

A Study on Developing the Teacher Education Program for Mathematical Excellence

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To develop the content and form of the teacher education program for mathematical excellence, we reviewed several teacher education programs. CGI is an excellent model for teacher education program for mathematical excellence. We developed the 12 teacher education programs based on mathematical tasks developed for the gifted children and have applied them to teacher education. It is not so difficult to develop more programs, because we have made a lot of tasks for the gifted in mathematics for 8 years. Wooden Die for Drinking Game which is one of 12 programs is introduced in this article.

Keywords: Teacher education, Wooden Die for Drinking Game.

ZDM classification: B52, B53, U62, U63

MSC2000 classification: 97B50, 97C80

I. INTRODUCTION

The Korea Science Foundation and Ministry of Science and Technology have helped to establish the Centers for Science Gifted Education in 15 universities since 1998 (see Shin & Han 2000, pp. 81–84 for details). Also, the Ministry of Education has established a special school, and classes for gifted children since March 2002, as described in the Gifted and Talented Education Act of 2000. Such fundamental and systematic support at the national level can be helpful in realizing a desirable education system for a gifted students, but what is more important for its success is to emphasize teacher education. To improve education opportunities for America's top students, they suggested such steps as setting challenging curriculum standards, providing more challenging opportunities to learn, increasing access to early childhood education, increasing learning opportunities for disadvantaged and minority children with outstanding talents, broadening the

definition of gifted, emphasizing teacher development, and matching world performance (OERI, US Department of Education 1993).

We have made an effort to realize a gifted education in mathematics, science, and information technology. The Center for Science Gifted Education (CSGE) of Chongju National University of Education was established in 1998 with the financial support of the National Science Foundation and Ministry of Science and Technology of Korea. Now we have made a lot of talented education programs which in-service teachers could apply to mathematics classroom for mathematical excellence.

The content of this study is as follows: Firstly, to develop the content and form of the teacher education program for mathematical excellence on the basis of reviewing several teacher education programs. Secondly, to develop the teacher education programs based on mathematical tasks developed for the gifted children and to apply them to teacher education.

II. CGI AS A TEACHER EDUCATION PROGRAM

The Cognitively Guided Instruction (CGI) research program at the University of Wisconsin has shown that providing teachers with knowledge of how students think and develop strategies in specific content domains influences their teaching practices and, in turn, student learning. Students in CGI classes demonstrated increased learning, particularly in problem solving, when compared to students in control classes. There were no performance differences between two groups on computational tasks (Carpenter, Fennema, Peterson, Ching & Loef 1989).

The success of the CGI model in enhancing the professional development of practicing teachers led to investigations of using the CGI concepts and methods in the preparation of pre-service teachers. Furthermore, they had 2nd Biennial CGI National Conference in which consisted of such following two tracks as track A and B at St. Paul, MN during October 25–26, 2002. Most of participants were teachers who were interested in CGI or had practiced CGI in the classroom. The experiences of CGI teachers could be a best program for teacher education.

1. Program for track A

- (1) Cognitively Guided Instruction in Context: Observing Children & Understanding a Developmental Framework — In this session participants explored the CGI problem types, strategies that students used to solve these problems, the relationship between the problem types and strategies, and how that information could be used to inform and shape instruction. Videotapes of students solving

problems and CGI classrooms were examined.

- (2) Children's Development of Base Ten Understanding — This session explored how children began to build their tens and ones understanding while working with multidigit numbers. The session looked at specific multidigit addition and subtraction strategies children developed.
- (3) Children's Multidigit Multiplication & Division Strategies — Professor Baek in Arizona State University presented her research on children's strategies for multidigit multiplication & division. She shared different types of strategies, underlying concepts and skills, it's relationship with place value, and a hypothetical developmental map.
- (4) Kindergarteners in CGI Classrooms — Kindergarteners are capable mathematicians. This session looked at kindergarteners as they enter and as they develop over the year.
- (5) Working With Special Education, Basic Skills & Title I Students — CGI techniques work well with all students. The first part of this session focused on recognizing students' strengths and errors and utilizing scaffolding techniques that worked with students having difficulties. The latter part of this session looked at two intervention models that were adaptations of a Reading Recovery intervention model.
- (6) Fractions: Equal Sharing — Equal sharing problems were an entry point for young students to work with fractions. This session presented the strategies young children develop while building their understanding of fractions.
- (7) The Link Between Arithmetic & Algebra — As children develop efficiencies in their arithmetic strategies, they intuitively begin to draw upon algebraic thinking. This session looked at students understanding of equality, zero, the commutative property and other big ideas.
- (8) Analyzing Student Work — Participants participated in small groups sessions that reviewed student work. The object of the sessions was to explore what a student knew and what range of instructional decisions might be made.
- (9) What does the Data Say? — A panel presentation of student achievement data from two school districts where CGI professional development has taken place.

