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Factors of Korean Students' Achievement in Scientific Literacy

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ABSTRACT

Korean students ranked the 3rd out of 32 participating countries in the first cycle of PISA(Programme for International Student Assessment) science field, which assessed 15-years-old students' scientific literacy. PISA developed several variables such as parents' socio-economic status, parents' educational attainment, family wealth, and cultural possession, to investigate the effects of background variables on scientific literacy. On the other hand, motivation and engagement in science study were not given much attention, partly because science was the minor area in the first cycle of PISA. Therefore, PISA Korea developed a series of variables to collect data on students' learning motives and out-of-school activities in science as a national option. The results are as followings. First, Korea was found to be one of the PISA participating countries with the scientific literacy achievement least influenced by parents' socio-economic status, family wealth, and parents' cultural possession. Second, the degree of achievement in scientific literacy according to parents' educational attainment was in a positive correlation, similar to the overall tendency of PISA. Third, the most crucial learning motive for Korean students was their desire to develop scientific thinking abilities or obtain science knowledge. On the other hand, choosing jobs in the field of science or parental expectation was the least important learning motive. In particular, the motive for scientific learning was found to have a positive relationship with the degree of scientific literacy achievement. Therefore, the higher the students achievement, the stronger the motive for scientific learning in order to develop their ability to think scientifically or acquire science knowledge. Fourth, Korean students were shown to participate very little in out-of-school scientific activities other than watching TV programs related to science. Whatever the activities may be, the more actively involved students are in out-of-school scientific activities, the higher their scientific literacy achievement. Fifth, Korean girls were rather passive compared to boys in all areas, including science learning

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motive and out-of-school scientific activities. The gender difference was especially more pronounced in out-of-school scientific activities with wider gaps in such activities as reading scientific books or articles and visiting science-related web sites.

Key words: scientific literacy, PISA, socio-economic status, science learning motive, out-of-school activities, gender differences

I. Introduction

The PISA (Programme for International Student Assessment), an international assessment supervised by OECD, covered reading, mathematical, and scientific 'literacy'. PISA is not the first international comparative survey of student achievement. The previous international surveys, though, have concentrated on outcomes linked directly to the curriculum and then only to those parts of the curriculum that are essentially common across the participating countries. PISA takes a different approach in the sense that it examines the degree of preparedness of young people for adult life, which first assesses students' scientific literacy at international level.

Korean students have excelled in previous international science assessments such as SISS (Second International Science Study) and TIMSS (Third International Mathematics and Science Study). In recent two international assessments Korean students continued to show their distinguished achievement in science field, which ranked the 5th out of 38 participating countries in TIMSS-R (Repeat) (Martin *et al.*, 2000) and the 1st out of 32 participating countries in PISA (OECD, 2001).[1] In contrast to such good performance in cognitive domain, the affective index of Korean students was very low in TIMSS-R. Korean students tend to study science not because of their internal motive such as intellectual curiosity but because of their external motive such as college-entrance examination (Kim, 2000). Ironically, such external motive was proved to strongly affect on Korean students' outstanding achievement.

On the other hand, both results showed a common serious problem in gender differences, regardless of Korean students' outstanding achievement results (Mullis *et al.*, 2000; Shin and Ro, in press; Ro *et al.*, 2000). In addition to the large gender differences in cognitive domain, the gender differences were also seriously large in the affective domain of TIMSS-R. That is, more female students have a negative opinion on science than male counterparts. And more male students tend to relate science to their future career. Female students' negative attitude towards science directly affects science achievement, which results in female students' inferiority to male counterparts (Kim, 2000).

1) Korean students ranked the 9th in reading literacy and the 2nd in mathematical literacy (OECD, 2001).

Because PISA assesses scientific literacy, factors that affect students' scientific literacy will be different from those of TIMSS-R which emphasized science concepts. Therefore, the purpose of this study is to verify the relationship between students' home background and their achievement of scientific literacy. In particular, gender issues will be considered in explaining factors that affect students' scientific literacy.

II. Methods

Method of this study is reported in the following three parts, sample, background questionnaire, and data analysis.

1. Sample

The Korean sample included 4,992 students who are 15 years old at the time of testing. These students who were enrolled in middle and high schools reflected the characteristics of 15 year olds in Korea. PISA took two-stage sampling process. First, schools were selected in proportion to the number of general academic and vocational schools. Secondly, 38 students who were enrolled in the school sampled were randomly selected.

