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Analysis on the Mathematical Disposition of the Mathematically Gifted Students in the Middle School of Korea

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We study on the mathematical disposition of mathematically gifted students in the middle school of Korea. For this purpose, we use a tool which is a psychological test about disposition of mathematics disliking. The tool was developed by Kim et al. (2001: Studies on Exploring Mathematics Disliking Factors and Devising Tools to Analyze Students' Disliking Trends about School Mathematics. *J. Korea Soc. Math. Ed. Ser. A Mathematical Education.* **40(2)**, 217–239) to analyze the mathematical disposition of underachievers and we investigate the characteristic of it.

Key words: mathematical disposition, gifted students, mathematics disliking factor
ZDM Classification: C43
MSC2000 Classification: 97C30

AIM AND NECESSITY OF THE STUDY

In the school education, we must help the students show their latent ability. But the actual educational circumstance in Korea is considered poor as compared with those of other countries. The education of Korea has some problems such as the educational competition based solely on the entrance examination, poor facilities of the school, distrustful tendency of parents to the school education. These are the cause of the stumbling block to the education which brings up student's latent ability in Korea.

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Recently it is emphasized the importance of the education not only of the educations for all of the students but also the education for the gifted students in Korea. The government of Korea gives emphasis to the education of gifted students in the school. The law of promotion for the gifted students' education was established in 2002 in Korea. By this law, the education centers of gifted students were established in the 15 universities throughout the country, and some of science high schools carry out the program for gifted students. Also each offices of educational district established gifted students class and trained the teachers who take part in the education of gifted students

Mathematically gifted students are distinguished from their non-gifted peers by their mathematical reasoning, their capacity for learning, and their mathematical orientation (House 1987). In this research, we study on the mathematical disposition of mathematically gifted students in the middle school before we develop the teaching method and materials for mathematically gifted students. Especially we give priority to the following three points of view in this study; psychological point of view, environmental point of view and mathematical point of view. So we use a psychological test of disposition of mathematics disliking as a tool. The tool was developed by Kim, et al. (2001) to analyze the mathematical disposition of underachievers and investigate the characteristic of it.

THE CONTENTS OF THE STUDY

Many papers on the mathematically gifted students were appeared in Korea after the government of Korea recognized the importance of the gifted students' education. Although it was so late comparing with the other countries, but it was fortunate for the country that the government recognized the importance of the gifted students' education and the study on the gifted students' education become excited. Since the gifted students are the students who have various talents for mathematics, science, music, art and athletics, it is very important to develop the intellectual ability for the country. Especially mathematically gifted students are the men/women of talent who will develop primary subject in the future. So we must take interest in the development of the gifted students' latent ability. Also it is needed to study on the education for the mathematically gifted students continuously.

The mathematical disposition is a mind of good feeling and interest on the mathematics, and it is the same as mathematical cast of mind which was defined by Krutetskii (House 1987). We can see the self confidence, good feeling and the tenacity on the homework of mathematics in the mathematical disposition.

The mathematical disposition concerned with mathematics disliking, which was developed by Kim, et al. (2001), has three domains of factors such as psychological

domain, environmental domain and academic trait of mathematics domain. And each domain contains two factors, two factors and seven factors respectively. The following are the mathematics disliking factors (Kim 2002):

Psychological and environmental domain: This domain contains two factors which are related to learner's psychological characteristics and environmental influence. There are two factors in psychological domain as following.

1. Cognitive factor (mt1): Apart from their mental ability, some students do not succeed in learning mathematics because of their negative images about mathematics. Sometimes, the negative perceptions advance to the fear of mathematics learning. This is a factor that can be inferred by student's cognitive tendency or human nature such as aptitude, self-confidence, will, sub consciousness, versatility, and inquisitiveness, etc. (Shin, Hwang, Kim & Sung 1992).

2. Mental ability (mt2): This is a factor which can be inferred from the ability to concentrate, comprehend, reason, retentively memorize.

Environmental domain: This domain contains causes that are related with learner's environmental elements such as teacher, homely or social mathematics encouraging atmosphere. There are two factors in this domain.

3. Teacher related factor (en1): A factor which can be inferred by whether teacher's character, teaching method, level of teaching, and attitude for mathematics etc. are match students' anticipation or not.

4. Mathematics perception related factor (en2): A factor which can be inferred by whether student understanding the feature of mathematical knowledge, usefulness of mathematics and effective way of studying sufficiently or not. The degree of mathematics encouragement of society and family are also included in this factor.

