that this result can help suggest and propose study contents, curriculum, principles and laws for the gifted education in IT.

☞ keyword : Gifted Children in IT, Grade Difference, Programming Ability, Logical Thinking Ability

1. Introduction

We live in knowledge and information society. In the current knowledge and information society, a nation's economy mainly depends on IT industry and technology. The reason is that IT industry is brain-intensive. It means that, unlike labor-intensive industry, IT industry usually does not require a big land nor a big factory building. Even it does not require a great labor power. On the other hand, labor-intensive industry usually requires tremendous money and labor power to build the factory and to buy land. Even it takes long time to train laborers.

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Futhermore, IT industry has a strong influence on a nation's competativeness so that most countries are trying to concentrate effort into IT industry. For personal dimension, knowing and applying IT technologies in his or her daily life are now a measure of value. Also, for social point of view, communication through diverse SNS tools makes people more active and vivid in social activities.

In the literature, in IT industry, only a few prodigies like Bill Gates and Steve Jobs, have a big influence on innovative IT technology. Their technologies became IT products and contributed to world economy. Also those talented IT leaders have also affected a nation's competativeness. In this sense, identifying and fostering gifted children in IT is very important. So far, the gifted education in IT is relatively new subject. However, with strong national support from most countries, the gifted education in IT is getting more interests than any other subjects in various countries.

In many developed countries, IT education has a form of ICT(Information and Communication Technology) education. ICT education implies education based on computer and communication tools for the current knowledge and information society [9]. ICT education can be classified into two categories: ICT literacy education and ICT application education. ICT literacy education(also called computer education, and informatics education) means education about understanding of basic knowledge and principles on computer and information communication technologies. On the other hand, ICT application education is education about applying ICT to the daily life as well as to various subjects such as math, science, art, and foreign languages.

Recently, with advances in wireless communication technology, a new type of education, called smart learning, becomes popular. Smart learning is a new education paradigm that is based on smart devices and personalized contents and environments[3]. At this time, there is no agreement on the formal definition of smart learning. In [8], the basic principles of smart learning are explained as follows. In their work, smart learning consists of three elements: first, rich instructional resources as learning contents, second, participatory learning environments with interactions among teachers and learners as learning methods, third, practical and realistic contexts as learning environments. Recently interests in smart learning are increasing. There have been some research works for smart learning[1,5].

The purpose of this paper is to investigate the study performance among different grade students of the gifted children in IT. With understanding of difference among different grade students, we can make different study goals, study contents, curriculum, and evaluation strategy for different gifted students in IT.

Although understanding grade difference is important, to our best knowledge, there has been no research work on the grade comparion analysis for the gifted children in IT.

In order to investigate the grade comparison analysis, the gifted students in gifted science education center attached in a university at Seoul Metropolitan Area are selected. Their test scores for 8 years were collected and analyzed.

The rest of paper is organized as follows. In Chapter 2, related works are introduced. Some definitions and conditions of gifted children in IT, and importance of programming are introduced. In Chapter 3, grade comparison analysis among different grades students is presented. Finally, in Chapter 4, conclusions and further works are discussed.

2. Literature Review

2.1. Definition and Conditions of Gifted Children in IT

So far there is no agreement on the definition of the gifted children in IT. This is because the gifted education in IT is a relatively new gifted education subject. Also, research works on gifted education in IT are still in infant stage. In this paper, we introduce some definitions in the literature.

In [11], the gifted child in IT is defined as follows: A child who understands and analyzes a given problem, and collects, refines, recreates new information based on ICT application ability.

In [13], the gifted child in IT is defined as follows: As a child who has above average or higher ability in general

intelligence, curiosity for computers, high creativity, math-linguistic ability, task commitment for problem-solving, a child who has high potential in computer-related works.

In [2], the gifted child in IT is defined as follows: First, the gifted child in IT is a child who has above average or abobe ability in general intelligence, curiosity on computers, high creativity, math-linguistic ability, task commitment for the given project, as in [13]. Second, the gifted child is a child who is interested in applying programming and application software to the problem-solving activity. Third, the gifted child in IT is a child who has a great potential in adaptibility, creativity, and imagination power in computer works.

In [7], conditions for gifted students in IT are defined as in Table 1.

(Table 1) Conditions for Gifted Student in IT

Area	Contents
Comparative predominance	- Excellence in vocabulary use and linguistic expression over the same age - Possession of above-average ability for mathematics and linguistics - enthusiastic on reading
Investigation	- Strong curiosity and high scholastic achievement for computer-related subjects - Strong will to accomplish for a specific subject - Keen observance and good memory
Analysis and planning	- Ability to grasp and generalize general facts and relationships among facts - Ability to solve problems with efficient and diverse methods
Applicability	- Excellence in applying computer knowledge to new situation
Mental state	- Possession of infinite imaginative power, applicability, and initiative power
Expression	- Excellence in expressing new ideas and creative contents with computer

On the other hand, characteristics of gifted students in IT for various areas are presented in Table 2[11].

