Suggestions for Effective Teaching Methods through Analysis of the Learning and Thinking Styles of Gifted IT Students

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Abstract: - To suggest effective teaching and learning methods for gifted IT students, this study examines the characteristics of those students by using tools for learning and thinking styles. Based on analysis of the relationship between Grasha's learning styles and Sternberg's thinking styles, this study aims to suggest learning styles suited to the thinking styles of gifted IT students. According to the results, gifted IT students not only need to provide an environment where these students can take the initiative and actively participate in learning, but also provide competitive elements. Teachers also need to support participatory learning and reinforce collaborative learning by creating an environment where gifted students can interact through group activities.

Key-Words: - Gifted students, Learning style, Thinking style, Teaching methods, IT, Effective teaching

1 Introduction

In the fiercely competitive information society of the 21st century, national competitiveness can depend upon fostering talented people. Many countries have invested great energy into educating gifted students, and the education of gifted IT students who will lead future information society may be the key to becoming the world leader in information and technology. The value of giftedness changes according to social needs. Hence, the growing importance of information technology means that fostering talented people in informatics can be of great value in a knowledge-based information society. Education for gifted children in South Korea began before the 1970s with a gradeskipping or grade acceleration system and has been widely operated since the 2000s based on the Law on the Promotion of Gifted Education[1].

The definition of "gifted IT students" has been widely discussed, but this study defines them as "those with an interest, curiosity, and talent in informatics based on creative thinking, and excellent intellectual and problem-solving ability, and who can contribute to informatics by displaying logical and creative thinking based on inventive ideas and the use of information devices"[2]. Recently there has been an increase in studies on gifted IT students; as education for gifted children has been strengthened in schools in particular, much research is carried out on teaching-learning methods suited for gifted IT students. This trend was influenced by emphasizing constructivism in education. Constructivist learning basically presupposes differences in individual learners' characteristics and abilities. A behavioral pattern cannot be created in a short duration.[3]. Hence, personal learners' varied characteristics or tendencies have useful implications for teaching and learning methods. Existing researches related to gifted children have compared their thinking styles with those of average children in regard to teaching methods, but few studies have linked thinking style to learning style. Also, no research has been made on the learning-teaching situation. Nor has any detailed assessment been made on the relationship between the thinking and learning styles of gifted IT students. To improve the quality of education for these students, their characteristics must be fully understood and effective teaching methods developed accordingly. It has a lot of advantages for assessment and coaching as well as for learning and collaboration[4].

This study compared gifted and average students in informatics to identify the learning and thinking styles of gifted IT students. Furthermore, through analysis of their learning and thinking styles, the study aims at developing more effective teachinglearning methods for such students. Because teaching-learning is the product of interaction in the broad sense[5][6], suggestions for effective teaching methods for gifted IT students based on such analysis are expected to enhance the quality of teaching-learning methods for gifted IT students.

2 Learning and Thinking Styles

Grasha and Reichmann(1974) did not restrict the concept to cognitive issues. Viewing learning style as learning attitude or interaction occurring in the classroom, they defined it as encompassing learners' learning attitude, opinions toward teachers and diverse peers. and classroom activities[7]. Therefore, learning style includes learning attitudes, opinions, and responses. Based on learners' attitudes toward learning, opinions toward teachers and peers, and responses to classroom processes, Grasha and Reichmann divided learning styles into independent and dependent styles, collaborative and competitive styles, and participant and avoidance styles.

Based on the above definitive characteristics, they developed the Grasha Reichmann Student Learning Style Questionnaire (GRSLSQ), a learning style test tool that classifies learning styles according to learners' attitude or personal characteristics.

Sternberg argued that people have different ways of governing their behavior in their daily lives just as countries have forms of government suited to their own characteristics. He called this the theory of mental self-government[8][9][10]. Thinking styles, as forms of individual thinking processes, are individuals' preferred forms or methods of thinking. Also, thinking styles refer not so much to ability as to individuals' preferred ways of expressing or using something[11][12]. Sternberg suggested 13 thinking styles in the 5 areas of function, form, level, scope, and leaning. He also developed thinking-style measuring tools and standardized them by directly applying them to students and adults. The thinkingstyle measuring tools are composed of 8 items and 104 questions according to 13 thinking styles[13].