Academic trait of mathematics domain: As we mentioned previously, the academic aspect of mathematics is basically different from that of other objects of the secondary school. And such features can be radical reasons for students' disliking mathematics. So, to find out the factors causing mathematics disliking' specifically, we need to categorize school mathematics into some parts, depending on mental activities for learning. Considering the result of factor analysis of sample groups' response and argument, we categorized the school mathematics into three parts such as concept, relation, and application.

Concept category: In some respect, learning mathematics can be said to be getting concept. To get mathematical concept, students should think and read well. But generally

in mathematical writings there are many terms, symbols, notations, definitions, theorems, etc. (Bloom 1956). Moreover some sentences are so peculiar to mathematics that students have much difficulty in understanding the contents. There is one factor in this category.

5. Comprehension related factor (com): Factor which can be inferred by mathematical symbols, terms, basic facts which were taught in the preceding course and the ability to comprehend mathematical sentences.

Relational category: Since mathematics is a theoretical structure which starts from axioms to understand one part we need to know the related precedent facts. So it is desirable for students to study mathematics as a systematically entity rather than a pile of individual truths. To accomplish this, students should be concerned about conceptual hierarchy between various mathematical facts whenever they learn something new. But the students feel too much burned by this. There are four factors in this category.

6. Hierarchy factor (rl1): This is a factor which can be inferred by not knowing or not remembering the basic or already learned low ranked fact.

7. Connection related factor (rl2): Without regard to grade, school mathematics is composed of 5 or 6 separate units. Usually they are numbers and their operations, equations and inequalities, functions and their graphs, geometry and statistics. But students are apt to think there are no connections between these units. They think each unit is independent of others. This is a factor that can be inferred by these thought.

8. Operation related factor (rl3): A factor which can be inferred by frequent mistakes in calculation or burden of too much task which is offered for the sake of understanding and proficiency in algorithm.

9. Analysis and reasoning related factor (rl4): A factor which can be inferred by the difficulty in transforming given contents into mathematical model with hypothesis and result, relation, figure, or table.

Application category: One of the great features of mathematics is that its knowledge is abstract. So, mathematical facts can imply diverse situations. So as the learned mathematical knowledge to be students' mathematical power, they need to be able to apply the mathematical model to the real world problem. Thus students should digest the learned fact from memorization to full comprehension. There are two factors in this category.

10. Basic application factor (ap1): This factor is inferred by being unable to remind the necessary learned fact or unable to reach an idea to use appropriate learned property. This is rather simple degree of application.

11. Composite application factor (ap2): Rather than merely memorize mathematical facts, with composite application and diverse understanding of facts, students should be able to solve complex problem, i.e., this factor means the ability to solve tasks which require more than two steps.

We evaluate the cumulative percentage corresponding to the factor of mathematics disliking. So, the increasing appearance of the percentage means the factor of mathematics disliking is weakened. Conversely, the decreasing appearance of the percentage means that the corresponding factor of mathematics disliking is strong. If the percentage exceed more than 70%, we will define that the student does not have the disposition of mathematics disliking on the corresponding factor, and if the percentage shortage less than 30%, we will define that the student has the disposition of mathematics disliking on the corresponding factor (Korea Behavioral Science Research Center 1993).

In the pre-study, we already have analyzed the properties of underachievers' mathematics disliking disposition in 3 middle schools (Park, et al. 2004a). By using this result, we develop some materials to cure the disposition of underachievers' mathematics disliking and got some good result after applying those materials to the experimental group (Park, et al. 2004b).

The following Table 1 shows the means of cumulative percentage of mathematics disliking factors for each level of achievement in mathematics test results. In this table, we marked bold faced figure when they show meaningful difference compared with other groups.

Table 1. Factor achievement - 1

factor achievement	mt1	mt2	en1	en2	com	rl1	rl2	rl3	rl4	ap1	ap2
20-39 (21students)	20.7	18.0	16.9	**23.3**	23.4	**17.2**	16.8	20.1	24.6	17.8	24.3
40-59 (19)	**15.1**	19.7	14.1	**23.1**	28.4	**16.4**	16.7	19.0	27.4	14.1	19.5
60-79 (35)	**25.4**	22.5	20.7	**37.0**	34.1	**28.3**	22.7	25.2	25.3	22.4	22.4

Table 2 shows the numbers and percentages corresponding to mathematics disliking factor of each mathematics-disliking student's level of achievement, where the mathematics disliking students are the students who have at least three mathematics disliking factors. In this table, we marked bold faced figure when more than 80% of mathematics disliking underachievers are contained in the corresponding mathematics

disliking factor.