(Table 2) Characteristics of Gifted Children in IT for Various Areas

Area	Characteristics
General characteristics	- Excellence in understanding and manipulating things - Quick acquisition of basic functions - Right and quick decisive power - High curiosity - Enthusiasm about new thinking and challenge
Application software	- High imaginative power and applicability - Ability to grasp relationships - Ability to set up hypothesis and conjecture
Programming	- Excellence in grasping and understanding main principles - Insight to cause and effect - Enjoying new way of thinking and method
Multimedia	- Infinite imaginative power - Excellent artistic sense - Composed and delicate - Excellent creative activity - Ability to observe things sharply
Digital Contents	- Tenacity - Infinite imaginative power and applicability - Desire to win a game - Desire to have control - Desire to show off - Resolute decisive power

In [6], characteristics of gifted students in IT are presented in 2 categories as in Table 3.

(Table 3) Characteristics of Gifted Children in IT

Characteristic	Description
General Characteristics	- Excellent understanding and insight in early age - Logical and divergent thinking ability - Excellent imagination and curiosity - Great adventurer - Creativity - Task-commitment

Characteristic	Description
Computer-oriented Characteristics	**<Computer Science>** - Knowledge and application ability on software and multimedia - Programming ability - Achievement need and confidence in computer-related areas - Ability to develop a new algorithm **<Discrete Math>** - Intuitive insight - Temporalization/visualization ability - Mathematical inference ability - Organization ability for information - Mathematical abstraction ability - Generalization and application ability

With above literature works for conditions and characteristics of the gifted children in IT, we can summarize as follows.

(Table 4) Summary of Characteristics of the Gifted Children in IT

Characteristics	Description
General Characteristics	- High intelligence over general students - Excellent logical thinking power and creativity - Excellent task commitment and achievement need - Excellent intellectual curiosity - Excellent imagination and creativity
Computer-oriented Characteristics	- High curiosity in computer-related areas - High generalization ability - High ability to develop an algorithm - High information application ability - High generalization ability

2.2. Programming Ability and Logical Thinking

The significance of programming is discussed in [12]. In [12], it is insisted that one's cognitive skills are developed through computer programming education. In their work, 6 categories of cognitive skills can be developed through computer programming as follows.

First, mathematical and geometrical concepts and principles can be improved through computer programming. It means that a programming language has libraries that are related figures in mathematics so that mathematical and geometrical ability can be improved using those libraries by students.

Second, problem-solving ability can be enhanced through programming education. In this case, problem-solving ability can be enhanced by finding logical and gramatical errors and correting program codes during programming.

Third, logical inference and expression ability can be improved by programming education. This is due to that a student needs to express his/her ideas into program codes so that he/she can develop logical inference and expression ability.

Fourth, knowledge, thinking, and study ability can be enhanced by programming education. A student can improve knowledge, thinking, and study ability while processing and refining information.

Fifth, a cognitive style can be improved by programming education. Usually a programmer writes codes for a specific problem-solving. Students can make their own cognitive styles through many types of programming works.

Sixth, a student can improve passion and patience through programmming. Programming is usually time-consuming work so that programmers can be passionate and patient.

As we discussed above, programming ability and logical thinking ability are highly correlated with each other. In other words, programming is a strong tool to improve logical thinking ability. Also, if a student has high logical thinking power, he or she can write a program with ease.

3. Grade Comparison Analysis of Gifted Children in IT

3.1. Samples for the Analysis

For the analysis, gifted children in IT in a gifted science education center at Seoul Metropolitan Area have been selected. Table 5 shows a summary of the gifted child in IT.

(Table 5) A Summary of Samples for Analysis

Item	Information
Institute	A gifted science education center attached in a university at Seoul Metropolitan Area
Grade	4th, 5th and 6th grade in elementary school
Number of students	Total 157 (male students: 124, female students: 33)
Attending year of students	2003~2010

In the gifted science education center, for every year, 20 students are selected as gifted children in IT based on preliminary paper works like student record, written test scores, and interview. The applicants are eligible for 4th, 5th, and 6th grade students from all elementary schools at Seoul Metropolitan Area. The selected gifted children in IT are supposed to study the basic IT courses and get a certificate after one-year program. 6th grade children can be graduated and no more further courses are prepared for them. However, 4th and 5th grade students can apply to the advanced program depending on their scores during one-year program.

The gifted children are supposed to take two-semester courses. For each semester, children are required to take 8 weekend classes, an two outdoor camps(during summer and winter break), cyber classes, etc. For gifted students in IT, 8 weekend classes consist of 4 computer science classes and 4 common subjects (mathematics and science or other subjects like art). The detailed study information is shown at Table 6.

(Table 6) Study Process of Gifted Children in IT

Item	Information
Study contents	Spring semester: Programming Programming language: - Visual Basic & Visual C++
	Fall semester: Algorithm Contents: - Basic Data Structure - Searching algorithm - Sorting algorithm - Other algorithms
Evaluation Method	- Programming: Programming project test - Algorithm: Theoretic test
Evaluation Standards	5 scales 5: excellent 4: good 3: average 2: below average 1: poor

3.2. Grade Comparison Analysis

For grade comparison analysis among 4th grade, 5th grade, and 6th grade gifted children in IT, test scores of programming ability and logical thinking ability through algorithm study are adopted.