2. Program for track B

- (1) Conjecture & Proof — Presenters shared classroom applications for generating, writing, and justifying conjectures at the elementary level.
- (2) Opening the Door to Algebra: Understanding that the equals sign represents a relation between numbers is essential to students' understanding of arithmetic and

algebra. This session allowed participants to explore specific tasks that developed students' understanding of equality.

- (3) **Differentiation in Early Algebraic Thinking** — Multiage teachers Carla Nordness and Shannon Richards presented ideas and suggestions for meeting the needs of all learners in a 2nd/3rd graders classroom.
- (4) **Distributive & Associative Properties** — This session focused on the distributive and associative property and how they underlay most of our computational methods and algebra procedures. The session was based on the next to last chapter in "Thinking Mathematically (Carpenter, Franke & Levi 2003).
- (5) **Children's Development of Base Ten Understanding** — This session explored how children began to build their tens and ones understanding while working with multidigit numbers. The session looked at specific multidigit addition and subtraction strategies children developed.
- (6) **Children's Multidigit Multiplication & Division Strategies** — Professor Baek in Arizona State University presented her research on children's strategies for multidigit multiplication & division. She shared different types of strategies, underlying concepts and skills, it's relationship with place value, and a hypothetical developmental map.
- (7) **Classroom Action Research Project (CARP)** — Teachers from Madison, WI and Phonix, AZ joined together for collaborative research on early algebraic thinking. Over a two-year period these teachers identified questions that would deepen their own understanding of the content and further understand their students' thinking.
- (8) **Teachers Teaching Teachers** — After working with those teachers for many years, they proposed a staff development project in which they would instruct teachers in a rural school near there on CGI. Warfield and Lubinski conducted sessions with the experienced teachers as they planned and they collected data on their decision-making processes. They shared their findings and called it "Teachers Teaching Teachers".

They had such 9 more sessions as Using Videotaped Interviews as a Professional Development Tool, Filling Space: Volume at the Second & Third Grade Level, Exploring Linear Measurement, Problem Solving in the 3rd Dimension: Children's Thinking About Cubes, Pyramids, Prisms, Etc., Geometry: Net Exploration — a Mathematically Powerful Idea, Quilting: Transformational Geometry & Symmetry, Fractions: 'Half is somewhere in the middle': Children's Informal Language and Strategies for Fractions, CGI vs Traditional Instruction: First Graders' Perceptions of Mathematics, Analyzing Student Work.

Table 1. Types and Levels of Mathematical Tasks Developed

Task Type	Level		
	Grade 5 and under	Grade 6	Grade 7 and over
Experimental tasks (15)	Calculating Several Numbers by Calculator	Tower of Hanoi Pattern Block Top of the Mountain in the Map Simulation of Probability Circle Mystery Mathematical Puzzle	Six Cards Sand and Mathematics The Number of Cases Point, Line, and Face in Figure Exploration of Symmetry by GSP A Problem for Construction I am Pythagoras
Group Discussion task (15)	Gulliver's Travels Geoboard Tic-Tac-Toe and Mathematics	The Classification of Graphs Mathematics in Football Discussion in Mathematics Who is the Winner? Making the Best Basketball Team	Magic Card Mystery The Principle of Graphic Calculator Archimedian Weight and Volume Truth and Falsity of Statement From Natural to Real Number Eratosthenes
Open-Ended Problem Solving Task (32)	Logo Programming (1), (2), (3) Tangrams The World of 2,2,2	Pascal's Triangle Toothpick Puzzle Camel's Allotment Circular Tangrams Making Cubes and Polydrons Understanding 3-Dimension Angle in the Clock Graph by the Table of Frequency Distribution Hockey Problem Chess Problem Mathematical Puzzles Problem Solving on Some Topics Pentomino Problem	Theory of Probability Fibonacci Sequence Data Processing by Calculator Find the Shortest Way Polydron and Euler's Formula Who is the liar? Making Various Shapes Mathematical Puzzles Patterns in Number Painting the Map Magic Square Volume Problem Pyramid Exploration Factorization by Base Ten Block
Exposition Task (7)	The Foundation of Logo Programming	A Maze Problem An Interesting Mathematical Puzzle	Exploration with Tiles Exploration of Fractals The Foundation of Functions Distance Problems

