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A Status Analysis of Middle School Students' Preference for Science

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ABSTRACT

The purpose of this research was to survey middle school students' preference for science and its causal factors, so as to analyze the causal relationships between them.

Preference for science and its causal factors were defined theoretically, and a theoretical model was constructed to measure them and analyze the causal relationship by structural equation modeling. According to the theoretical model and a pilot test, a questionnaire was developed with three parts; the background information of a respondent, the preference for science, and the causal factors of preference.

The questionnaire was administered to one class per grade of randomly selected 8 middle schools from 4 areas across the country, and 819 students' data were collected.

Preference for science was defined as a state of mind. It revealed to what extent, and how, one likes science. It consisted of 3 categories - 'emotional response', 'behavioral volition', 'valuational comprehension', and each category was divided into two subcategories. Causal factors affecting the preference for science consisted of three categories - personal, educational and social factors, and each was divided into 2 or 3 subcategories.

Middle school students' preference for science was middling as a total. Curiosity about contents of science and valuation of science were high, comparatively, but behavioral volition about science was especially low. Students' responses to the causal factors were relatively high in every educational factor and sociocultural valuation of social factors, but relatively low in socioeconomic rewards of social factors, and especially low in personal factors.

The causal relationship about the preference for science was investigated by multiple regression analysis and path analysis, using the structural equation model. Multiple regression analysis about the preference for science and its causal factors revealed important factors. The important factors were personal ability, the personal traits, rewards in school science, and contents of school science in order of magnitude of standardized regression coefficient β. Stepwise regression analysis with each of the subcategories of the preference for science as dependent variables showed what factors were important in each subcategory.

According to the result of structural equation modeling, personal factors affected 'emotional response' and 'behavioral volition' directly, and social factors affected 'valuational comprehension'

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directly. Educational factors affected all categories of the preference for science by influencing not only 'emotional response' and 'valuational comprehension' directly, but also 'behavioral volition' indirectly.

The way to promote middle school students' preference for science was suggested, based on the analysis result.

Key words: middle school students, preference for science, casual factors, emotional response, behavioral volition, valuational comprehension, structural equation model

Ⅰ. Background and Purpose of Research

Major goals of science education are to develop science literacy for all, and to train future scientists and engineers. However, a recent tendency of a sharp decline in science track choice of high school students in College Scholastic Ability Test, which attracted public attention recently, makes it harder to secure national competitiveness through training of future scientists and engineers in science education (Woolnough, 1997). Recent international comparisons revealed that science achievement of elementary and secondary students was high, but lower as students became older, and students' interest in science declined (IEA, 2000; Benett, 2001; Sjoberg, 2000).

The problems of school science education have been indicated as an inner educational cause of this phenomenon for a long time, and efforts to improve this situation have been made on a national scale by relevant associations and organizations (Committee on Science Education Development, 2002; The Association of Science Culture Promotion, 2001; The Korean Association for Research in Science Education, 2001).

There is a need for extensive research, to more fully identify the many dimensions of the "avoidance of science" phenomenon by Korean youth, to target causal factors, and to progress toward a national policy aimed at reversing the trend.

It is judged that the strongest counter-measure to youth's evasion of science and technology lies in the improvement of science education. Preference for science by youth will be proposed as a goal of science education, which encompasses the raising of interest and intellectual curiosity about nature and science, increase of practical ability of inquiry, and increasing career awareness in science-related fields, as well as increasing comprehension of value and right belief about science. The first task is to survey and analyze in depth the status and causal factors of preference for science by youth, and to make plans to increase preference for science for each target group.

The purpose of this research is to survey and analyze in depth the status of middle school students' preference for science.

Specific research questions to deal in this research are as follows.

1) What is the status of middle school students' preference for science?

2) What are the causal factors of middle school students' preference for science?

3) What is the causal relationship between middle school students' preference for science and its causal factors?

According to the research results, some suggestions to enhance middle school students' preference for science will be made.

Ⅱ. Theoretical Discussion

To survey the status of middle school students' thinking, relative to their preference for science, it is necessary to define it well. A good definition of preference for science is essential to develop an appropriate instrument to measure it, and interpret the results that follow from the use of the instrument (Anderson, 1981). It is also required to know the factors affecting preference for science in order to present some suggestions, based on those factors, for enhancing middle school students' preference for science.

Therefore, after defining the preference for science conceptually, and identifying the causal factors behind such preference from previous research and theoretical discussions, theoretical models to describe the causal relationships will be offered on how to enhance preference for science among middle school students.

1. Definition of the preference for science.

There are some cases in which preference was mentioned in science education research. For example, preservice elementary teachers' science preference was measured by Markle (1978) as a kind of subject preference. Choi and Song studied students' preferences for different contexts of learning science (Choi and Song, 1996). Yoon selected preference for science learning as one of the major factors of science-related career choice (Yoon, 2001). Though meaning of preference was used variously in each research, Getzels defined a preference as "a disposition to receive one object as against another", a tendency to choose one object, activity or idea as opposed to another object, activity or idea. As an affective characteristic, preference may involve attitudes, interests or values. Preferences are most likely learned and possess a degree of stability (Getzels, 1966, re-quoted in Anderson, 1981).

