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Development of Shimane Academic Motivation Test for School Mathematics (SHIMANE-AMTM) (2)

——On the Scale for Measuring
Attitudes toward Mathematics Learning (MLAS)——
Dedicated to Professor Miyuki Yamada
on his 60th birthday

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Abstract: In this papar, I report the validity and reliability of the MLAS developed by the author to measure attitudes toward mathematics learning.

The summaries of this study are following:

(1) The good-poor analysis and analysis by correlating item scores with total scores of the MLAS were conducted to examine the discrimination validity of the MLAS. As the result, the MLAS obtained a moderately high discrimination validity.

(2) 3 reliability coefficients (Cronbach's α coefficient, A split-half reliability coefficient, and A test-retest reliability coefficient) for the MLAS were calculated. As the result, the MLAS obtained a moderately high reliability.

(3) A principal components solution using the principal axis method with varimax rotation resulted four factors: favor to mathematics learning, value of mathematics learning, enjoyment of thinking, and importance of mathematics to society.

1 Introduction

1—1 Rationale for the study

Recently, topics related to the affective domain in mathematics learnig have been much concern in Japan. Minato (1979), Saeki (1979), Ito (1980), and Imai (1986) translated some attitudinal instruments which were developed in U.S.A. into Japanese, and they administered these instruments to Japanese students to test these reliability and validity.

These instruments are as follows:

(1) A Thurstone-type attitude scale toward arithmetic developed by Dutton (1962),

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(2) A Likert-type mathematics attitude scale developed by Aiken (1972),
(3) A Semantic Differential Scale constructed by McCallon and Brown (1971),
(4) A Likert-type enjoyment and value scales by Aiken (1972),
(5) A mathematics attitude inventory developed as the multidimensional instruments by Sandman (1973),
(6) A Likert-type mathematics attitude scale developed as the multidimensional instruments by Aiken (1979).

With the experience of translation and examination of these instruments, some attitudinal instruments were developed recently in Japan.

Minato (1983) developed a semantic differential, simply referred to as the MSD, for measuing attitudes toward school mathematics.

Imai (1985) developed a Likert-type mathematical problem solving attitude scale.

Ito, et al. (1986) developed a Likert-Type Achievement Motivation Scale in Mathematics Learning (AMSAL) to measure the tendency to achieve success in mathematics learning, and a Likert-Type Anxiety Scale in Mathematics Learning (ASML) to measure the tendency to avoid failure in mathematics learning.

Moreover Ito, et al. (1986) developed a Likert-Type Mathematics Self Concept Scale (MSCS) to measure the self concept toward school mathematics and a Likert-Type Mathematical Problem Solving Attitude Scale (MPSAS) to measure attitudes toward mathematical problem solving.

From now on, students'attitudes toward school mathematics will get greater and greater with students' academic motivations in mathematics learning.

In this papar, I will report the validity and reliability of the MLAS developed by the author.

1 — 2 Purposes of the study

The purposes of this study are as follows:
(1) to describe results of item analysis,
(2) to describe some reliability coefficients,
(3) to describe factor analytic results.

1 — 3 Definition of terms

Since the turn of the century, the study of attitudes has been a major concern of social psychologists.

Many definitions of attitudes have been advanced.

Most of these definitions indicate that an attitude is a predisposition to react in a consistant way to certain stimuli.

Many investigators have considered attitude to consist of cognitive, affective and behavioral components.

From the precedent studies of attitudes, the following definition of attitude toward mathematics learning results:

An attitude toward mathematics learning is a tendency to respond to mathematics learning in a consistently favoable or unfavorable, and consists of "studends' feelings such as enjoyment, interest and liking of mathematics learning" and "students' belief such as importance of mathematics and value of mathematics learning"

2 Procedure

2 — 1 Subjects

The subjects of this study were as follows:

(1) 83 students (35 males and 48 females) in the second grade of a public junior high school, located in a small city, Shimane Prefecture, Japan,

(2) 40 prospective secondary school mathematics techers (19 males and 21 females) of Shimane University.