3 Sampling and Analytic Methods

3.1 Sampling and Analysis Methods for Comparison of Learning Styles and Thinking Styles

An empirical analysis was used to compare the learning styles of gifted IT students and average students. Two-stage group random sampling and three-stage group random sampling were used on the gifted and average students, respectively. In the case of gifted IT students, first-stage sampling took place in five cities and provinces among sixteen cities and provinces where education for gifted IT children was carried out and where consent was granted by the students' teachers and parents. In the second stage, all the gifted IT students from the five cities and provinces were sampled. In the case of average students, 5 cities and provinces were randomly sampled among the 16 cities and provinces from the first stage, and 5 elementary schools were randomly sampled among the 5 cities and provinces in the second stage. In the third stage, a grade six class was sampled from among the schools in the second stage and where the consent had been granted by the principal, homeroom teacher, and parents. As a result, 305 students were finally sampled from 5 educational institutes for gifted IT students and 347 average students from 5 elementary schools as subjects of this study.

To process the collected data, descriptive analysis, ttest, and correlation coefficient test were conducted by using Statistical Package for the Social Sciences (SPSS, Version 13). After carrying out the t-test, an analysis of effect size was conducted to measure the size difference between the two groups. First, a t-test was conducted and afterwards the effect size was analyzed

Second, a meta-analysis was performed using Sternberg's thinking style-measuring tools.

4 Results of Analysis

4.1 Comparison and Analysis of Learning Styles

GRSLSQ, Grasha's learning style test tool, was used to measure the learning styles of gifted and average students in informatics. The tool divided learning styles into 6 types (independent, avoidance, collaborative, dependent, competitive, and participant styles) and consisted of 60 questions. This study measured the reliability of questions by the type of learning style through Cronbach's α (alpha) coefficient. The results are shown in Table 1.

Table 1. Learning Style Types and Reliability Coefficient

Learning styles	Cronbach α	Learning style	Cronbach α	Learning style	Cronbach α
Independent	0.747	Collaborative	0.826	Competitive	0.823
Avoidance	0.790	Dependent	0.688	Participant	0.810

The results of the t-test for the two groups by the six types of learning styles showed a significant difference between the two groups, except in the avoidance style as shown in Table 2. Gifted IT students (3.74) showed a higher tendency than average students (3.33)(p < 0.05) in the independent style, and in the dependent style.

Table 2. Analysis	of Difference	in Learning Styles
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Learning Style	Gifted IT Students M (SD)	Average Students M (SD)	t-value	Effect Size
Independent	3.74 (0.63)	3.33 (0.59)	8.75***	.69
Dependent	3.46 (0.56)	3.29 (0.49)	4.08***	.35
Collaborative	3.81 (0.76)	3.52 (0.69)	5.00***	.42
Competitive	3.68 (0.69)	3.24 (0.74)	7.78***	.59
Participant	3.70 (0.74)	3.29 (0.69)	7.28***	.59
Avoidance	2.73 (0.78)	2.84 (0.70)	-1.85	.16

(*p < 0.05, **p < 0.01, ***p < 0.001)

In other words, gifted IT students tend to be independent and dependent at the same time. This means that they have a strong will to learn on their own and a great tendency to analyze and accept others' opinions when necessary. Gifted IT students (3.81) showed a higher value than average students (3.52) in the collaborative style, and in the competitive style (p < .05). Therefore, it is understood that gifted students like to learn by themselves based on their own learning ability, interact with others by exchanging ideas, learn a great deal, and prefer to learn in a competitive situation with their peers. Based on the above results, it can be concluded that gifted Korean students in informatics have independent, dependent. collaborative. competitive, and participant learning styles. The analysis showed that gifted students had an effect size of more than | .5 in the independent, competitive, and participant learning styles where they showed a clear difference from average students. This can be interpreted to mean that gifted students like to learn independently based on new ideas and tend to learn through exchange with their peers and experts. In other words, they actively participate in group activities and tend to compete with other students. Therefore, it is believed that teaching-learning tools should be designed to accommodate self-initiated learning or interaction with others, and group activities.