In this study, preference for science in an affective domain was defined conceptually as follows. It has multidimensional attributes, not simply represent the one-dimensional degree of like or disgust about certain target emotionally (Im & Pak, 2000). As a concept to describe the goal of elementary and secondary school science education, preference for science was defined provisionally as a state of mind revealing to what extent and how one likes science. According to the degree of internalization, the meaning of preference for science can be divided into 3 categories such as emotional response which represents preferring response to science and

science learning, behavioral volition to study science and choose science-related studies and careers, and valuational comprehension about science, technology and science learning. Each category can be divided into 2 subcategories as follows, according to concept attributes. Details of the meaning of categories and subcategories can be referred in previous research (Pak, 2002).

A. 'Emotional response' category
  A1. Curiosity about science contents
  A2. Interest in science learning

B. 'Behavioral volition' category
  B1. Volition for devotion to doing science
  B2. Willingness for choosing science-related studies and careers

C. 'Valuation comprehension' category
  C1. Valuation of science
  C2. Belief in learning science

2. Causal factors of preference for science

There are many factors affecting students' preference for science. Some previous research showed certain relationships among those factors. Head (1980) studied a model to link personality characteristics to preference for science. Stark and Gray (1999) showed gender difference in pupils' preferences for science topics and learning experience in school. Baird et al. (1984) studied students' preferences and choices regarding science subjects. From an examination of the previous research and theoretical considerations, the causal factors can be categorized by two standard systems.

Factors of the preference for science can be categorized according to motive and analyzed into two factors - internal factors such as self-efficacy or quality of science class, and external factors such as home environment or socioeconomic rewards. On the other hand, preference can also be rooted in personal factors, educational factors and social factors.

In order to select a statistically suitable model with more reasonable factor attribute categorization, the two available models were compared on the result of preliminary survey analysis and causal factor categorization model by factor origin was chosen.

The following illustrates the category of causal factors of preference for science by factor origin selected in this research (Pak, 2002).

P. Personal factor
  P1. Personal ability
  P2. Personal traits

P3. Home environment

E. Educational factor
E1. Contents of school science education
E2. Rewards of school science education
E3. Out-of-school science-related experience

S. Social factor
S1. Socioeconomic rewards
S2. Sociocultural valuation

3. Causal relationship analysis model of preference for science

To know the causal relationship between the preference for science and its causal factors, all of the three categories of preference for science and the three categories of causal factors were defined as latent variables. After confirming the theoretical structure of latent variables, a theoretical model was constructed to test their causal relationships.

The theoretical model (1) considered the correlations between independent variables (exogenous variables) of the 3 categories of causal factors, because they correlated highly (Fig. 1).

On the other hand, the correlated independent variables can have theoretical causal relationships so that educational factors can affect personal factors, such as personal ability or personal traits. Similarly, educational factors can also have influence on the social factors, such as sociocultural valuation. Theoretical model (2) represented these causal relationships (See Fig. 2).

There are various possibilities in the causal relationships between independent variables (exogenous variables) besides theoretical model (2). Path diagram for middle school students' preference for science was set up for the theoretical model (1) and (2). Competing model 1 was established on the theoretical model (1), which hypothesized only correlations between exogenous variables. Competing model 2, 3, 4 were established on theoretical model (2), which hypothesized causal relationships between exogenous variables as follows.

Competing model 1: hypothesized correlations between exogenous latent variables (personal factor, education factor, social factor)

Competing model 2: hypothesized educational factor affecting personal and social factor.

Competing model 3: hypothesized personal factor affecting educational and social factor.

Competing model 4: hypothesized social factor affecting educational and personal factor.

All the possible paths (parameters) were considered in the competing models. The paths were modified as modifying selected competing models.

To test the goodness of fit of competing models, statistical fitness indices were compared. The

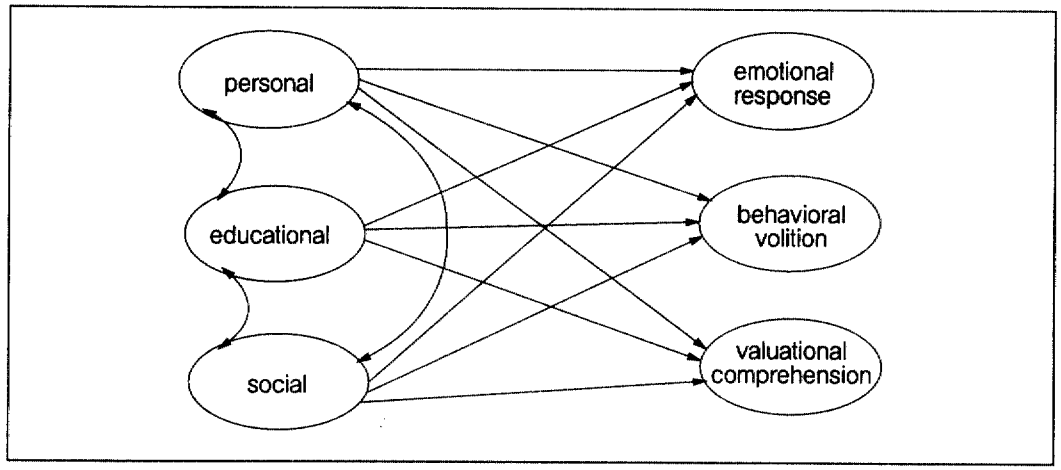

Fig. 1. Theoretical model (1)