They were conducted during July 1987.

2 — 2 Construction of the MLAS

40 Items conceived to attitudes toward mathematics learning were collected with the following categories based on the precedent studies toward school mathematics (Aiken, 1972, 1974, 1979; Dutton, 1962; Sandman, 1973; Imai, 1985; Ito, et al., 1986; Objectives of the School Mathematics in the Course of Study in Japan, 1958, 1969, 1977);

(1) Enjoyment of mathematics learning,
(2) Interest of mathematics learning,
(3) Liking of mathematics learning,
(4) Importance of mathematics to society,
(5) Value of mathematics learning.

This 40 items test was given to 40 prospective secondary school mathematics teachers of Shimane University (the same subjects as this study) during April 1987.

The good group consists of the subjects of the upper one-fourth of students and the poor group, the lower one-fourth.

For each item, there were the mean differences test between the good group and the poor group.

As the result, a 25 item Likert-Type Mathematics Learning Attitude Scale (MLAS) such as to indicate in Table 1 was obtained.

Table 1 Mathematics Learning Attitude Scale (MLAS)

Directions. Draw a circle around the numeral that show how closely you agree or disagree with each statement:

0 ··················Strongly Disagree
1 ··················Disagree
2 ··················Undecided
3 ··················Agree
4 ··················Strongly Agree

1. Studying mathematics is not enjoybale to me. 0 — 1 — 2 — 3 — 4
2. I enjoy solving mathematics problems. 0 — 1 — 2 — 3 — 4
3. When I attend a mathematics class and hear mathematics being discussed, I get a enjoyable feeling. 0 — 1 — 2 — 3 — 4
4. To reason logically in studying mathematics in school is enjoyable to me. 0 — 1 — 2 — 3 — 4
5. I enjoy thinking out a solution in studying mathematics. 0 — 1 — 2 — 3 — 4
6. I am interested in solving mathematics problems. 0 — 1 — 2 — 3 — 4
7. To read mathematics text-books or to examine refrence-books for the study of mathematics is interesting to me. 0 — 1 — 2 — 3 — 4
8. I feel studying mathematics to be dull and boring. 0 — 1 — 2 — 3 — 4
9. I am not interested in studying mathematics as symbols, the terms and diagrams make an appearance in mathematics. 0 — 1 — 2 — 3 — 4
10. Studying mathematics is interesting to me since I often find myself able to think in a variety of ways when studying mathematics. 0 — 1 — 2 — 3 — 4
11. I like trying to solve puzzles and to play games that involve some intellectual challenge in studying mathematics. 0 — 1 — 2 — 3 — 4
12. I don't like studying mathematics. 0 — 1 — 2 — 3 — 4
13. I would not like to challege new problems in mathematics. 0 — 1 — 2 — 3 — 4
14. I like studying mathematics since it gives me pleasures of thinking. 0 — 1 — 2 — 3 — 4
15. I like to find rules or to think in a variety of ways in studying mathematics. 0 — 1 — 2 — 3 — 4
16. Mathematics is not useful in everyday life. 0 — 1 — 2 — 3 — 4
17. Mathematics is necessary in science and other fields of knowledge. 0 — 1 — 2 — 3 — 4
18. Mathematics is important to artists and writers. 0 — 1 — 2 — 3 — 4
19. Mathematics is not more important than art and literature. 0 — 1 — 2 — 3 — 4
20. Mathematics is necessary for advancement of civilization and society. 0 — 1 — 2 — 3 — 4
21. Studying mathematics helps a person have a good think. 0 — 1 — 2 — 3 — 4
22. Studying mathematics doesn't teach a person to think new thoughts. 0 — 1 — 2 — 3 — 4
23. Studying mathematics teaches a person to devise. 0 — 1 — 2 — 3 — 4
24. Studying mathematics teaches a person to think in a variety of ways. 0 — 1 — 2 — 3 — 4
25. Studying mathematics hepls a person develop to reason and to explain logically. 0 — 1 — 2 — 3 — 4

The MLAS scores obtained by finding the sum of the ratings of the 25 items may range from 0 to 100.