4.2 Comparison and Analysis of Thinking Styles

4.2.1 Analysis of Thinking Styles

The thinking styles of gifted IT students and average students were assessed using Sternberg's measuring tools. The terms and statements of questions were adjusted to the level of elementary school students, the object of this study. Each question was measured on a scale of 7 (7 being the highest score and 1 the lowest) as in the original questionnaire. The questions and reliability coefficient of thinking styles are as follows.

Table 3. Reliability	Coefficient
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Dimension	Thinking Style	Cronbach α	Dimension	Thinking Style	Cronbach α	
	Legislative	0.809		Global	0.761	
Function	Executive	0.766	Level			
1 unetion				Local	0.721	
	Judicial 0.807		Internal	0.824		
	Monarchic	0.820	Scope	Internal	0.024	
				External	0.867	
Form	Hierarchic	0.882				
	Oligarahia	0 808	Looning	Conservative	0.808	
	ongatemic	0.808	Leaning	Liberal	0.901	
	Anarchic	0.729		Liebiu	0.501	

Through the t-test, this study analyzed thinking styles to examine whether there is a meaningful difference between the two groups. The results of the ES analysis, aimed at measuring the effect size by thinking style, are as follows.

Table 4. Analysis of Thinking Styles of Gifted IT Students and Average Students

Thinking Style		Gifted IT Average Students Students		t value	Effect
		M (SD) M (SD)		(p value)	5120
	Legislative	5.31 (1.00)	4.58 (1.07)	8.86***	.68
Function	Executive	4.95 (1.04)	4.59 (1.06)	4.29***	.34
	Judicial	4.93 (1.13)	4.34 (1.14)	6.60***	.52
	Monarchic	4.98 (1.10)	4.51 (1.16)	5.19***	.41
Б	Hierarchic	4.99 (1.29)	4.50 (1.18)	5.01***	.41
Form	Oligarchic	4.27 (1.25)	3.99 (1.18)	2.89**	.24
	Anarchic	4.85 (1.04)	4.45 (1.00)	4.99***	.40
Level	Global	4.87 (1.06)	4.37 (.92)	6.53***	.54
Lever	Local	4.84 (1.08)	4.32 (1.26)	6.41***	.51
Scope	Internal	5.10 (1.17)	4.36 (1.12)	8.22***	.66
Scope	External	5.20 (1.22)	5.04 (1.18)	1.71	-
Leaning	Liberal	5.38 (1.21)	4.55 (1.39)	7.98***	.37
Leaning	Conservative	4.48 (1.26)	4.12 (.97)	4.06***	.60

(*p < 0.05, **p < 0.01, ***p < 0.001)

The analysis showed that gifted IT students had higher values in all areas of function (legislative, executive, and judicial styles) (p < 0.05). In terms of form, gifted IT students had higher values in monarchic, hierarchic, oligarchic, and anarchic styles (p < 0.05). In the level dimension, gifted IT students also marked higher values in global and local styles of thinking (p < 0.05). The difference between the two styles seems to result from the gifted students having the characteristics of both of these styles. In other words, people who possess global style tend to like abstract problems and to identify the whole rather than the parts. People with local style tend to like problems requiring precision, an attribute required of gifted IT students, who deal with computer programming and computer systems.

The results showed that there was a difference in all thinking styles, except external style. However, it would be absurd to present the characteristics of gifted IT students from these differences alone. Clearly understanding the characteristics of gifted IT students through the comparison of their effect size with that of average students will provide more accurate information in finding directions for teaching-learning methods.

4.2.2 Meta-Analysis of Preceding-Research on the Thinking Styles of Gifted Students

Researches have been conducted on the premise that gifted students and average students differ from each other in thinking styles. Many studies have been carried out to discover the thinking styles of gifted students through comparison with average children. In addition, apart from the researches conducted on gifted IT students, researches on "gifted students" and "gifted students in science" can indicate the thinking styles of gifted IT students. This is because gifted IT students generally share common characteristics with other gifted students and have a great interest in and talent for informatics. It is likely that gifted IT students have similar thinking styles to gifted students in science given that they major in science and engineering. Therefore, common points in thinking styles among gifted students, gifted students in science, and gifted IT students can help us to infer the thinking styles of gifted IT students. All of the researches used for meta-analysis in this study utilized the thinking style measurement tools recommended by Sternberg.