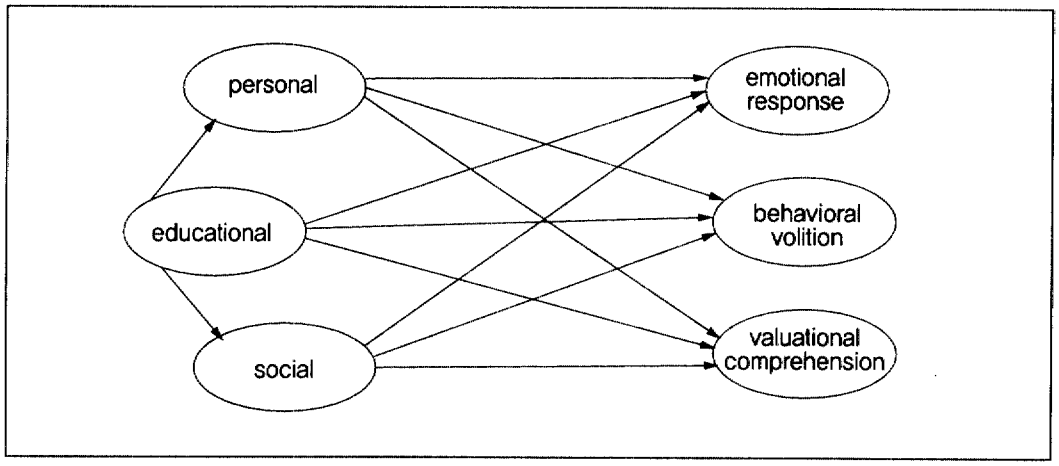

Fig. 2. Theoretical model (2)

result of comparison in the fitness indices such as chi-square value, root mean square residual (RMR), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI) showed that competing models (1) and (2) were plausible at the same value. That is, these two models fitted well into the collected data.

But competing model 3 and 4 were discarded because they showed low fitness indices and squared multiple correlation estimates. Competing model (1) and (2) showed the same fitness, but competing model (2), in which it was hypothesized educational factor affected personal factor and social factor, was selected to analyze the causal relationship of preference for science in this research.

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Ⅲ. Method of Research

1. Development of research instrument

To measure multidimensional preference for science, a multiple-choice self-report type of questionnaire was developed. The items of the questionnaire were statements describing some aspects of subcategories of preference for science. Students were asked to choose one from the five-point Likert scale, from strong denial to strong affirmation, according to their thoughts. A total of 24 items, 4 items in each subcategory, were selected after pilot test with 2 classes of 8th grade, using 36 items.

To find out the causal factors of preference for science, another 2 classes of 8th grade students were asked to write freely the reasons for their liking science. The analysis results showed more agreement with factor categorization by factor origin than factor motive. The same type of 33 items, 3 items in each 11 subcategory, was developed for pilot testing according to the categorization by factor origin. Using the factor analysis results of the pilot tests given to the 2 classes of 8th grade, the causal factor categories finally settled on 3 categories and 8 subcategories. The type of 5-point Likert scale items were developed 3 items per subcategory, a total of 24 items. This structure of causal factors was confirmed through factor analysis.

The reliability of items was acceptable, though differing in each subcategory (from 0.59 to 0.89). The Cronbach's alpha for 24 items to measure preference for science was 0.92, and that for 24 items to measure causal factors was 0.90.

Apart from the Likert type items to measure preference for science and its causal factors, basic questions for the background information of the respondent were composed. The contents of the basic questions were school, grade, gender, parents' occupation, and perception of their own science achievement. Future career choices, and direct questioning of present preference for science, were also contained. Two questions asked students to write freely the reasons for disliking and liking science without relation to present preference for science.

Finally, the instrument to investigate the preference for science consisted of a set of questions - 10 items for basic questions, 24 items for measurement of science preference questions and 24 items for measurement of causal factors questions.

2. Subject of research

The sample was selected randomly to represent the total middle school students in Korea. The whole country was divided into four areas and two schools were selected in each area, one in an urban area and the other in a rural area. The questionnaire was administered to one class per grade, in each selected school, with the help of science teachers or homeroom teachers, in July, 2002.

The number of students in each grade was almost the same, 280 7th graders (34.2%), 266 8th

graders (32.5%), and 268 9th graders (32.7%). But, gender distribution was slightly uneven, 480 boy students (58.6%) and 331 girl students (40.4%).

3. Method of Data Analysis

The results were analyzed using SPSS package to investigate preference for science and its causal factors in each category.

Descriptive statistics were adopted to describe the distribution of responses to each subcategory of preference for science and its causal factors. Basic questions about the background of respondents, parents' occupation, the perception of their own science achievement, future career choices, and direct questions about present preference for science, and the freely written answers of the reasons of disliking and liking science, were also analyzed by descriptive statistics.

