DEVELOPING A MATHEMATICS ACHIEVEMENT TEST FOR GIFTED MATHEMATICS STUDENT IN GRADE 10 BY USING HIGHER LEVEL OF THINKING PROCESSES

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Abstract: The objectives of this dissertation were (1) to develop a mathematics achievement test for gifted mathematics student in grade 10 by using higher level of thinking processes, and (2) to assess the mathematics ability of gifted mathematics student. The samples were 241 grade 10 students of a government secondary school studying in science and mathematics specialized program. The mathematics achievement test for gifted mathematics student by using higher level of thinking processes was composed of 28 items including 25 gap-filling items, designed in the cross-dimensional test, (content dimension x process dimension) and 3 essay-typed questions. The test was implemented by computers.

The researching findings were summarized as follows:

1. 40 criteria were developed including 28 criteria for item interpretation, 5 criteria for content, 5 criteria for process, 1 criterion for advanced thinking skills and 1 criterion for mathematics ability.

2. The assessment results in terms of advanced thinking skill were found out that 58.09 percent of the samples were extremely gifted, and 12.03 percent of the samples did not indicate any mathematics talent.

3. The assessment results in terms of mathematics ability were found out that 2.90 percent of the samples showed the extreme ability; 31.12 percent of the samples showed the exceptional ability; 39.83 percent of the samples showed the high ability; 14.11 percent of the samples showed the moderate ability; and 12.03 percent of the samples showed the mild ability.

Keywords: A Mathematics Achievement Test, Gifted Mathematics Student, Higher Level of Thinking Processes

Introduction

The process management on Mathematics teaching and learning according to the need of gifted mathematics students is the important step for fulfilling students' potential. Consequently, the model of teaching and learning must be considered from the content target of teaching and the characteristics of learners in order to establish the efficiency teaching and learning process for gifted mathematic students. Therefore, the teachers, firstly, have to assess each student' mathematics ability and evaluate their strength and weak points. This information will be the essential information technology to enhance the strength point and improve the weak point immediately. To achieve that, the mathematics ability measurement is the important mechanism for successful education management for gifted mathematics students. However, some problems will arise from inappropriate measurement instrument development system. If the simple test is used to compare the students' ability level as the instrument, it will not only result in the over high scores or ceiling scores (Lupkowski-Shoplik, Benbow, Assouline and Brody, 2003), but will also affect the information technology the teachers will get. Therefore, the instrument or the test should have a high degree of difficulty and be suitable for gifted students' abilities. From the study of the concept of gifted mathematics students, it was found that the gifted students were able to find out the answers with high speed and accuracy more than the ordinary students were at the same age and with similar experience (Oxford Brookes University, 2007). Hence, the time spent in doing the test is used to evaluate the level of students' abilities.

Typically, a paper-pencil test has some limitation for gaining information technology concerning the time spent since it could not calculate the time spent as conveniently, correctly, and accurately as using technology to do so. In order to diminish such limitation, it is essential to develop the measurement instrument by using computer-bases test. Moreover, the concept of the traditional test used in the present also has the important limitation because the variation of the parameter of the test between the tester group and the observed scores or abilities evaluation of testers depended on the questions and the test being used (Sirichai Kanjanawasi, 2007). This means that the estimation of students' abilities needs to apply the Item Response Theory to time spent in each question of the test for getting the highest information technology.

The researcher, thus, was interested in developing the mathematics ability measurement instrument for gifted mathematics students in the upper secondary school level that focus on the high level of thinking ability. The instrument is applied by using the Item Response Theory and time spent in doing the test of each student as the key indicators to filter students' level of mathematics abilities. Time spent in doing each item of the test can be measured by using computer – based test and then the result can be used as the criteria for giving the score to each item of test.

The Purposes of the Study

1. To develop a mathematics achievement test for gifted mathematics student in grade 10 by using higher level of thinking processes.

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2. To assess the mathematics ability of gifted mathematics student in grade 10 by using higher level of thinking processes.