3 Analyses of the data and discussion

3－1 Validity of the MLAS

The Good group (G group) consists of the subjects of the upper one-fourth of students for the MLAS scores, and the Poor group (P group), the lower one-fourth of the students.

The Table 2 indcates the results of mean differences test between G group and P group for prospective secondary school mathematics teachers.

For all items, there were significant mean differences between G group and P group.

The Table 3 indicates the results of mean differences test between G Group and P group for junior high school students.

For all items except item 16, 17, and 20, there were significant mean differences between G group and P group.

The good-poor analysis procedure showed that subjects of this study discriminated all items of the MLAS.

The Table 4 indicates correlations between each item score and the total scores for prospective secondary school mathematics teachers.

Such as to indicate in Table 4, correlations between each item and the total scores were all significant for prospective secondary school mathematics teachers.

The Table 5 indicates correlations between each item score and the total scores for junior high school students.

Such as to indicate in Table 5, correlations between each item score and the total scores for junior high school students were all significant except item 16, 19, and 24.

Thus, each item of the MLAS made significant contribution to the total scores.

3－2 Reliability of the MLAS

3－2－1 Cronbach's α coefficient

The Table 6 indicates Cronbach's α coefficient used for the internal consistency of the MLAS.

Cronbach's α coefficient is given by:

$$r=\frac{n}{n-1}\left[1-\frac{S_j^2}{S_x^2}\right]$$

where n is the number of items, S_j^2 is the scores-variance on each item and S_x^2 is the variance of the scores on all items.

Table 2 Mean differences between G group and P group for prospective secondary school mathematics teachers

Item	G group		P group		Difference
	Mean	Variance	Mean	Variance	
1	3.4	0.20	2.2	0.76	**
2	3.4	0.44	2.4	0.76	**
3	3.1	0.29	2.3	0.21	**
4	3.3	0.21	2.2	0.36	**
5	3.3	0.21	2.3	0.41	**
6	3.5	0.25	2.5	0.85	**
7	2.9	0.49	1.8	0.36	**
8	3.5	0.25	2.4	0.76	**
9	3.1	0.49	2.4	0.44	**
10	3.4	0.24	2.3	0.41	**
11	3.7	0.21	2.6	1.04	**
12	3.4	0.24	2.7	0.61	**
13	3.4	0.24	2.5	0.85	**
14	3.0	0.40	2.3	0.41	**
15	3.1	0.09	2.5	0.45	**
16	3.4	0.24	2.6	0.64	**
17	3.6	0.24	3.1	1.00	*
18	3.8	0.20	3.1	0.89	**
19	3.4	0.24	2.8	0.96	*
20	3.5	0.25	2.9	0.89	*
21	3.2	0.36	2.1	0.09	**
22	3.5	0.25	2.3	0.41	**
23	3.3	0.21	2.2	0.16	**
24	3.3	0.21	2.3	0.41	**
25	3.3	0.21	2.2	0.16	**

** Significant at 1% level,
* Significant at 5% level.

Table 3 Mean differences between G group and P group for junior high school students