Multiple regression analysis was used to investigate the relationship of causal factors to the dependent variables of preference for science, although it had limitations.

For the analysis of causal relationships of preference for science, a structural equation model, which enables one to infer the causal relationships between latent variables, was used. Theoretical structure constructed in the theoretical model of preference for science and its causal factors was confirmed through factor analysis. Structural model was constructed on this result. For the structural equation modeling, AMOS 4.0 was used to test the theoretical models. (Rhee, 2000; Bae, 2000; Kim, 2001).

Ⅳ. Result of Research

1. Middle school students' preference for science

1) The result of direct measurement of preference for science

Students were asked to respond to the direct question if they liked science according to their thought or feeling, by choosing one from the 5-point Likert scale.

The result was that 42.9% responded 'so so', 31.9%(8.1% of them, 'very much') responded positively and 24.5%(12.2% of them, 'never') responded negatively. This result of direct measurement of preference for science showed that the preference of middle school students was somewhat affirmative.

However, this result can not accurately show the actual degree of students' preference for science, because the respondents have a tendency to respond to a direct measurement of the preference for science mainly emotionally, and there are possibilities of different answers according as the respondents thinking on the target of preference for science, whether as science contents or science learning. But, this type of question is meaningful to grasp the tendency about preference for science that show prompt reaction of students, and also, it supports the results of indirect measurement of preference for science through questions in categories.

2) The results of indirect measurement of preference for science

The result of students' responses to indirect measurement of preference for science was as follows (Table 1). The mean of all subcategories was 3.00, the midpoint of the 5-point Likert scale.

If we see the result at the level of each 3 large category, the middle school students' preference for science was highest in 'valuational comprehension', followed by 'emotional response', and lowest in 'behavioral volition'. If we see the mean of each subcategory, it was 3.38 in 'curiosity about contents of science' and 3.03 in 'interest in learning science' in the 'emotional response' category. In the 'behavioral volition' category, the means of subcategories were 2.73 in 'volition for devotion to doing science' and 2.26 in 'willingness to choose science-related studies and careers'. In the 'valuational comprehension' category, the mean of 'valuation of science' was 3.54, the highest from all of the subcategories, and the mean of 'belief in learning science' was 3.12, higher than average.

On the whole, the middle school students' preference for science was comparatively positive in 'curiosity about contents of science' and 'valuation of science', but negative in 'volition for devotion to doing science' and 'willingness to choose science-related studies and careers'.

3) The difference of preference for science by target subgroup

The difference of direct and indirect measurement of preference for science by target subgroups was tested through the basic questions set to know the antecedent factors affecting preference for science. The result showed that there were significant differences in means of direct and indirect measurement of preference for science by gender, grade, father's occupation, perception about science achievement, and future career choice. But there was no significant difference by mother's occupation.

Regarding the gender difference, boys like science more than girls. The means of direct measurement of preference for science were 3.26 for boys and 2.70 for girls (Table 2). Boys' mean of the indirect measure of average science preference was 3.13, and that of girls was 2.83.

Regarding the changes of means of preference for science by grade, it became lower as grades

Table 1. Students' response to the 'preference for science'

category	subcategory	mean	SD
emotional response	(A1) curiosity about contents of science	3.38	0.82
	(A2) interest in learning science	3.03	0.82
behavioral volition	(B1) volition for devotion to doing science	2.73	0.87
	(B2) willingness to choose science-related courses and careers	2.26	0.91
valuational comprehension	(C1) valuation of science	3.54	0.73
	(C2) belief in learning science	3.12	0.83
	Total	3.00	0.65

rose (Table 3). 9th graders' preference for science was significantly lower than that of 7th and 8th graders'. Means of direct measurement of preference for science were 3.26 in 7th grade, 3.21 in 8th grade but 2.62 in 9th grade, which became low sharply. Means of indirect measurement of preference for science in each grade showed the same tendency.

The response to perception about science achievement was most frequent in 'moderate' (47.0%), followed by negative perception (36.1%) and positive perception (15.9%). The perception about science achievement of middle school students was negative, comparatively. The differences in means of preference for science by perception about science achievement were significant. The more negative perception about science achievement one had, the lower was preference for science, and the more positive perception about science achievement one had, the higher was preference for science. Except between the subgroups having the perception of 'good at science' and 'very good at science', there were significant differences in all the subgroups with different perception about science (Table 4).

The result of a survey of parents' occupations showed that only 13.6% of fathers and 4.4% of mothers had occupations in the science and technology field. The differences in means of science preference among students, relative to mothers' occupations was insignificant, but the means of science preference among students whose fathers had a science-related occupation was significantly higher than those whose fathers had other occupations.