Framework of the Study

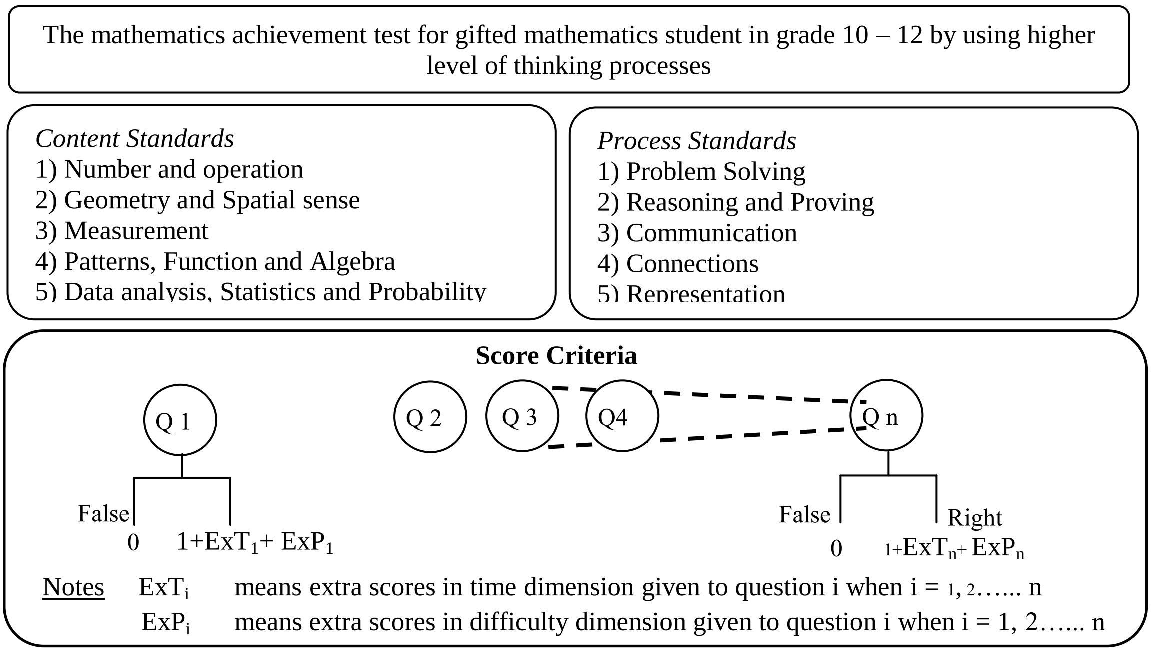

Figure 1: the Framework of the

Research Methodology

The methodology adopted in this study was divided into 4 steps as follows: (1) forming a table of mathematics achievement test for gifted mathematics student, (2) collecting the data, (3) analyzing the quality of the mathematics achievement test, and (4) setting the standard criteria of mathematics achievement test.

Step 1 - Forming a table of mathematics achievement test by using the framework of mathematics curriculum of National Council of Teachers of Mathematics- 2002 (Gurganus, 2007). The results are shown in Table 1 and Table 2.

Step 2 - Collecting Data The researcher collected the data from 241 grade 10 students of a government secondary school studying in science and mathematics specialized program provided for gifted mathematics students.

Step 3 - Analyzing the quality of mathematics achievement test. The researcher examined whether the developed instrument met the need of its structure by using the Confirmatory Factor Analysis, together with the scores gained from developed instrument, to calculate the coefficient value correlated with the scores gained from the standard instrument.

Step 4 – Setting the standard criteria for the mathematics achievement test which consists of 5 sub-criteria as follows:

Table 1: Table of Mathematics Achievement Test for Gifted Mathematics Student in Grade 10 by Using Higher Level of Thinking Processes (Completion Test)

Content Standards	Process Standards					Notes
	Problem Solving	Reasoning and Prove	Communication	Connections	Representation	
1. Number and operation	Q 1	Q 2	Q 3	Q 4	Q 5	Q 1-5
2. Geometry and Spatial sense	Q 6	Q 7	Q 8	Q 9	Q 10	Q 6-10
3. Measurement	Q 11	Q 12	Q 13	Q 14	Q 15	Q 11-15
4. Patterns, Function and Algebra	Q 16	Q 17	Q 18	Q 19	Q 20	Q 16-20
5. Data analysis, Statistics and Probability	Q 21	Q 22	Q 23	Q 24	Q 25	Q 21-25
Total (items)	5	5	5	5	5	25

Table 2: Table of Mathematics Achievement Test for Gifted Mathematics Student in Grade 10 by Using Higher Level of Thinking Processes (Subjective Test)

Problem Solving, Reasoning and Prove	Communication and connection	Representation
Q 26	Q 27	Q 28

Notes This is the integration of 5 aspects of standard content, which are 1) number and operation 2) geometry and spatial sense 3) measurement 4) patterns, function and algebra 5) data analysis, statistics and probability.

4.1 Standard criteria for giving extra score in time dimension. The researcher will take the time spent in doing the test correctly to set as the standard criteria for giving extra score in time dimension. The results are shown in Figure 2.