2. Background questionnaire

The study investigated the effects of background variables on scientific literacy. The background variables are listed in Table 1. These variables could be classified into two groups. First group of variables involves family background of individual students. Second group includes variables related to motivation and engagement in learning. Family background variables were selected based on the common interest of participating countries. On the other hand, motivation and engagement in science study were not given much attention. It is partly because reading was the major area in the first cycle of PISA. Even though science was a minor area in the first cycle of PISA, the background variables affecting the scientific literacy development should be investigated. Therefore, PISA Korea developed a series of variables to collect data on students' learning motives and out-of-school activities in science as a national option.[2)]

3. Data analysis

Students' responses to the questionnaires were analyzed using SPSS/PC for Window

2) Detailed description of the variables are provided in Ro *et al.* (2000).

(version 10.0) and KeyQuest (Wu *et al.*, 1996). Frequency analysis was conducted using SPSS/PC to check the distribution of students to each response categories.

Table 1. Content of factors that affect scientific literacy in this study

Category		Item description
Home background	Parents' socio-economic status	Parents' occupational status, activities associated with their occupation
	Parents'educational attainment	Mother's educational level (completion of primary or lower secondary education, completion of the upper secondary level of education, and completion of tertiary education)
	Family wealth	Availability of a dish washer, a room of their own, educational software, a link to the internet, the number of cellular telephones, TV sets, computers, automobiles, and bathrooms
	Cultural possession	Availability of classic literature, books of poetry, and works of arts (such as paintings)
Science learning motive		To acquire science knowledge and principles, to develop scientifically thinking abilities, to apply science to real life, to be involved in science-related careers, to develop creativity, to utilize in social life, to satisfy parents' expectation
Out-of-school science activities		Reading science books or articles, watching TV science programs, visiting science-related web sites, visiting museums, exhibitions, nature trip, etc., subscribing science magazines

The index of parental socio-economic status (SES) was derived from students' responses on parental occupation. The index indicates the attributes of occupations that convert parents' education into income. The SES index ranges from 0 to 90, with low values representing low socio-economic status and high values representing high socio-economic status.

To investigate the influence of family wealth and cultural possessions on students' performance, composite indicators rather than individual items were used. In other words, the composite indicators were produced to represent the underlying constructs such as family wealth and cultural possessions. The composite approach works better than individual items because the group of variables such as the number of rooms, telephone and cars in a family provides a more comprehensive information on the family wealth. The composite index was estimated using Rasch Model[3] (Wu *et al.*, 1996). The estimates of

3) one parameter item response model

composite scale ranged from -2 to 2 with a OECD mean of 0 and standard deviation of 1.

The items on science learning motives and out-of-school activities had a scale of 1 to 4 with 1 representing low level of motivation or less frequent engagement in out-of-school science activities. The motives and activity composites were derived by summing the responses to the related variables because the variables were developed for Korea only and could not anchor the scores to the OECD mean.

III. Results

Results in scientific literacy achievement will be reported in terms of three factors, students' home background, students' learning motive, and students' out-of-school activities.

1. Students' home background and scientific literacy

PISA allows to examine the relationship between proficiency in scientific literacy and various aspects of socio-economic status such as their parents' education and occupation, their exposure to various levels of cultural and economical capital. These dimensions of socio-economic status are, of course, closely interrelated and their effects on student performance are not independent as follows.

1) Parents' socio-economic status and scientific literacy

Students whose parents' occupational status is high might have more opportunities in their learning experiences, in the sense that "higher parental occupational status can influence children's occupational aspirations and expectations and, in turn, commitment to learning as the means of satisfying high aspirations." (OECD, 2001). Four groups were divided to understand how much the parents' socio-economic status affects students' scientific literacy achievement (Table 2). In Korea, the mean score among students in top- and bottom quarter was 575 and 534, respectively, which showed 41 score points difference. Such score was about as half as OECD's overall mean differences between two groups. This suggests that differences in socio-economic status are not strong predictors of performance in Korea, compared with OECD's overall mean.

2) Parents' educational attainment and scientific literacy

Parents' educational level is likely to influence on students' achievement. It is somewhat risky to conclude that there is a positive relationship between parents' educational attainment and children's educational performance. Nobody, however, cannot disagree that students whose parents completed higher level of education have more advantages in their

learning process because of supporting children's education through day-to-day interactions of higher 'intellectual quality' between parents and children (OECD, 2001).

Table 2. Parents' socio-economic status and scientific literacy

	Mean of socio-economic status*					Mean score in each group				Influence index
	Total	1	2	3	4	1	2	3	4	
Korea	43.00	26.50	35.89	45.97	62.87	534	549	559	575	18.3
OECD mean	48.81	29.24	42.32	53.51	70.21	465	490	512	543	30.5

* Number of socio-economic status ranges from 20 to 80, which means that the higher the score the higher parents' socio-economic status.

As studies of Willms (1986), mother's educational attainment, rather than father's, seems to be strongly associated with students' educational performance. As in most countries participating in PISA, Korean students whose mothers have completed upper secondary or tertiary education achieve higher levels of performance in scientific literacy (Table 3). Compared with OECD mean (67 points), Korean students show smaller differences (43 points) in mean science scores between the lowest and uppermost categories of mothers' educational attainment.