Table 5 shows the results of analysis on thinking style-related researches conducted on gifted students. Researches were analyzed focusing on Korean data because each study can have different views about utilizing and understanding the thinking styles of gifted children.

Table 5. Comparison and Analysis of Thinking Styles Researches

Classification		Gifted Students		Gifted Students in Science	Gifted IT Students
	Legislative	A,B ,C ,D	,E	G, H, I, J, K	M, N
Function	Executive	E		G, L	
	Judicial	A, B, C, D, E		G,H,I,J,K.L	M, N
	Monarchic	D		G, K, L	M, N
Form	Hierarchic	E, F		G, L	
Form	Oligarchic	D, F			
	Anarchic	D		Ι	Ν
Laval	Global	D, F		I, K, L	М
Level	Local			G, H, J, K	Ν
Scope	Internal	E, D, F		G, H, J, K, L	M, N
Scope	External			Ι	
Leaning	Conservative				
Leaning	Liberal	A, B, C, D, F	3	G, H, I, J, K, L	М
A : Dai&Feldhusen (1999)[14]) ¹ C : Zhang (2000)[16] E : Kim Jin-cheol (2004)[18] G : Han Gi-sun et al (2003)[20] I : ParkSu-gyeong et al (2005)[22] K : Oh Min-ju (2006)[24] M : Yun Seong-bee (2005)[26]			B F: H J: N	: Yun Mi-seon : Jo Min-ji (20) : Yun So-jeong : Go Hye-jin (2 Jin Seok-eon (: Na Dong-jin c : Lim So-hye ((1999)[15] 03)[17] (2001)[19] 2003)[21] 2004)[23] 21 al(2004)[25] 2006)[27]

That is, only Korean literature was discussed to suggest teaching-learning methods suitable for Korean gifted students, given that genius can be defined differently according to the social and cultural values of a society[28][29].

From the significant difference between gifted students and average students, which is presented in Table 6, it is hard to know how much difference exists among the thinking styles. The analysis was made by examining the research which presented basic data such as average and standard deviations. Therefore, effect size was analyzed to find the size difference of thinking styles between gifted students and average students, as suggested by the preceding researches. If an effect size of 1 means that average students have giftedness, it can be interpreted that each thinking style will mark a point whose standard deviation is higher than before by one point. This means that the larger the absolute value of effect size, the larger the difference between average students and gifted students in their thinking styles.

The analysis results were presented only when they were over |.1|. Factors with an effect size of more than |.5| were used to analyze the difference between gifted students and average students and to deduce the characteristics of gifted students' thinking styles.

Table 6. Effect Size Analysis of Researches on Thinking Styles

Th	inking		Effect Size									
Style		F	Н	D	L	Е	J	М	Ι	K	N	NO.
Euro	Legisla tive		1.04	1.26	.47	.39	1.04	.75	.28	.38	.88	5
tion	Executive		44		.72	.27	44	69	43		.24	2
	Judicial		1.03	1.13	.93	.11	1.03	.55	.44	.56	.50	7
	Monar chic		.51	1.26	.29	.14	.51	1.03	.15	.34	.41	4
Form	Hierarchic	44	.39		.71	.41	.39	.37	18		.34	1
	Oligarchic	44	.15		50		15	20	34	28		1
	Anarchic		.50	1.13	36		.50	.24	.23	.11	.48	3
Level	Global		.69	1.25	.28		.69	.79	.35	.29	.22	4
Leve	Local		.88			.20	.88	.38		.32	.60	3
Score	Internal	.33	.97		.89	.41	.97	.66	.14	.67	.62	6
Supe	External		.13			16	.13		.26	.12	.27	
Lean	Conser vative		.81		72	44	81	78	30	38		4
nig	Liberal		.89		.41	.44	.89	.63	.24	.36	.28	3

NO. : Shaded sections are the researches where the effect size is larger than $\mid .5 \mid$

According to the analysis results of each dimension's thinking style, the number of researches, among a total of ten researches, whose effect sizes were larger than .5 is as follows. In the legislative style of "function," gifted students showed stronger

characteristics than average students in five researches, and in judicial style, seven researches. Therefore, it can be said that gifted students have "legislative" and "judicial" thinking styles in the dimension of "function."