Those who intended to make a career choice in the science and technology field were very few

Table 2. 'Preference for science' differences in gender

science preference	male	female	t-value	Sig.
	mean(SD)	mean(SD)		
direct measurement	3.26(1.04)	2.70(1.07)	7.38	0.000
indirect measurement	3.13(0.62)	2.83(0.64)	6.46	0.000

Table 3. 'Preference for science' differences in grade

science preference	7th grade	8th grade	9th grade	F	Sig.
	mean(SD)	mean(SD)	mean(SD)		
direct measurement	3.26(0.97)	3.21(1.05)	2.62(1.12)	31.12	0.000
indirect measurement	3.15(0.60)	3.10(0.60)	2.76(0.66)	29.75	0.000

Table 4. 'Preference for science' differences in self-awareness of science achievement

science preference	very poor	poor	so so	good	very good	F	Sig.
	mean(SD)	mean(SD)	mean(SD)	mean(SD)	mean(SD)		
direct measurement	1.67(0.92)	2.55(0.94)	3.23(0.86)	3.80(1.00)	4.19(1.33)	76.74	0.000
indirect measurement	2.35(0.76)	2.75(0.54)	3.10(0.56)	3.42(0.62)	3.44(0.79)	41.91	0.000

(10.1% of all), and those who wanted to be a doctor, dentist or pharmacist were fewer (8.3% of all). Those who intended to choose a future careers in humanities and social studies field were 29.1%, noticeably almost 3 times larger than in the science and technology field. Those choosing future careers in the art and sports field were 20.1%. The mean of science preference among those choosing future careers in the science and technology field was significantly higher than any other group choosing other fields (Table 5).

2. Causal factors of middle school students' preference for science

1) The reasons for disliking and liking science

As a method to find causal factors of students' preference for science, they were asked to write freely the reasons for disliking and liking science without relation to their present preference for science.

The students' reasons for disliking science were categorized and analyzed. 26.2% of middle school students didn't write the reasons for disliking science, probably because they didn't have special reasons for disking science or they didn't want to give their reasons. The responses giving reasons for disliking science were categorized in 9 large categories, coded by subcategories, and the response distribution was found. The most frequent response was 'difficult' (39.9%), followed by 'uninteresting'(9.4%) and 'science achievement' (8.7%).

The reasons for liking science were also categorized and analyzed. 28.5% of respondents didn't write the reason for liking science. The responses giving reasons for liking science were also categorized in 9 large categories, coded by subcategories, and the response distribution was found. The most frequent response was 'experiment' (31.2%), followed by 'interesting' (20%) and 'easy' (5.3%).

2) The results regarding causal factors of preference for science

The results of students' responses to the causal factors of preference for science in 8 subcategories are presented in Table 6.

On personal factors, the means of response were 2.28 in personal ability, 2.98 in personal

Table 5. 'Preference for science' differences in future career choice

science preference	humanities/ social studies	medical/ phamacy	science/ engineering	arts/ sports	the others	F	Sig.
	mean(SD)	mean(SD)	mean(SD)	mean(SD)	mean(SD)		
direct measurement	2.91(1.10)	3.26(1.07)	4.05(0.76)	2.72(1.02)	2.96(1.02)	25.95	0.000
indirect measurement	2.92(0.63)	3.26(0.52)	3.67(0.51)	2.80(0.64)	2.93(0.58)	32.21	0.000

Table 6. Students' response to the causal factors of 'preference for science'

Category	Subcategory	Mean	S.D.
Personal	(P1)personal ability	2.28	0.92
	(P2)personal traits	2.98	0.91
	(P3)home environment	2.16	0.82
Educational	(E1)contents of school science	3.05	0.86
	(E2)rewards in school science	3.10	0.86
	(E3)out-of-school science-related experience	3.19	0.88
Social	(S1)socioeconomic rewards	2.75	0.89
	(S2)sociocultural valuation	3.28	0.89

traits, and 2.16, the lowest, in home environment. On educational factors, the means of response were 3.05 in contents of school science, 3.1 in rewards in school science and 3.19 in out-of-school, science-related experience. On social factors, the means of response were 2.75 in socioeconomic rewards, but 3.28, the highest, in sociocultural valuation.

Regarding the results of causal factors of preference for science, students responded negatively to personal factors such as personal ability or traits, especially negatively to home environment, and somewhat positively to educational factors. They seemed to perceive affirmatively, sociocultural value of science. But the distribution of response to the causal factors can't show the causal relationship between students' preference for science and its causal factors. It is required to analyze the causal relationship through regression analysis and structural equation modeling.

3. The analysis of causal relationship between preference for science and its causal factors

1) Multiple regression analysis

As a method to analyze the causal relationship between students' preference for science and its causal factors, multiple regression analysis was adopted. To examine the relationship of the independent variables of subcategories of causal factors to the dependent variable of preference for science, a stepwise regression analysis was used assuming the linear relation between these variables.

It explained how much influence each subcategory of causal factors had on the preference for science by the regression coefficient. The result of multiple regression analysis with independent variables of 8 subcategories of causal factors and dependent variables of direct measurement of preference for science was as follows. This model explained 47.3% of variance. The regression coefficients β of significant factors were 0.37 in personal ability, 0.21 in personal traits, 0.18 in rewards of school science, and 0.10 in contents of school science. From 8 subcategories of causal factors, personal ability factor explained 23.3% of variance, personal trait factor, 11.8%,

rewards in school science 8.8% and contents of school science explained 5.1% of variance. When students were asked directly if they liked science, the answers could be interpreted as indicating that the most important factor as a basis for prompt response was personal ability.