Table 3. Mother's educational attainment and scientific literacy

	Completion of primary or lower secondary education	Completion of the upper secondary level of education	Completion of tertiary education
Korea	536	559	579
OECD mean	465	510	532

3) Family wealth and scientific literacy

By definition, "wealthier people have access to more resources, have more discretionary income than do the less wealthy, and find it easier to acquire what they want, including goods and services of high quality" (OECD, 2001). And one of the services is education. Therefore, as in the case of the relationship between parents' educational attainment and children's performance, it is likely to exist a positive relationship between family wealth and students' achievement. As Table 4 shows, students from wealthier families tend to do better than students from less wealthy families. In Korea, the differences in scores between the highest and lowest quarters are 27 points, which is less than the differences in OECD mean (36 points).

Table 4. Family wealth and scientific literacy

	Mean of family wealth*					Mean score in each group				Influence index
	Total	1	2	3	4	1	2	3	4	
Korea	-0.26	-1.11	-0.40	-0.02	0.50	535	552	560	562	16.9
OECD mean	0.00	-1.05	-0.26	0.25	1.05	481	498	507	517	16.9

* For the OECD mean, this index has a mean of 0 and a standard deviation of 1. The + means wealthier than OECD mean and the - means less wealthy than OECD mean.

4) Cultural possessions in the family home and scientific literacy

PISA is also interested in cultural possessions of students' home, probably being reflective of an educationally supportive home environment. PISA distinguished cultural possessions from family wealth because cultural possessions are more readily available and can be increased more easily than family wealth (OECD, 2001). In other words, being wealthy parents is a different thing from providing fruitful cultural possessions to children. Less wealthy parents might offer better educational opportunities to their children and vice versa. As can be seen in Table 5, students with high values on cultural possessions have the highest average scores. In Korea, the differences in scores between the highest and lowest quarters are 42 points, which is less than the differences in OECD mean (61 points).[4)]

Table 5. Cultural possession and scientific literacy

	Mean of cultural possession*					Mean score in each group				Influence index
	Total	1	2	3	4	1	2	3	4	
Korea	0.25	-1.00	0.06	0.78	1.15	528	549	563	570	19.6
OECD mean	0.00	-1.28	-0.32	0.46	1.12	470	492	512	531	25.1

* For the OECD mean, this index has a mean of 0 and a standard deviation of 1. The + means more cultural possession than OECD mean and the - means less cultural possession than OECD mean.

4) The least values, where changes in cultural possessions contribute to the smallest increases in science performance, are found in Iceland and Korea. The highest values, where changes in cultural possessions contribute to the largest increases in science performance, are found in Luxemburg, Belgium, France, and United States (OECD, 2001).

2. Students' learning motive and scientific literacy

As can be seen in Table 6, students' most influential learning motive is their desire to develop scientific thinking abilities (2.81 points), followed by their desire to acquire science knowledge and apply science to real life (2.77 points). On the other hand, parental expectation is the least influential learning motives (2.13 points). Seen from gender differences in science learning motives, female students' science learning motives are lower than male students'. In particular, the largest gender differences appeared in their learning motives to be a science-related career in the future.

Four groups were divided to understand the relationship between students' science learning motives and their scientific literacy achievement. In general, 8 science learning motives have a tendency to show a positive relationship with science performance. Among them, the stronger students' motives in developing scientific thinking abilities and in acquiring science knowledge the higher students' science performance. In contrast, science learning motives, such as application science to real life, preparedness for future career, and parental expectation, do not show strong relationship with science performance.

Table 6. Science learning motives and scientific literacy

Science learning motive	Total		Male		Female		1 (< 25%)		2 (25~49%)		3 (50~74%)		4 (> 75%)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Scientific thinking	2.81	0.02	2.83	0.03	2.78	0.03	2.65	0.05	2.68	0.04	2.89	0.04	3.01	0.03
Science knowledge	2.77	0.02	2.81	0.03	2.73	0.03	2.51	0.04	2.70	0.04	2.88	0.03	3.00	0.03
Application to real life	2.77	0.02	2.82	0.03	2.71	0.03	2.69	0.05	2.64	0.04	2.82	0.04	2.92	0.04
Creativity	2.75	0.02	2.78	0.03	2.72	0.03	2.67	0.05	2.69	0.05	2.79	0.04	2.85	0.04
Scientific principle	2.72	0.02	2.77	0.03	2.65	0.03	2.55	0.05	2.63	0.04	2.76	0.04	2.93	0.03
Social life	2.50	0.02	2.52	0.03	2.48	0.03	2.45	0.05	2.48	0.05	2.52	0.04	2.56	0.04
Future career	2.18	0.02	2.31	0.03	2.03	0.03	2.10	0.05	2.02	0.04	2.23	0.04	2.40	0.04
Parents' expectations	2.13	0.02	2.21	0.03	2.02	0.03	2.02	0.05	2.16	0.04	2.12	0.04	2.20	0.04

Students' most important science learning motives are different in each achievement level; the most influential learning motives for students in the highest quarter are developing scientific thinking abilities and acquiring science knowledge whereas the most influential learning motives for students in the lowest quarter are applying science to real life and

developing their creativity.