III. MATHEMATICS GIFTED EDUCATION PROGRAM IN CNUE REFERENCES

We have a number of programs for Super Saturday, Summer School, Winter School, and Mathematics and Science Gifted Camp in Chongju National University of Education. Each program is suitable for 90 or 180 minutes of class time. The types of tasks developed can be divided into experimental, group discussion, open-ended problem solving, and exposition and problem solving tasks (Kim 2001). A lot of programs for talented education could be transformed to the programs for teacher education for mathematical excellence.

Levels of the tasks developed for talented elementary students in mathematics can be further divided into grade 5 and under, grade 6, and grade 7 and over (see Table 1).

IV. WOODEN DIE FOR DRINKING GAME (木製酒令具) AS A TEACHER EDUCATION PROGRAM DEVELOPED IN CNUE

The fundamental rules of creating a teacher education program for mathematical excellence are as follows.

Firstly, create a formal system of program, which consists of Learning Purposes, Preparation Activities, Exploration Activities, Enrichment Activities. Secondly, present an open-ended problem situation which motivates active exploration and problem solving on the basis of students' own creative ideas, and specific students' responses, if possible. Thirdly, develop some programs which require using technology such as calculators and computers and their manual for use. Fourthly, develop tasks that cover the contents of the mathematics curriculum impartially, which consists of numbers and operations, geometry, measurement, probability and statistics, letters and expressions, patterns and functions (problem solving).

1. Learning Purpose

It was made of wooden tetradeca-hedron and was unearthed at Anapzi, the site of a pond in the royal gardens in the era of Unified Silla around 674 AD. Archaeologists suggested that it was used for making a promise of a method of drinking rice wine and giving a zest to a banquet when a lot of people came together for a ceremonial feast.

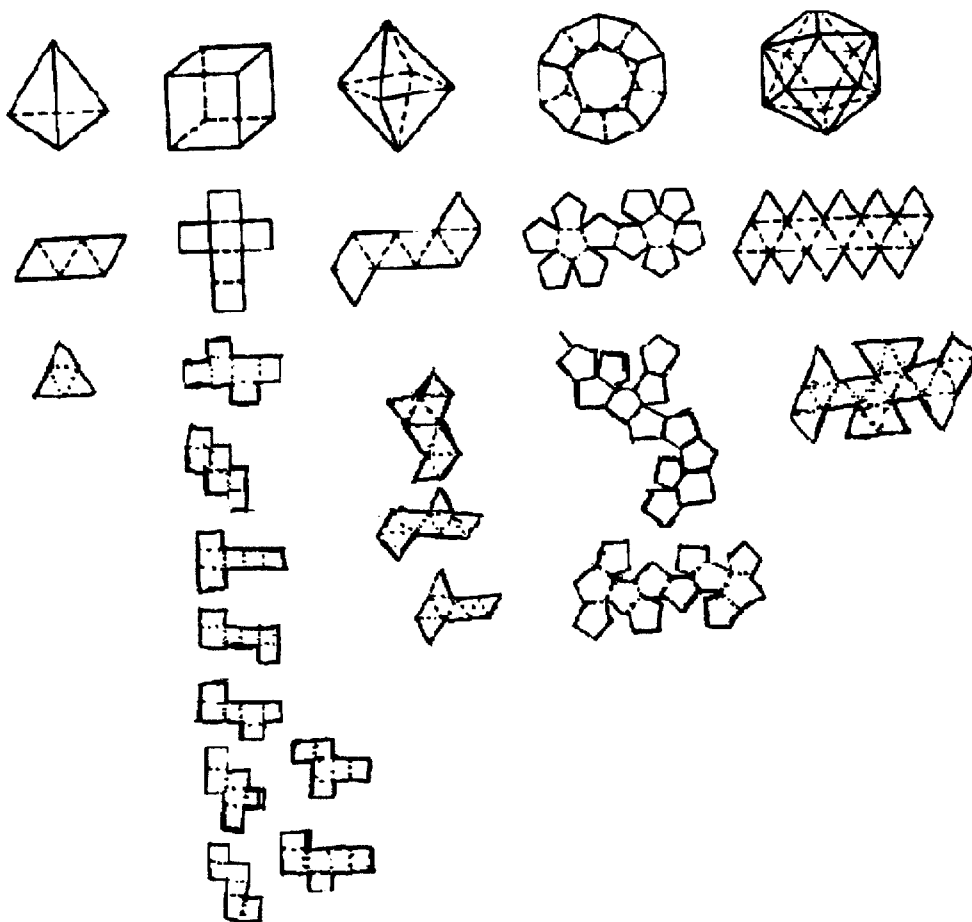
Learning Purpose is to explore a lot of mathematical concepts and principles in relation to this wooden die for drinking game.