The multiple regression model with independent variables of 8 subcategories of causal factors and dependent variables of indirect measurement of average preference for science explained 78.4% of variance. In this model, all 8 subcategories had a significant effect on the average preference for science (Table 7). The regression coefficients were 0.31, the biggest in personal traits, followed by 0.23 in personal ability, 0.16 in contents of school science, 0.15 in sociocultural valuation and 0.14 in rewards in school science. The personal traits factor explained 23.9% of variance, the personal ability factor explained 15.9%, contents of school science explained 11.0%, rewards in school science explained 9.1% and social value explained 9.0% of variance of average preference for science. The percentage of explanation of home environment (3.7%) and socioeconomic rewards (2.1%) was very low. The result of regression analysis revealed the important factors affecting the preference for science were personal traits, personal ability, contents of school science, rewards in school science and sociocultural valuation.

To find out the causal relationships between causal factors and preference for science more deeply, it is necessary to do multiple regression analysis with dependent variables of each 6 subcategory of preference for science. The result of multiple regression analysis with the independent variables of 8 subcategories of causal factors and dependent variable of each 6 subcategory of preference for science is presented in Table 8. Stepwise regression analysis with each of the subcategories of preference for science as dependent variables revealed that important factors differed in each subcategory.

The most important factors of each subcategory of preference for science were as follows. The

Table 7. Stepwise regression result with 'indirect measure of science preference' as dependent variable

Category	Subcategory	Corelation coefficient(r)	β	($r \times \beta$)
Personal	(P1)	.69**	.23	.1587
	(P2)	.77**	.31	.2387
	(P3)	.53**	.07	.0371
Educational	(E1)	.69**	.16	.1104
	(E2)	.65**	.14	.0910
	(E3)	.57**	.05	.0285
Sociocultural	(S1)	.41**	.05	.0205
	(S2)	.60**	.15	.0900
$R=.886$ $R^2=.784$ $F=306.563$ $p=.000$				.7749

Table 8. Stepwise regression result with 'subcategories of preference for science' as dependent variable

	A1			A2			B1			B2			C1			C2		
	r	β	rβ	r	β	rβ	r	β	rβ	r	β	rβ	r	β	rβ	r	β	rβ
P1	.49**	.12	.0588	.68**	.35	.2380	.57**	.18	.1026	.63**	.38	.2394	.36**			.45**		
P2	.64**	.42	.2688	.67**	.25	.1675	.66**	.31	.2046	.57**	.16	.0912	.45**	.14	.0630	.57**	.20	.1140
P3	.37**			.41**			.47**	.11	.0517	.51**	.22	.1122	.24**	-.10	-.024	.40**		
E1	.51**	.12	.0612	.51**	.23	.1173	.53**			.46**			.47**	.15	.0705	.43**	.23	.0989
E2	.47**			.47**	.09	.0423	.51**	.14	.0714	.45**	.09	.0405	.47**	.16	.0752	.58**	.13	.0754
E3	.43**			.43**			.55**	.19	.1045	.36**			.40**	.10	.0400	.55**		
S1	.24**			.24**			.26**	-.07	-.018	.31**	.06	.0186	.36**	.13	.0468	.44**	.13	.0572
S2	.47**	.17	.0799	.47**	.06	.0282	.46**	.09	.0414	.36**			.45**	.18	.0810	.43**	.23	.0989
R,R^2 F, p	R=.685 R^2=.470 F=161.600 p=.000		.4687	R=.797 R^2=.636 F=252.511 p=.000		.5933	R=.753 R^2=.566 F=134.870 p=.000		.5582	R=.709 R^2=.503 F=146.978 p=.000		.5019	R=.594 R^2=.353 F=56.122 p=.000		.3525	R=.712 R^2=.507 F=147.204 p=.000		.4444

personal traits factor was most important to 'curiosity about contents of science' and 'volition for devotion to doing science'. The personal ability factor was most important to 'interest in learning science' and 'willingness for choosing science-related courses and careers'. The sociocultural valuation factor was most important to 'valuation of science'. Contents of school science and sociocultural valuation factors were most important to 'belief in learning science'.

Causal factors affected each subcategory of preference for science as follows.

Regarding the personal factor, personal traits affected all subcategories of preference for science, and personal ability affected 'emotional response' and 'behavioral volition'. Home environment affected 'behavioral volition' such as 'willingness for choosing science-related courses and careers' and 'volition for devotion to doing science'.

Regarding the educational factor, mainly 'contents of school science' and 'rewards in school science' affected preference for science. 'Out-of-school science-related experience' affected little, compared with the other two subfactors. 'Contents of school science' influenced not on 'behavioral volition' but on 'emotional response' and 'valuational comprehension'. 'Rewards in school science' affected all subcategories of preference for science, except 'curiosity about science contents'. 'Out-of-school science-related experience' influenced on 'volition for devotion to doing science' and 'valuation of science.

Regarding the social factor, the sociocultural valuation factor affected more preference for science than the socioeconomic rewards factor. The socioeconomic rewards factor affected 'valuational comprehension' and influenced a little on 'willingness for choosing science-related courses and careers' but influenced negatively 'volition for devotion to doing science'. The

sociocultural valuation factor influenced all subcategories of preference for science except 'willingness to choose science-related courses and careers', and affected more the 'valuational comprehension'.