According to Table 6, the "legislative" and "judicial" styles in the dimension of function and the "internal" style in the dimension of scope have effect sizes higher than .5 in more than five studies. Therefore, the thinking styles of gifted IT students are legislative, judicial and internal.

4.2.3 Thinking Style Characteristics of Gifted IT Students

During the analysis, factors with an effect size higher than | .5|, the meta-analysis standard of preceding studies, were used to identify the thinking style characteristics of gifted IT students. The thinking styles of gifted IT students were deduced from the studies of Yun(2005) and Lim(2006). Their analysis of thinking styles is presented in Table 4 and compared in Table 6, the comparison material for the meta-analysis.

In this study, thinking styles with an effect size higher than | .5| were legislative and judicial styles in the "function" dimension, global style in the "level" dimension, liberal style in the "scope" dimension, and liberal style in the "leaning" dimension. Compared with the preceding researches by Yun(2005) and Lim(2006), which compared the thinking styles of gifted IT students, legislative, judicial, and internal thinking styles along with global and liberal styles had an effect size higher than .5 as in the preceding researches. Therefore, those styles can be considered to be characteristics unique to gifted IT students.

4.3 Analysis of Relation between Thinking Styles and Learning Styles of Gifted IT Students

A correlation between the thinking styles and learning styles of gifted IT students is as follows.

Table 7. Correlation between Thinking Styles and LearningStyles of Gifted IT Students

Classification	Independent	Avoidance	Collaborative	Dependent	Competitive	Participatory
Internal	.48**	.01	.05	.23**	.33**	.31**
External	.12	.02	.61**	.22**	.28**	.30**
Legislative	.59**	07	.31**	.31**	.44**	.43**
Executive	.28**	.02	.29**	.50**	.41**	.43**
Judicial	.46**	.01	.42**	.36**	.55**	.47**
Libeal	.57**	04	.47**	.25**	.46**	.48**
Conservative	.15*	.17*	.24**	.47**	.30**	.22**

Gidbal	.35**	.18*	.35**	.48**	.42**	.33**
Local	.46**	.02	.46**	.41**	.41**	.48**
Monachic	.56**	.02	.44**	.48**	.53**	.54**
Hieathic	.57**	08	.51**	.47**	.52**	.60**
Oligathic	.15*	.38**	.19*	.39**	.20**	.15*
Anachic	.43**	.06	.50**	.38**	.44**	.47**

(* p < .01, ** p < .001)

According to the analysis results of correlation between thinking styles and learning styles of gifted IT students, external style and collaborative style had the highest correlation coefficient of .61.. Therefore, it can be said that gifted IT students with a high level of external thinking style also have high disposition for a collaborative learning style. Next, the correlation coefficient between hierarchic style and collaborative style is .60, which means that gifted IT students with a high level of hierarchic style, who want to approach a problem systematically from diverse points of view, show a higher disposition for the collaborative learning style. Therefore, gifted IT students with a hierarchic thinking style actively participate in classes and extracurricular activities.

5 Suggestions on Teaching & Learning Methods for Gifted Students

5.1 Teaching & Learning Methods for Gifted IT Students by Learning Style

The learning style characteristics of gifted IT students can be organized as follows.

Table 8. Learning Styles of Gifted IT	Students
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Learning Style	Characteristics	Learning Style of Gifted IT Students
Independent	-like studying on their own -learner-oriented learning method is efficient	Dependent
Dependent	-want to told what to do and expect to be given detailed guidelines -like teacher-oriented class	
Collaborative	-like studying with other people such as teachers or classmates -cooperative in small-group discussions	
Competitive	-make efforts to outdo other students -like competitive environments	Competitive
Participant	 -like participating in class to learn -like discussions about assignments -like teachers who are good at analyzing and integrating assignments 	Participant
Avoidance	-not interested in class -do not want to get along with teachers or classmates	

Independent learning style means studying, thinking, and making efforts on one's own. Therefore, it is a learning style suitable for gifted IT students, who have to deal with given assignments in a creative way. Gifted IT students should be allowed to plan and carry out their study like project learning. Teachers of independent style students have to be guides rather than leaders. Ideally gifted IT students with a distinct independent learning style should be presented a self-initiated learning process, which consists of basic courses, advanced courses, and elective courses. Competitive style students prefer a learning environment where they can compete with their classmates to outdo them or attract the attention of teachers. Therefore, they need a learning environment where friendly rivalry of diverse types is provided.