Item	G group		P group		Difference
	Mean	Variance	Mean	Variance	
1	3.1	0.40	2.1	0.59	**
2	3.0	0.47	1.9	0.52	**
3	2.9	0.33	2.1	0.56	**
4	2.7	0.29	2.1	0.46	**
5	2.7	0.37	1.7	0.18	**
6	3.0	0.33	2.1	0.65	**
7	2.4	0.33	1.5	0.43	**
8	3.3	0.29	2.1	0.88	**
9	2.6	0.71	2.0	0.47	**
10	2.8	0.40	1.9	0.27	**
11	3.3	0.50	2.6	0.50	**
12	3.0	0.38	1.8	0.63	**
13	3.1	0.46	2.1	0.34	**
14	2.2	0.37	1.6	0.33	**
15	2.9	0.37	1.8	0.40	**
16	3.0	0.99	2.8	0.78	
17	3.3	0.41	3.0	0.66	
18	3.3	0.41	2.8	0.34	**
19	2.7	0.49	2.1	0.56	**
20	3.1	0.50	3.0	0.19	
21	2.8	0.53	2.2	0.65	**
22	3.2	0.27	2.2	0.53	**
23	2.8	0.53	2.3	0.61	*
24	3.1	0.37	2.6	0.41	**
25	3.0	0.38	2.3	0.41	**

** Significant at 1% level,
* Significant at 5% level.

Table 4 Correlation between each item score and the total scores for prospective secondary school mathematics teachers

Item	Correlation
1	0.696 **
2	0.640 **
3	0.511 **
4	0.739 **
5	0.729 **
6	0.721 **
7	0.556 **
8	0.646 **
9	0.651 **
10	0.720 **
11	0.578 **
12	0.634 **
13	0.647 **
14	0.597 **
15	0.572 **

Item	Correlation
16	0.323 *
17	0.517 **
18	0.425 **
19	0.324 *
20	0.448 **
21	0.515 **
22	0.637 **
23	0.611 **
24	0.570 **
25	0.613 **

** Significant at 1% level,
* Significant at 5% level.

Such as to indicate in Table 6, the MLAS for prospective secondary school mathematics teachers obtained a high internal-consistency reliability.

But there was obtained a low internal-consistency reliability of the MLAS for junior high school students.

Thus, it was estimated that the MLAS obtained a moderately high internal-consistency.

3 — 2 — 2 Reliability coefficient by the split-half method

I splited into groups: odd-numberd items and even-numbered items, and got the correlation coefficient (r). And I got reliability coefficient by Spearman-Brown formula.

Reliability coefficient by Spearman-Brown formula is given by:

$$r_x = 2r/(1+r)$$

The r_x was 0.929 for prospective secondary school mathematics teachers and 0.727 for junior high school students.

The split-half reliability was high for prospective secondary school mathematics tearchers, whereas was low for junior high school students.

Thus, it was estimated that the MLAS had a moderately high reliability.

Table 5 Correlation between each item score and total scores for junior high school students

Item	Correlation	Item	Correlation
1	0.527 **	16	0.205
2	0.586 **	17	0.328 **
3	0.416 **	18	0.226 *
4	0.454 **	19	0.025
5	0.568 **	20	0.236 *
6	0.519 **	21	0.310 **
7	0.380 **	22	0.354 **
8	0.555 **	23	0.259 *
9	0.298 *	24	0.212
10	0.590 **	25	0.328 **
11	0.373 **		
12	0.575 **		
13	0.493 **		
14	0.387 **		
15	0.576 **		

** Significant at 1% level,
* Significant at 5% level.

Table 6 Cronbach's α coefficient for the MLAS

Students	College	Junior high school
α	0.930	0.757

3 — 2 — 3 Reliability coefficient by the test-retest method

The correlation coefficient between the MLAS scores on the pilot study and the MLAS scores on this study for prospective secondary school mathematics teachers was calculated.

The test-retest reliability was 0.830.

The MLAS obtained a moderately high test-retest reliability.

3 — 3 Factor analytic results

A principal factor analysis using the principal axis method with varimax rotation was performed for the MLAS scores of prospective secondary school mathematics teachers.

Four factors obtained were as follows:

(1) Factor 1: favor to mathematics learning,

(2) Factor 2: value of mathematics learning,

(3) Factor 3: enjoyment of thinking,

(4) Factor 4: importance of mathematics to society.

The Table 7 indicates the varimax rotated factor matrix for the MLAS of prospective secondary school mathematics teachers.