Table 2. Teacher Education Program Developed in CNUE

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1. Gulliver's Travels
 2. Pascal's Triangle
 3. Wooden Die for Drinking Game
 4. Data Processing by Calculator
 5. Mathematics in Soma Cube
 6. Finding the fastest way to go from A to B
 7. Mathematics in Football
 8. Mathematics in Geoboard
 9. Exploring the Figures in Paper Work
 10. Finding the Pythagorean Theorem using Various Square
 11. Finding the Pythagorean Theorem using Various Square
 12. Problem Solving using Same Area Transformation
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2. Preparation Activity

- 1) Draw a lot of development figures of following regular polyhedrons, if possible.



2) What is the reason for existing just five regular polyhedron?

3. Exploration Activity

1) Roll the dice and play the following game.

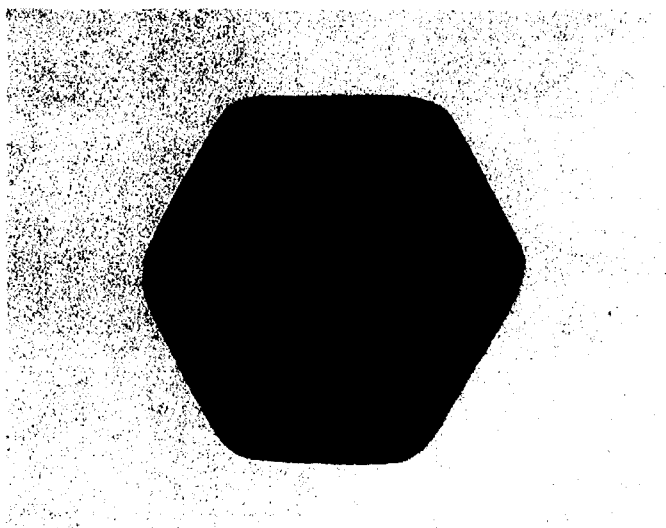


Figure 1. Wooden Die for Drinking Game(木製酒令具) (Ko 1996)