Participant style students do their best to participate in class and enjoy discussing subjects with others. It is a desirable style for students who learn by exchanging knowledge and ideas with others through discussion or cooperative learning.

5.2 Teaching & Learning Methods for Gifted IT Students by Thinking Style

The thinking styles presented by Sternberg(1997) suggest how to teach and evaluate learners with various thinking styles[8]. As seen in analysis of the thinking styles of gifted IT students, they have different characteristics from average students in legislative, judicial, internal, and liberal styles. Table 9 suggests teaching methods for gifted IT students by thinking style, drawn up based on the analysis result of this study.

Table 9. Thinking Styles and Teaching Methods for Gifted IT Students

Teaching Method	Thinking Styles Suited to the Teaching Method	Identified Thinking styles of Gifted IT Students
Lecture	Executive, Hierarchic	
Asking questions based on thinking	Judicial, Legislative	Judicial, Legislative
Cooperative (group) learning	External	
Solving problems	Executive	
Project	Legislative	Legislative
Small-group: answering factual questions	External, Executive	
Small-group: discussions about ideas	External, Judicial	Judicial
Reading	Internal, Hierarchic	Internal

As to teaching methods, creating questions based on thinking, project classes, and discussing ideas seem to be necessary for gifted IT students. First, lectures do not seem to suit students with a liberal thinking style who want to seek active and new solutions to problems because lectures focus on the teacher's unilateral provision of materials and solutions. As seen in Table 8, lectures are also not suitable for those students with competitive and independent dispositions. Secondly, cooperative (group) learning is also not suitable for gifted IT students. Slavin(1991) argued that cooperative learning is a learning method in which students study common assignments together and encourage one another, where anyone can teach and learn from one another, and where teachers generally present the information that has to be dealt with. He also pointed out that cooperative learning is better for all the students, rather than individual learning[30]. However, since it is more effective for external style learners who enjoy group activities and actively participate in them, gifted IT students with an internal thinking style who prefer individual activities may be unwilling to participate. As shown in Table 8, gifted IT students prefer a competitive environment where they can outdo classmates; thus, a simple style of cooperative learning is not suitable for them. Third, project learning is defined as the learning style in which students play a leading role in researching themes, topics, problems, and issues and in producing results of those activities[31]. In addition, Katx and Chard defined project learning as in-depth study of topics worthy of teaching, conducted mostly by small-groups or sometimes by the whole class or individual students[32]. Project learning is a learning method in which students learn by choosing topics and solving problems on their own or under the guidance of their teachers. It is suitable for those with a legislative thinking style and for gifted IT students. However, since gifted IT students have an internal thinking style, the learning process should focus on individual projects or restrictive small-group activities. Fourth, as to asking questions based on thinking, gifted IT students design the structure of a class in which the contents are presented by teachers by asking questions. Such a method should be actively utilized for the education of gifted IT students. In particular, when it comes to the legislative thinking style, asking questions to suppose a situation or call for analysis and judgment, as suited to the judicial thinking style, is assumed to improve the creative, critical, and analytical thinking of gifted IT students. Therefore, teachers should ask questions taking these factors into account. Table 10 presents suitable evaluation methods devised by combining the methods of Sternberg evaluation with the characteristics of gifted IT students.

Table 10	. Thinking	Styles	and	Eva	luation	Methods
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Evaluation Method	Major Capabilities	Suitable Thinking Style	Identified Thinking Style of Gifted IT Students
Short- answer Questions & Multiple- choice Questions	Memorization	Executive, Local	
	Analysis	Judicial, Local	Judicial
	Time Allocation	Hierarchic	
	Studying on One's Own	Internal	Internal
Essay Test	Memorization	Executive, Local	
	Macroscopic Analysis	Judicial, Global	Judicial
	Microscopic Analysis	Judicial, Local	Judicial
	Creativity	Legislative	Legislative
	Systematization	Hierarchic	
	Time Allocation	Hierarchic	
	Accepting Teacher's View	Conservative	
	Studying on One's Own	Internal	Internal
Project & Portfolio	Analysis	Judicial	Judicial
	Creativity	Legislative	Legislative
	Collaboration	External	
	Studying on One's Own	Internal	Internal
	Systematization	Hierarchic	
	High-level of Involvement	Monarchic	
Interviews	Social Skills	External	