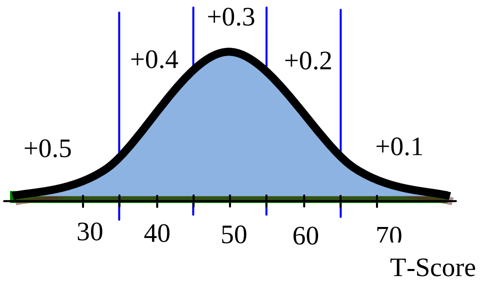

Figure 2: Standard Criteria for Giving Extra Score in Time Dimension

4.2 Standard criteria for giving extra score to the test in difficulty dimension. The researcher used the parameter of the difficulty degree provided to each item of the test calculated from estimated parameter of each item of the test by using the Item Response Model- type 1 and set the result as the standard criteria for giving extra score in difficulty dimension. The results are shown in Figure 3.

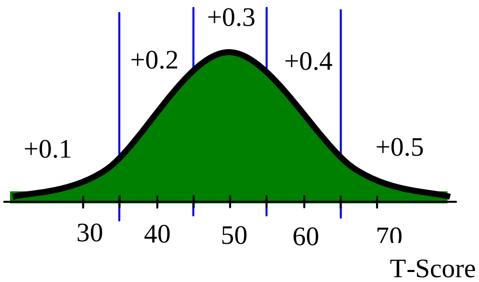

Figure 3: Standard Criteria for Giving Extra Score in Difficulty Dimension

4.3 Standard criteria for giving extra score to completion test. The researcher set the standard criteria for giving extra score to completion test by giving score to each item of the test as follows: 1) giving the fault answer to item 1 will get 0 point and 2) giving the right answer to item 2 will get 1 point plus extra scores from time dimension and from the difficulty dimension. In case of giving the right answer to item i, it can be summarized in the equation:

$$S\ (i) = 1 + ExT_i + ExP_i$$

When: S (i) means the score given to item i for the right answer.
ExT_i means the extra score given to item i in time dimension.
ExP_i means the extra score given to item i in difficulty dimension.

4.4 Standard criteria for giving extra score to subjective test. The researcher set the standard criteria for giving extra score to subjective test in 3 items, 2 points for each item. The criteria for giving extra score was considered from1) Fluency- giving the more direct to the point answers in a limited time 2) Flexibility- optional thinking not focusing on only one concept 3) Originality- new thinking different from the past, and 4) Elaboration- detailed consideration used to decorate the more complete thought.

4.5 Standard criteria for the interpretation of the mathematics achievement test. The researcher set the standard criteria for the interpretation of each item of the test in the aspects of content, process, advanced thinking skill, and the over all of the upper secondary school students who have gifted mathematics abilities. The level of gifted mathematics abilities is divided into 6 levels as shown in Table 3.

Table 3: Standard Criteria for Translating the Meaning of the Mathematics Achievement Test

Level	Standard Scores	Gifted Mathematics Ability Level
6	Above 65 points	Extremely
5	Between 55 – 64 points	Exceptionally
4	Between 45 – 54 points	Highly
3	Between 35 – 44 points	Moderately
2	Below 35 points and raw point ≠ 0	Mildly
1	Below 35 points and raw point = 0	None

The Research Results

The results from this research can be summarized in 3 issues as follows:

1. Creating 28 criteria for the interpretation by item of the test, 5 for Content, 5 for Process, 1 for Advanced thinking skill, and 1 for mathematics ability total 40 criteria. The detail is shown in Table 4.

3. Mathematics ability evaluation. The evaluation of gifted mathematics ability of 241 Grade 10 students of a government secondary school studying in science and mathematics specialized program indicated that 39.83% of students were in highly level of gifted mathematics ability, while 31.12 % were in exceptionally level. Only 12.03% showed their abilities in mildly level. The detail is shown in Table 6 (see in next page).