禁聲作舞: dance silently

有犯空過: stay motionless regardless of persons' rushing upon oneself

飲盡大笑: give a loud laugh after drinking

衆人打鼻: hit on the nose

自唱自飲: sing and drink for oneself

三盞一去: drink three cups of wine at once

曲臂卽盡: drink in one gulp with bending one's forearm

弄面孔過: stay motionless regardless of people' tickling your face

任意請歌: have someone sing a song

月鏡一曲: sing a tune for 12 months

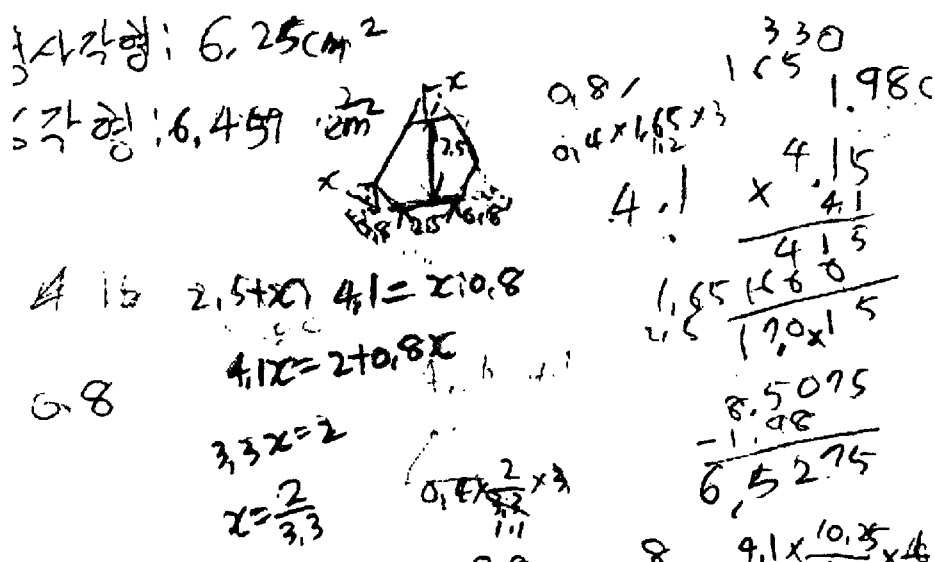
自唱 卦來晚: sing a special song for oneself

空詠詩過: compose a poem

兩盞則放: throw out one's cups if you have two cups of wine

醜物莫放: do not throw away an ugly object

2) It has 6 facets of $2.5\text{cm} \times 2.5\text{cm}$ regular squares and 8 facets of $2.5\text{cm} \times 0.8\text{cm}$ hexagons. It is geometrically harmonized with a height of 4.8cm. Calculate the areas of 14 surfaces, and make an experiment on the probability of 14 surfaces.



A student found that the area of square (6.25cm^2) was almost same as the area of hexagon (6.45cm^2). 18 students integrated their experimental data and found that the probability of 14 faces was the same as $1/14$. For example, $P(1)=0.100961538$, $P(2)=0.105082417$. It was the same as Park & Lee's (1987) argument that 14 surfaces have the same probability.