Table 2. Factor achievement - 2

factor achievement	mt1	mt2	en1	en2	com	rl1	rl2	rl3	rl4	ap1	ap2
20-39 (14students)	**13 (92.9)**	11 (78.6)	**12 (85.7)**	10 (71.4)	**12 (85.7)**	**13 (92.9)**	**13 (92.9)**	**12 (85.7)**	11 (78.6)	11 (78.6)	9 (64.7)
40-59 (14)	**13 (92.9)**	**12 (85.7)**	**13 (92.9)**	11 (78.6)	8 (57.1)	**13 (92.9)**	**12 (85.7)**	**12 (85.7)**	9 (64.7)	**12 (85.7)**	**13 (92.9)**
60-79 (19)	13 (68.4)	13 (68.4)	15 (78.9)	7 (36.8)	9 (47.4)	11 (57.9)	14 (73.9)	12 (63.2)	15 (78.9)	13 (68.4)	14 (73.7)

From above two tables, we can find that mathematical underachievers show meaningful difference in the mathematics disliking factors such as cognitive factor (mt1), teacher related factor (en1), mathematics perception related factor (en2), hierarchy factor (rl1), connection related factor (rl2), and operation related factor (rl3).

Above result is the analysis of disposition of mathematics-disliking focusing on the underachievers. It has a striking difference between underachievers and gifted students. So, it is needed to survey the difference between mathematically gifted students and the other students.

Now, we investigate the mathematical disposition of mathematically gifted students by using the definitions of mathematical disposition. For this purpose, 126 mathematically gifted students of the middle school who are participate in the programs for the mathematically gifted students were picked out for the subject of investigation.

Table 3 shows the distribution of students for each level of the cumulative percentage on the mathematics disliking factors, where the numbers in Table 3 means number of students, and the numbers in the parenthesis mean the percentage for the whole 126 students.

From Table 3, the percentage of mathematically gifted students for the whole in the top 10% grade is as the following,

About 80 percent of mathematically gifted students are contained in mathematics connection related factor (rl2), it is meant that about 80 percent of the mathematically gifted students don't regard mathematics connection related factor as the factor of mathematics disliking. About 75 percent of the mathematically gifted students are contained in the comprehension related factor (com), basic application factor (ap1), composite application factor (ap2), and hierarchy factor (rl1). This data also mean that about 75 percent of the mathematically gifted students don't regard those factors as the

factor of mathematics disliking.

Table 3. Factor cumulative percent - 1

factor cumulative percent	mt1	mt2	en1	en2	com	rl1	rl2	rl3	rl4	ap1	ap2
90-100	79 (62.7)	87 (69.0)	73 (57.9)	77 (61.1)	**96 (76.2)**	**94 (74.6)**	**101 (80.2)**	76 (60.3)	88 (69.8)	**95 (75.4)**	**95 (75.4)**
80-89	31 (24.6)	21 (16.7)	18 (14.3)	18 (14.3)	20 (15.9)	21 (16.7)	16 (12.7)	12 (9.5)	13 (10.3)	7 (5.6)	18 (14.3)
70-79	4 (3.2)	5 (4.0)	5 (4.0)	13 (10.3)	6 (4.8)	26 (20.6)	3 (2.4)	11 (8.7)	26 (20.6)	15 (11.9)	3 (2.4)
30-69	11 (8.7)	11 (8.7)	24 (19.5)	14 (11.1)	3 (2.4)	5 (4.0)	4 (3.2)	18 (14.3)	6 (4.8)	8 (6.3)	8 (6.3)
0-29	4 (3.2)	2 (1.6)	**6 (4.8)**	4 (3.2)	1 (0.8)	1 (0.8)	**2** (1.6)	**9 (7.1)**	**6 (4.8)**	1 (0.8)	2 (1.6)

The following shows the percentage of factors for the mathematically gifted students who contained in top 10% (90-100) grade.

connection related factor (rl2) : 80.2 %
comprehension related factor (com) : 76.2%
basic application factor (ap1) : 75.4%
composite application factor (ap2) : 75.4%
hierarchy factor (rl1) : 74.6%
analysis and reasoning related factor (rl4) : 69.8%
mental ability (mt2) : 69.0%
cognitive factor (mt1) : 62.7%
mathematics perception related factor (en2) : 61.1%
operation related factor (rl3) : 60.3%
teacher related factor (en1) : 57.9%

From the above data, we can find that the mathematically gifted students like mathematics because of the academic trait of mathematics. And we can find that teacher related factor (en1) and the operation related factor (rl3) may be the vulnerable point on the mathematically gifted students' part in some sense. So, it is seen that the teacher related factor and a tedious operation may act as the factor of mathematics disliking in some measure with respect to the other factors.