2) Analysis result of structural equation modeling

To analyze causal relationship of preference for science, structural analysis of covariance was conducted, using competing model (2) of the previous theoretical discussion, which hypothesized that the educational factor affects personal factor and social factor.

Using the result of testing parameters of the structural equation model, path diagram was modified, considering all the paths from exogenous latent variable to endogenous latent variables. The result showed that the personal factor affected 'emotional response' and 'behavioral volition', the educational factor affected 'emotional response' and 'valuational comprehension', and the social factor significantly affected 'valuational comprehension'(Fig. 3).

The result of estimating parameters of the modified path diagram showed that exogenous variables, causal factors of preference for science, affected endogenous variables, each category of preference for science as follows (Table 9).

Personal factor had an effect on 'emotional response' with standardized direct effect

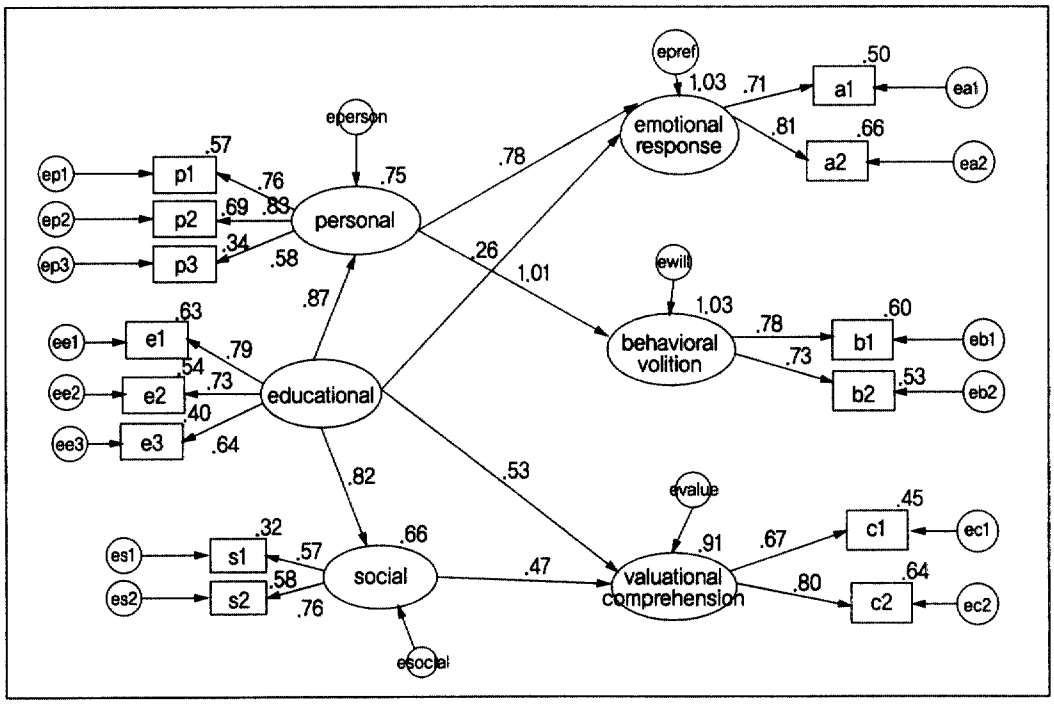

Fig. 3. The Structural equation of model of preference for science and its causal factors and estimated parameters

Table 9. The effect of causal factors to middle school students' preference for science

Science preference	Causal factors	Direct effect	Indirect effect	Total effect
Emotional response	Personal	0.78	-	0.78
	Educational	0.26	0.68	0.94
	Social	-	-	-
Behavioral volition	Personal	1.01	-	1.01
	Educational	-	0.88	0.88
	Social	-	-	-
Valuational comprehension	Personal	-	-	-
	Educational	0.53	0.39	0.91
	Social	0.47	-	0.47

coefficient 0.78 and on 'behavioral volition' with standardized direct effect coefficient 1.01. The educational factor had an effect on 'emotional response' with standardized total effect coefficient 0.94 (direct effect 0.26, indirect effect 0.68), on 'behavioral volition', with standardized indirect effect coefficient 0.88 and on 'valuational comprehension', with standardized total effect coefficient 0.91 (direct effect 0.53, indirect effect 0.39). The social factor had an effect on 'valuational comprehension', with standardized direct effect coefficient 0.47.

'Emotional response' and 'behavioral volition' were influenced most directly by personal factors, and 'valuational comprehension' was influenced directly by social factors. But considering the total effect including the indirect effect of educational factors to the personal and social factors, the educational factors affected evenly all the categories of science preference, such as 'emotional response', 'behavioral volition' and 'valuational comprehension'.

Ⅴ. Conclusion and Suggestion

1. Summary and conclusion

Preference for science, a goal of elementary and secondary school science education, including emotional response, behavioral volition and valuational comprehension, was defined theoretically. It consisted of three categories and 6 subcategories. Causal factors of preference for science were categorized in 3 categories and 8 subcategories. A questionnaire was developed to survey students' preference for science and its causal factors, and to analyze their causal relationships. A theoretical model to analyze the causal relationship was constructed according to the conceptual definition of preference for science.