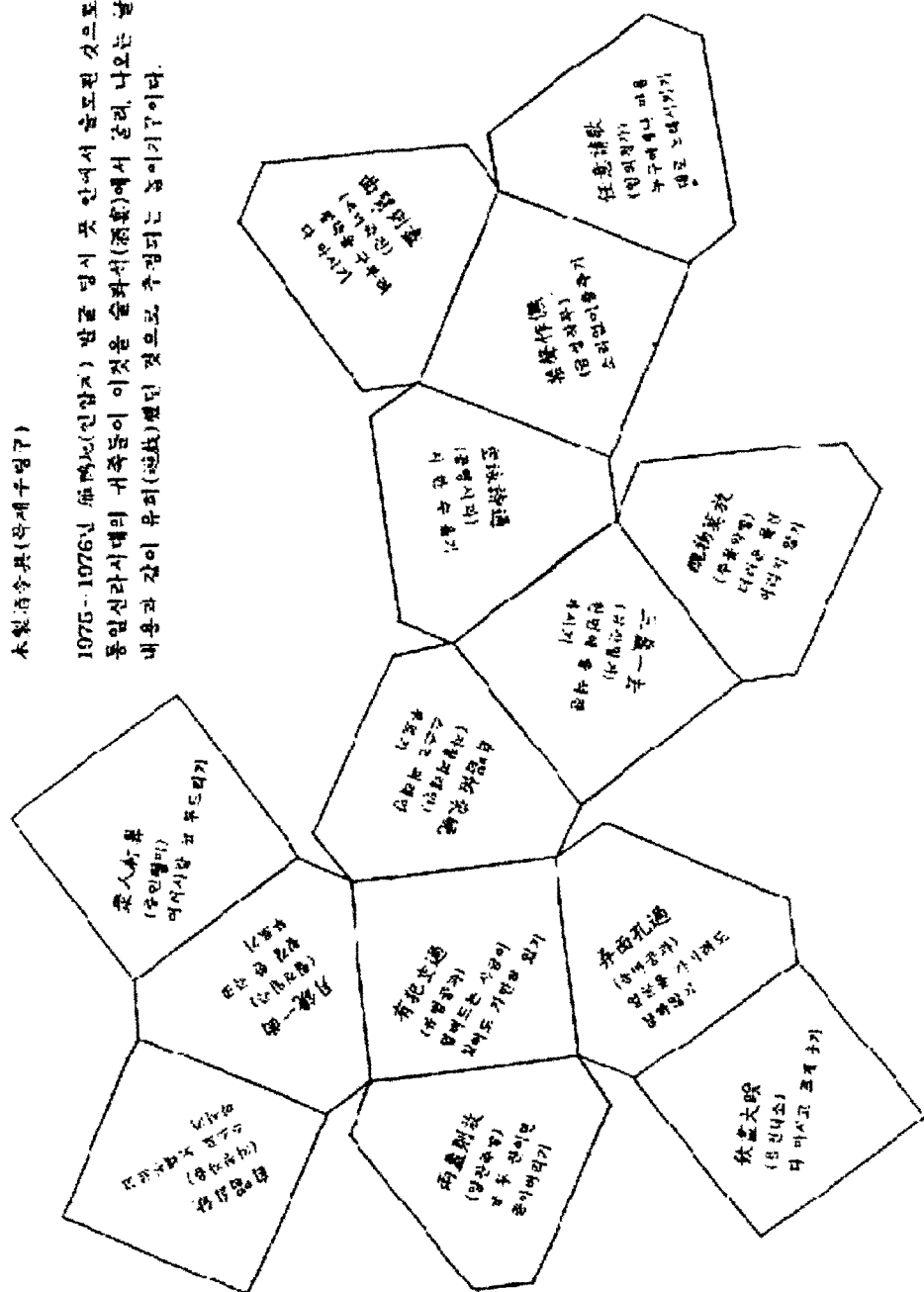
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	11	6	3	7	13	10	10	6	18	12		5	5		9	10	8	44	0.100761538
2	4	16	13	9	8	8	7	6	13	13	6			10		15	7	6	153	0.106082417
3	4	9	4	8	7	7	8	12	11	9	14			5						
4	3	7	3											4						
5	2	8	10											4						
6	7	12	2											7						
7	2	6	2											1						
8	3	7	1											4						
9	2	10	8											4						
10	2	4	8											3						
11	1	13	4											3						
12	1	5	5											0						
13	3	6	6											0						
14	2	21	2											0						

3. Enrichment Activity

Make the Wooden Die for Drinking Game using the following development figure. It is an excellent idea to cut 8 vertices from a cube not to be pointed, and make a tetradehedron. It can be made from an octahedron to cut six vertices as well.

木製消令果(목제구령구)

1075-1076년 雁鴈池(인암지) 발굴 당시 뜻 안에서 출토된 것으로,
동일신라시대의 귀족들이 이것을 술화석(酒花石)에서 골라 나오는 별자의
내용과 같이 유희(遊戱)했던 것으로 추정되는 놀이기구이다.



V. CONCLUSION

To develop the content and form of the teacher education program for mathematical excellence, we reviewed several teacher education programs. We found several projects and studies that addressed mathematics teacher education. Such projects and programs as Cognitively Guided Instruction (CGI), Problem-Centered Mathematics Project (PCMP), The Atlanta Mathe Project (AMP), Elementary Mathematics Project (EMP), Teacher Education and Learning to Teach Study (TELTS), Quantitative Understanding: Amplifying Student Achievement and Reasoning (QUASAR) Project, SummerMath for Teachers Program (SMT), and Teachers Improving Mathematics Education (TIME) are considered representative of those available (Grouws & Schultz 1996). CGI was an excellent model for teacher education program for mathematical excellence, because CGI teachers have exchanged their own experiences and taught teachers in National Conference every year since 2002.

We developed the 12 teacher education programs based on mathematical tasks developed for the gifted children and have applied them to teacher education. The specific written protocols of talented children could be a good material for teacher education for mathematical excellence.

It is not so difficult to develop more programs, because we have made a lot of tasks for the gifted in mathematics for 8 years. The types of tasks developed can be divided into experimental, group discussion, open-ended problem solving, and exposition and problem solving tasks. Levels of the tasks developed for talented elementary students in mathematics can be further divided into grade 5 and under, grade 6, and grade 7 and over.

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