To describe the factor loading classifies as follows:

(1) near zero (0.00-0.29)

(2) small (0.30-0.49)

(3) moderate (0.50-0.69)

(4) strong (0.70-1.00)

The factor loadings above 0.30 are shown with * in the table 7.

Items 1,2,6,8,12, and 13 loaded strongly on factor 1 while items 3,9, and 11 loaded small.

Since each of these items contains one or more of the words 'enjoyble', 'interesting', 'dull', 'boring', or 'like' with reference to mathematics learning, the decision was made to call factor 1 the favor to mathematics learning.

Items 23 and 24 loaded strongly on factor 2 while items 14,22, and 25 loaded moderately. These five items contain such phrases as 'pleasures of thinking', 'teach a person to think new thoughts', 'helps a person develop to reason and to explain logically', and 'teach a person to devise' with reference to mathematics learning.

Thus, factor 2 was identified as value of mathematics learning.

Items 4,10, and 21 loaded moderately on factor 3 while items 5,7, and 15 loaded small. These items contain such phrases as'enjoy thinking out', 'like to think in a variety of ways', and 'to reason logically is enjoybale to me'. The decision was made to call factor 3 the enjoyment of thinking.

Items 19 and 20 loaded strongly on factor 4 while items 17 loaded moderately. Items 16 and 18 loaded small on factor 4. These five items contain such phrases as 'necessary for

Table 7 Varimax rotated factor matrix for the MLAS

Item	Factor			
	1	2	3	4
1	0.751 *	0.112	−0.261	0.179
2	0.831 *	0.120	−0.079	0.077
3	0.418 *	−0.034	−0.397 *	0.198
4	0.354 *	0.335 *	−0.584 *	0.209
5	0.437 *	0.364 *	−0.360 *	−0.074
6	0.828 *	0.197	−0.091	0.191
7	0.240	0.312 *	−0.487 *	−0.070
8	0.733 *	0.153	−0.122	0.225
9	0.452 *	0.521 *	−0.158	0.031
10	0.419 *	0.270 *	−0.568 *	−0.217
11	0.345 *	0.067	−0.405 *	0.067
12	0.765 *	0.243	−0.034	0.146
13	0.841 *	0.114	−0.106	0.110
14	0.351 *	0.590 *	−0.160	−0.074
15	0.492 *	0.145	−0.474 *	−0.136
16	−0.019	−0.011	−0.342 *	0.384 *
17	0.245	0.283	−0.079	0.501 *
18	0.197	0.369 *	0.026	0.365 *
19	0.022	−0.179	−0.312	0.763 *
20	0.226	0.359 *	0.273	0.733 *
21	0.148	0.239	−0.573 *	0.057
22	0.049	0.590 *	−0.222	0.592 *
23	0.019	0.706 *	−0.523 *	−0.052
24	0.130	0.832 *	−0.001	0.255
25	0.139	0.652 *	−0.255	0.215

advancement of civilization and society', 'useful in everday life', 'important to artists and writers', and 'necessary in science'.

Thus, factor 4 was identified as the importance of mathematics to society.

4 Conclusions

In this papar, I reported the validity and reliability of the MLAS to measure attitudes toward mathematics learning.

The summaries of conclusions of this study are following:

(1) The good-poor analysis and analysis by correlating item scores with total scores of the MLAS were conducted to examine the discrimination validity of the MLAS.

As the result, the MLAS obtained a moderately high discrimination validity.

(2) 3 reliability coefficients (Cronbach's α coefficient, A split-half reliability coefficient, and A test-retest reliability coefficient) for the MLAS were calculated.

As the result, the MLAS obtained a moderately high reliability.

(3) A principal components solution using the principal axis method with varimax rotation resulted four factors: favor to mathematics learning, value of mathematics learning, enjoyment of thinking, and importance of mathematics to society.

Since Shimane University is a small, private, urban school, the sample of this study may not be representative of the population of all prospective secondary school mathematics teachers.

Therefore, the results of this study may not be generalizable.

This study may need further study.

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