On the contrary, in Table 2 we have noted that 90% of mathematics disliking students

show the disposition of mathematics disliking on the cognitive factor (mt1), teacher related factor (en1), hierarchy factor (rl1), and connection related factor (rl2). This result is sharp contrast to that of mathematically gifted students.

Meanwhile, it is found that some mathematically gifted students show the disposition of mathematics disliking (*cf.* Table 3). In such cases, they have disposition of mathematics disliking on the operation related factor (rl3, 9.1%), teacher related factor (en1, 4.8%), and analysis and reasoning related factor (rl4, 4.8%) etc.

Table 4 shows the detailed data of facts which 60% of mathematically gifted students are contained in top 10%.

Table 4. Factor cumulative percent - 2

factor cumulative percent	mt1	mt2	en1	en2	com	rl1	rl2	rl3	rl4	ap1	ap2
98-100	37 (29.4)	37 (29.4)	34 (27.0)	30 (23.8)	36 (28.6)	**50 (39.7)**	**52 (41.3)**	37 (29.4)	41 (32.5)	41 (32.5)	**53 (42.1)**
95-97	20 (15.9)	21 (16.7)	12 (9.5)	29 (23.0)	35 (27.8)	23 (18.3)	31 (24.6)	19 (15.1)	34 (27.0)	30 (23.8)	14 (11.1)
90-94	22 (17.5)	29 (23.0)	27 (21.4)	18 (14.3)	25 (19.8)	21 (16.7)	18 (14.3)	20 (15.9)	13 (10.3)	24 (19.0)	28 (22.2)
sum	79 (62.7)	87 (69.0)	73 (57.9)	77 (61.1)	96 (76.2)	94 (74.6)	101 (80.2)	76 (60.3)	88 (69.8)	95 (75.4)	95 (75.4)

From above table we can see that about 40% of the mathematically gifted students are contained in top 2% of hierarchy factor (rl1), connection related factor (rl2), and composite application factor (ap2) respectively. In the next, about 30% of the mathematically gifted students are contained in top 2% of the analysis and reasoning related factor (rl4), basic application factor (ap1), cognitive factor (mt1), mental ability (mt2), operation related factor (rl3), and comprehension related factor (com) respectively.

The following shows the order of factors according to the number of the mathematically gifted students who are contained in top 5% of the corresponding factor.

connection related factor (rl2) : 65.9 %
analysis and reasoning related factor (rl4) : 59.5%
hierarchy factor (rl1) : 57.9%
basic application factor (ap1): 56.3%
comprehension related factor (com) : 56.3%
composite application factor (ap2) : 53.2%
mathematics perception related factor (en2) : 46.8%

mental ability (mt2) : 46.0%
cognitive factor (mt1) : 45.2%
operation related factor (rl3) : 44.4%
teacher related factor (en1) : 36.5%

From the above data, we can find that about 66% of the mathematically gifted students are contained in top 5% of the connection related factor (rl2). This factor is seen as the characteristic of the mathematically gifted students for the mathematics disliking factor. On the contrary, only 36.5% of the mathematically gifted students are contained in top 5% of the teacher related factor (en1). This means that the teacher related factor merely have the characteristic of the mathematically gifted students in comparison with other mathematics disliking factors.

From this result, we are able to develop the teaching method and materials adapt to mathematical disposition for the mathematically gifted students.

That is, when we product the teaching materials for the mathematically gifted students we must concentrate upon the product of materials which are related to the connection related factor (rl2) and the analysis and reasoning related factor (rl4). Also we take great number of the materials which are related to the hierarchy factor (rl1) and application factor (ap1, ap2) to product the teaching materials for the mathematically gifted students. That would make the mathematically gifted students be interested in the mathematics considerably. Especially it is thought that the mathematically gifted students are weak in the operation related factor (rl3), so students have to practice for the operation related factor adequately. And teachers must concentrate their effort to make the educational environments in which student be able to solve their project by themselves.

THE EXPECTATION EFFECT FOR THE STUDY AND SUGGESTIONS

In this study we analyze the mathematical disposition of the mathematically gifted students depend on factors and we investigate the characteristic of its factors. This is the basic study aimed at preparing teaching plan for the mathematical disposition of the mathematically gifted students. The object students are middle school students who are take part in some programs for the mathematically gifted students. So it may be unreasonable to apply the result to general case. To make up for the weak points, it is needed to increase the number of object for investigation countrywide. We expect to develop the program and materials for the mathematically gifted students on the basis of the result of our study, and we must examine the effect of such program and materials. Especially, it is urgent subjects to develop the curriculum and textbooks in accordance with mathematically gifted students' abilities and their interests.

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