In consideration of their thinking styles, evaluation methods such as short answer questions, multiplechoice questions, essay tests, projects, and portfolios are suitable for gifted IT students who enjoy studying on their own. However, short answer questions and multiple-choice questions should be the type that require analysis, such as mathematical questions, not simply asking memorized information such as, "Who made Linux?"

As to essay tests, their success depends on the evaluation of answers, not on the questions[8]. Therefore, evaluation standards and test questions should be created to allow for assessment of students' creativity and analytical skills. In particular, essay tests that help to develop creativity can be used to evaluate the legislative thinking style and independent learning style of gifted IT students. Therefore, students should be made aware of this evaluation standard so that they can present creative ideas. The above-mentioned evaluation methods are consistent with the results of a Korean study which recommended experts' evaluations, oral tests, presentations and discussion tests, group project output, essay tests such as research papers, or

portfolios and project evaluations in order to evaluate gifted IT students[33]. Based on Table 10, which discusses evaluation methods suitable for gifted IT students, along with Table 7, Table 8, and Table 9, we present the following teaching and learning methods for gifted IT students. When developing curriculum or education contents for gifted IT students, strategies such as "asking questions based on thinking", "project class", and "discussing ideas" should be fully utilized, as they are desirable teaching and learning methods for gifted IT students with a competitive learning style (those who enjoy discussions with classmates), or a judicial thinking style (those who enjoy small-group discussions). In addition, if a test is developed which enables a "test of independent study" or "macroscopic analysis" or an evaluation requiring "analytical thinking", classes and evaluations suitable for Gifted IT Students can be conducted simultaneously. Project classes are not only consistent with project and portfolio evaluation methods but are also a desirable teaching and evaluation method for gifted IT students with a judicial thinking style and a participant learning style, who enjoy analysis and integration of assignments.

6 Conclusions and Suggestions

Setting educational goals is closely connected to overall teaching and learning and evaluations after class. For example, consistency among educational goals, classes, and evaluation methods for the education of gifted students will contribute to the efficiency and effectiveness of education.

This study has suggested teaching and learning methods for gifted IT students as well as evaluation methods for them based on analysis of their learning styles and thinking styles. The results can be utilized to develop teaching and learning methods and evaluation methods for gifted IT students. Therefore, learning styles and thinking styles are helpful in analyzing individual tendencies and contribute to the design of teaching and learning programs that reflect the characteristics of learners.

Based on the results of this study, we propose the following support and studies for effective teaching and learning methods for gifted IT students.

First, teaching methods should be adjusted to the learning styles of gifted IT students and training workshops should be provided for teachers. Classes should be participatory rather than lecture-oriented. Such classes mean a larger role for teachers, who need sufficient time to research and prepare educational material. Therefore, training courses for teachers of various types should be developed.

Second, teaching materials should be developed for new types of classes to enable various activities and self-initiated learning, rather than simple knowledge-imparting. In addition, materials which can be utilized as a source of information as well as diverse learning themes should be provided.

Third, project learning or a teaching method that encourages questions based on thinking should be conducted. As gifted IT students are characterized by their legislative and judicial thinking styles, the effectiveness of education can be maximized through individual project-type learning rather than common cooperative learning. Also, the characteristics of students can be reflected and learning effectiveness improved with Q&A-type teaching and learning using questions based on thinking rather than memorization.

Fourth, For the purpose of improvement of their capacity and performance, it might be needed to create gifted student's learning community to encourage their "Giftedness" through mentoring of gifted students with similar thinking styles.

Fifth, as for the evaluation method, performance evaluations such as essay tests which require macroscopic analysis, and projects or portfolios which enable students to demonstrate their creativity should be conducted. Evaluation methods that can expand learners' thinking from a macroscopic point of view will be more effective than short-answer questions based on memorization in demonstrating the characteristics of gifted IT students.

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