Table 4: Meaning Interpretation Criteria Created from the Test

Question No.	Level of gifted mathematics ability					
	None	Mildly	Moderately	Highly	Exceptionally	Extremely
Each item criteria						
No. 1, 5 and 25	0	1.2	1.3	1.4	1.5	1.6
No. 2, 3, 7, 9, 12, 14, 15, 16 and 22	0	1.4	1.5	1.6	1.7	1.8
No. 4, 6, 21 and 24	0	1.3	1.4	1.5	1.6	1.7
No. 8,10, 13, 17, 19, 20 and 23	0	1.5	1.6	1.7	1.8	1.9
No. 11 and 18	0	1.6	1.7	1.8	1.9	2.0
No. 26, 27 and 28	0	-	1	-	-	2
Content Criteria						
Number and operation	0	1.2 - 1.9	2.0 - 4.3	4.4 - 6.8	6.9 - 9.2	Above 9.3
Geometry and Spatial sense	0	1.2 - 1.3	1.4 - 4.3	4.4 - 7.2	7.3 - 10.2	Above10.3
Measurement	0	1.2 - 1.5	1.6 - 4.3	4.4 - 7.0	7.1 - 9.8	Above 9.9
Patterns, Function and Algebra	0	1.2 - 1.3	1.4 - 4.3	4.4 - 7.3	7.4 - 10.3	Above 10.4
Data analysis, Statistics and Probability	0	1.2 - 1.8	1.9 - 4.3	4.4 - 6.7	6.8 - 9.1	Above 9.2
Process Criteria						
Problem Solving	0	1.2 – 2.5	2.6 – 4.6	4.7 – 6.7	6.8 – 8.7	Above 8.8
Reasoning and Prove	0	1.2 – 2.2	2.3 – 4.5	4.6 – 6.7	6.8 – 9.0	Above 9.1
Communication	0	1.2 – 2.0	2.1 – 4.5	4.6 – 7.1	7.2 – 9.6	Above 9.7
Connections	0	1.2 – 3.0	3.1 – 4.7	4.8 – 6.4	6.5 – 8.2	Above 8.3
Representation	0	1.2 – 2.4	2.5 – 4.6	4.7 – 6.8	6.9 – 8.9	Above 9.0
Advanced thinking skill Criteria	0-1	2	3	4	5	6
Mathematics ability Criteria	0	1.0-21.6	21.7-29.3	29.4-36.9	37.0-44.6	Above 44.7

2. Mathematics ability evaluation in advanced thinking skill aspect. The evaluation of gifted mathematics ability in advanced thinking skill of 241 grade 10 students of a government secondary school specialized in science and mathematics study program indicated that 58.09 % of those students performed the extremely level of mathematics ability. Only 12.03% didn’t show any the mathematics ability in advanced thinking skill. The detail is shown in Table 5.

Research Discussion

The results from the mathematics achievement test for gifted mathematics student in grade 10 by using higher level of thinking processes indicated the interesting issues to be discussed as follows:

1. The mathematics achievement test constructed and developed from this study was the standard instrument according to the criteria of standard instrument development. Therefore, it reflected the validity and reliability in the following characteristics.

Table 5: Number and Percentage of Gifted Mathematics Students in Advanced Thinking Skill Aspect

Level of gifted mathematics ability	Number	%
1. None	29	12.03
2. Mildly	25	10.37
3. Moderately	7	2.90
4. Highly	27	11.20
5. Exceptionally	13	5.39
6. Extremely	140	58.09
Total	241	100.00

Table 6: Number and Percentage of Gifted Mathematics Students at the Different Level of Ability

Level of gifted mathematics ability	Number	%
1. None	0	0.00
2. Mildly	29	12.03
3. Moderately	34	14.11
4. Highly	96	39.83
5. Exceptionally	75	31.12
6. Extremely	7	2.90
Total	241	100.00

1.1 Content Validity - this set of instrument was approved from considering the definition, measurement structure, and content validity from 7 experts who graduated in Master or Doctoral degree of Mathematics together with the mathematics teaching experience in the upper secondary school level or the experience related to conducting the mathematics curriculum or national mathematics test for at least 2 years. Those experts agreed that the definition and structure of this instrument was correct and suitable to be used as the mathematics ability measurement for gifted mathematics students in the upper secondary school level.

1.2 Construct Validity - the Confirmatory Factor Analysis on the constructed instrument was considered from 5 content aspects and 5 process aspects in total 10 standards as follows:1) number and operation 2) geometry and spatial sense 3) measurement 4) patterns, function, and algebra 5) data analysis, statistics and probability 6) problem solving 7) reasoning and proof 8) communication 9) connections 10) representation showed that the results were in accordance with the definition, content structure from the related concept and documents. The results from this study can be used to prove and summarize with the empirical evidence that this instrument performs the construct validity.

1.3 Concurrent Validity - the analysis of the relation between the scores gained from the constructed instrument and scores gained from the mathematics test (focusing on analysis and problem solving aspect) constructed by a government scientific school showed the correlation coefficient value at 0.80. Besides, the analysis on the relation between the score gained from constructed instrument and mathematics ability evaluation showed the Pearson's correlation coefficient value at 0.80. Therefore, it can be concluded that this constructed instrument performs the concurrent validity.