The sample was 819 middle school students of 8 randomly selected schools and the results

were analyzed using SPSS 10.0 and AMOS 4.0.

Middle school students' direct measurement of preference for science was somewhat affirmative, but indirect measurement of preference for science was middling.

'Curiosity about contents of science' and 'valuation of science' were high comparatively, but practice by action, preferring science such as 'volition for devotion to doing science' and 'willingness to choose science-related courses and careers' was especially low.

Comparing the mean differences of preference for science by target subgroups according to the ANOVA, boys' preference for science was significantly higher than girls. 9th graders' preference for science was significantly lower than 7th and 8th graders. The more affirmative perception students have about their science achievement, the higher students' preference for science was, significantly. The preference for science of students who wish to become scientists or engineers was significantly higher than that of those who wish to advance to other fields. Students' preference for science whose father had a science-related profession was significantly higher than that of students whose father had other professions.

According to the analysis results of the responses to questions that directly ask to write freely the reasons for disliking and liking science, students disliked science because science was difficult and uninteresting. They liked science because of the experiments, and because of interest. The results of students' responses to the factors of preference for science were low in the personal factors, especially in home environment, but relatively high in the educational factor. In the social factor, two subfactors were contrasting. The socioeconomic rewards factor was low, but the sociocultural valuation factor was highest of all subfactors. This implies that their actual experience or thought about each item statement related to factors of preference for science. They have low self-confidence in science, rare parental encouragement, and negative perception of socioeconomic rewards in the science and technology field.

As a method to find causal relationships, multiple regression analysis was carried out. Stepwise regression analysis on the direct measure of science preference showed five important factors. The important factors were personal ability, the personal traits, rewards in school science, and contents of school science in order of magnitude of standardized regression coefficient β. The five factors explained 47.3% of the total variance of 'direct measure of science preference'. Personal factors explained 35.1%, educational factors, 13.9% of the variance of 'direct measure of science preference'.

Stepwise regression analysis on the indirect measure of average preference for science showed that all of the eight factors were important. The order of important factors was changed slightly - the personal traits, the personal ability, contents of school science, sociocultural valuation, and rewards in school science in order of magnitude of standardized regression coefficient β. The eight factors explained 78.4% of the total variance of indirect measurement of average preference for science. Personal factors explained 43.5%, educational factors, 23.0% and social factors 11.1% of the variance of indirect measurement of average preference for science.

Stepwise regression analysis with each of the subcategory of preference for science as

dependent variables revealed that important factors were different in each subcategory. The most important factors of each subcategory of preference for science were as follows. The personal ability factor was most important to 'interest in learning science' and 'willingness to choose science-related courses and careers'. The personal traits factor was most important to 'curiosity about contents of science' and 'volition for devotion to doing science'. The sociocultural valuation factor was most important to 'valuation of science'. Contents of school science and sociocultural valuation factors were most important at the same rate to 'belief in learning science'.

According to the result of structural equation modeling, the personal factor influenced directly mostly on 'emotional response' and 'behavioral volition', and the social factor caused direct influence on 'valuational comprehension'. The educational factor influenced directly largely on valuational comprehension, and a little on emotional response. But, the total effect, if we consider indirect effect of educational factors to the personal and social factors, showed that educational factors affected all three categories of preference for science, such as 'emotional response', 'behavioral volition' and 'valuational comprehension'.

It could be concluded from the results of causal relationship analysis that personal factors affected emotional response and behavioral volition, and educational factors had large effects on valuational comprehension and small effects on emotional response. Social factors influenced mainly on valuational comprehension.

2. Suggestions

The way to promote middle school students' preference for science was suggested on the analysis result.

When we establish a plan to increase preference for science, it is necessary to present a proper plan according to each subcategory's important causal factors, because there are different major factors in each subcategory. The result of reasons for liking and disliking science should also be consulted. In order to increase middle school students' preference for science generally, intensive effort should be made on the 9th graders and girls, who showed especially low preference for science.

Personal factors such as personal traits and personal ability that are affecting importantly on students' preference for science can be changed by educational factors. So, it is necessary to make a concrete preference for science promotion plan in relation to educational factors. Firstly, the behavioral volition category being affected largely by personal factors should be encouraged by improving educational and social factors. Educational factors such as rewards in school science, and out-of-school science-related experience to increase emotional response and contents of school science to improve behavioral volition, should be reinforced.

A plan to promote middle school students' preference for science can be proposed as follows on the analysis result.

1) Science curriculum and teaching material should be developed according to middle school students' developmental level and request, especially considering their interests.

2) Student organization and science teacher's teaching situation must be improved so that activity-centered science learning may be available.

3) Well equipped laboratories and scientific instruments that are safe, convenient and exact should be supplied.

4) Out-of-school science-related experiences, including activities through mass media, can be performed variously and associated with school science education.

5) Data and information that can make it possible to explore science-related careers should be offered to allow students to be well informed about science-related careers.

In order to increase the numbers of future scientists and engineers through enhancing students' preference for science, changes are needed in home, school and society, and they can be started by changing educational factors.

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