The following Table 7 shows analysis results of the gifted children in IT for programming ability.

(Table 7) Grade Comparison Results for Programming Ability

Grade	N	Average	SD	F	p-value
4^{th} grade	22	3.82	1.305	1.427	.241
5^{th} grade	108	3.41	1.578		
6^{th} grade	411	3.28	1.564		
Sum	541	3.33	1.558		

where N represents the number of overall tests and 5 is the perfect score

In order to compare test scores of programming abilitty, one-way anova is adopted. After statistical analysis, 4th grade has 3.82, 5th grade has 3.41, and 6th grade has 3.28, respectively. This means that lower grade students have higher test scores, however, there is no significant difference in the level of p<.05.

The following Table 8 shows analysis results of the gifted children in IT for logical thinking ability.

(Table 8) Grade Comparison Results for Logical Thinking Ability

Grade	N	Average	SD	F	p-value
4th grade	24	3.63	1.304	.477	.621
5th grade	123	3.31	1.584		
6th grade	452	3.40	1.478		
Sum	599	3.39	1.493		

where N represents the number of overall tests and 5 is the perfect score

In order to compare test scores of logical thinking ability, one-way anova is also adopted. The statistical analysis shows that 4th grade has 3.63, 5th grade has 3.31, and 6th grade has 3.40, respectively. Although 4th grade children represent the highest scores, however, there is no significant difference in the level of p<.05.

Based on the above statistical analysis for grade difference of programming ability and logical thinking ability, we can conclude that there is no significant difference among 4th grade, 5th grade, and 6th grade gifted children in IT.

3.3. Significance of the Analysis Results

The statistical analysis results can be explained as follows.

First, the giftedness in IT does not depend on age or student grade. In normal school classes, study performance depends on student grade. That is, generally the higher grade means high test score. This is because the older students have more time to study and more chances to experience study activity. Hoever, for gifted children in IT, age really does not matter.

Second, there is not significant difference for education contents, curriculum, test evaluation criteria depending on grade. We can organize and build study contents for the gifted children in IT regardless of their grade.

Third, we can make selection test or standard for identification of the gifted children in IT regardless of grade. We can actually more generalized test and selection standards.

Fourth, the gifted in IT is acquired ability rather than innate ability. Usually lower grade gifted child in IT have less chances to learn computer science courses. However, once they are entered, they can make a big progress as long as they concentrate their study activity.

Fifth, programming education needs not to be differentiated for different grade students. So far we usually spend more efforts and time for teaching low grade students for programming education. However, according to the statistical analysis, there is no difference for programming education. It means that we does not have to put more efforts for lower grade students.

Sixth, as the statistical analysis shows that there is no significant difference for logical thinking ability, we can put more efforts on mathematical study, especially on discrete math. So far, we have not emphasize mathematical study contents since we thought there is some difference on logical ability depending on grades. With the same logical thinking ability, we can put more mathematics study on lower grade students.

4. Conclusions and Further Works

In the current knowledge and information society, IT industry has been leading a nation's economy power. Also, IT industry is naturally brain-intensive industry so that it can promote a nation's economy in a short period of time. It means that a few talented persons in IT can wield strong influence over major IT industry and business. In this sense, the gifted education in IT is very important and necessary to identify and foster potential gifted children in IT.

Currently the gifted education in IT becomes popular gradually since it has been supported by a government and the public in most nations. Although the gifted education in IT is not mature yet, many research works will be done in

the near future. Also, it is expected that more gifted education institutions will adopt the gifted education in IT as a main subject.

The purpose of this paper is to investigate study performance of different grade gifted children in IT. As performance measures, we are interested in their programming ability and logical thinking ability. So far there has been no research work for this grade comparison.

For grade comparison analysis, we collected and analysize the test scores of 157 gifted children in IT for 8 years(2003 ~ 2010). The gifted children in IT have attended a gifted science education center attached to a university at Seoul Metropolitan Area. For an objective analysis, we are concerned with only their test scores. We also adopt 5 likert scales for analysis.

Based on thorough statistical analysis, we can conclude that there is no significant difference depending on the gifted chilren's grade for programming ability and logical thinking ability. This results imply that we need not differentiate different grade gifted children for study contents, curriculum, and evaluation methods, etc.

Future researh works are as follows.

First, for further grade comparison analysis, we consider diverse evaluation standards other than programming ability and logical thinking ability. Recently there have been research works on genenal characteristics such as psychological characteristics[10] and cognitive style[4] for the gifted children in IT. We are also interested in psychological evaluation standards like creativity, and task commitment, etc.

Second, we are developing standard curriculum for gifted education in IT. Unfortunately there has been no universal textbooks and curriculum for the gifted education in IT. Our immediate task is to develop standard curriculum for the gifted children in IT.

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