1.4 Reliability - the analysis of the constructed instrument evaluated by content aspect standard showed the reliability value at 0.79 - 0.86. This result indicated that the constructed instrument evaluated by content aspect standard has the reliability value at the appropriate level. In addition, the reliability value analyzed on the constructed instrument evaluated by the process aspect standard was at 0.52 - 0.62. Because the set of item of the test focusing on each aspect of the process standard. Therefore, students who have high level of the process skill, but do not have knowledge in each content aspect could not answer the question correctly. Thus, it reflected the moderate level of reliability value.

2. Regarding to the criteria for constructed mathematics achievement test interpretation, the researcher used the T-score as the indicator for interpretation and used difficulty parameter of the test and time spent in doing the test as the indicator for giving extra score. The criteria can be divided into 6 levels: T- scores above 65 is considered at the extremely level, 55- 64 at exceptionally level, 45-54 at highly level, and 35-44 at moderately level. For the T-score below 35, if the raw score is more than 0, it is considered at the mildly level. Moreover, if the raw score equals to 0, it indicated none of giftedness. These results were in accordance with the ability level evaluated by Gagne' Metric-Based (Gagne, 2003). Besides, the created interpretation criteria separated by item, aspect, advanced thinking skill, and overall were the important information technology for improving the mathematics ability of gifted mathematics students in the upper secondary school level including solving the ceiling score problem (Lupkowski-Shoplik, Benbow, Assouline and Brody, 2003). Moreover, these created criteria will stimulate learners to practice more and find out the mathematics solution more accurate and speedy.

3. The evaluation of mathematics ability of gifted mathematics students in grade 10 in advanced thinking skill aspect revealed that 58.09 % of the samples showed the mathematics ability at extremely level. Meanwhile only 12.03 % did not indicate any mathematics talent. Moreover, the evaluation of students' mathematics ability found that 2.90%, 31.12 %, 39.83%, 14.11%, and 12.03% are extremely, exceptionally, highly, moderately, mildly level, respectively. These results were in accordance with the selection process of this school in selecting the highly level of mathematics and scientific abilities students. The evaluation of the constructed instrument can be used to distinguish the students who can answer the test correctly but in different period. As the result, more information technology is gained than the test used in the past. Furthermore, reviewing the evaluation of advanced thinking skill aspect and of mathematics ability, it was found that the evaluation was consistency to the Spearman's correlation at the value of 0.83 and identified the correlation between the evaluation of advanced thinking skill aspect and of mathematics ability.

Suggestion

1. Implication for Using the Test

1.1 The executives of educational institutions should consider the developed mathematics ability measurement instrument for gifted mathematics ability students in grade 10-12 and employ this instrument as the filter to select those students to study in their schools. This is because this instrument use the time spent in doing the test correctly and difficulty index of the test as the criteria for giving extra score. As the result, selecting giftedness level can be done more efficient than the previous instrument.

1.2 The Head and teachers of the mathematics department of this government scientific school should apply the information technology gained from this research to im-prove and develop the curriculum including learning and teaching or teaching material management for personal potential development.

1.3 Students should take advantage of the information technology gained from the gifted mathematics ability test, i.e., the evaluation of mathematics ability, the content evaluation of 5 aspects, i.e., 1) number and operation, 2) geometry and spatial sense, 3) measurement, 4) patterns, function, and algebra, and 5) data analysis, statistics and probability, together with the process evaluation in 5 standards, i.e., 1) problem solving, 2) reasoning and proof, 3) communication, 4) connections, and 5) representation , and the evaluation by item to compare with the criteria for self-improvement and development.

1.4 Since the constructed instrument or test created by the researcher was recorded in the PDF file, it can be changed anytime to meet the need and the gifted ability of children academics Moreover, anyone who is interested can use this constructed instrument being applied to the gifted mathematics student selection process of other level or to the other gifted students in Thailand.

2. Suggestion for the Further Study

2.1 Appling the concept of time spent in doing the test correctly and difficulty index by item of the test as the criteria for giving extra score to other gifted students in order to develop the competency of measurement and evaluation gifted students, which will be useful for education management for gifted students in Thailand.

2.2 From this research, 7 students were found out of the extremely level of gifted mathematics ability. Therefore, the further study should be focused on the function of these students' brain including conducting the comparative study of the brain's electrical activity between male and female while they are doing the high difficulty level test. The result will be used as the guide for studying gifted mathematics students and further filtering those students.

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