3. Students' out-of-School activities and scientific literacy

Table 7 proves that students participate in watching science-related TV programs most frequently, at least once a month. Reading science books or articles are followed, which occurs much less frequently than watching TV programs, just several times a year. Subscribing science magazines are rarely occurred. Seen from gender differences, frequency of female students' participation in out-of-school science activities are generally fewer than male students'. In particular, prominent gender differences appeared in the activities such as reading science books or articles and visiting science-related web sites. Few gender differences occur in watching TV science programs.

Four groups were divided to understand the relationship between students' out-of-school science activities and their scientific literacy achievement. In general, 5 out-of-school science activities have a tendency to show a positive relationship with science performance. Watching TV science programs are proved to be the most frequently involved science activities, regardless of students' achievement level. Subscribing science magazines is turned out to be the most rarely occurred science activities, which shows few differences between the highest- and lowest quarters. The higher students' scientific literacy achievement, the more frequently students' watching TV science programs and reading science books or articles.

Table 7. Out-of-school science activities and scientific literacy

	Total		Male		Female		1 (< 25%)		2 (25~49%)		3 (50~74%)		4 (> 75%)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Watching science TV	3.35	0.02	3.36	0.03	3.34	0.03	2.87	0.06	3.34	0.05	3.50	0.04	3.68	0.04
Reading science books/articles	2.02	0.03	2.14	0.03	1.88	0.04	1.70	0.06	1.80	0.05	2.15	0.05	2.43	0.05
Visiting science web site	1.88	0.02	2.06	0.03	1.66	0.03	1.58	0.05	1.76	0.05	2.01	0.05	2.18	0.05
Visiting museums, etc.	1.59	0.02	1.65	0.02	1.50	0.03	1.46	0.04	1.51	0.03	1.64	0.03	1.73	0.03
Subscribing magazine	1.38	0.02	1.44	0.03	1.30	0.03	1.43	0.05	1.27	0.03	1.38	0.04	1.43	0.04

Table 8. Correlation between out-of-school science activities and scientific literacy

	Reading science books/articles	Watching science TV	Visiting science web site	Visiting museums, etc.	Subscribing magazine
Scientific literacy achievement	.217*	.253*	.196*	.119*	.004

* $p<.001$

To have more clear understanding about the relationship between out-of-school science activities and scientific literacy achievement, the correlation was analyzed (Table 8). The highest correlated activity is watching TV science programs (r=0.253), followed by reading science books or articles (r=0.217), visiting science-related web sites (r=0.196), and visiting museums, exhibitions, nature trip, etc. (r=0.119). It is noteworthy that the correlation between subscribing science magazines and scientific literacy achievement is very low (r=0.004).

Ⅳ. Discussion

An examination of factors that affect scientific literacy achievement, such as home background and psychological motive for learning, yielded the following tendencies among Korean students.

First, Korea was found to be one of the PISA participating countries with the scientific literacy achievement least influenced by parents' socio-economic status, family wealth, and parents' cultural possession. Even in Korea, of course, the tendency held true that the higher the socio-economic status and the more family wealth and cultural possession parents have, the greater the degree of achievement. However it is noteworthy that such inclination was very miniscule compared to other countries in PISA. Recently, some in Korea have voiced concerns over the phenomenon that children's learning achievement is considerably affected by parents' socio-economic status. Nonetheless such phenomenon is not as serious as other OECD member countries or so-called advanced countries. The cause for such phenomenon needs to be studied in an in-depth and diverse manner from educational- and social aspects.

Second, the degree of achievement in scientific literacy according to parents' educational attainment was in a positive correlation, similar to the overall tendency of PISA, but the impact of parents' cultural activities on children's scientific literacy was not that great. In case of Korea, however, it is worth noting that mother's educational attainment as measured by classifying mothers into two groups, the mothers with high school education and above and those with less than high school education, did not appear to have a great

bearing in children's scientific literacy achievement. As a matter of fact, the differences between the two groups were much smaller than the average differences observed in PISA.

Third, the most crucial learning motive for Korean students was their desire to develop scientific thinking abilities or obtain science knowledge. On the other hand, choosing jobs in the field of science or parental expectation was the least important learning motive. In particular, the motive for scientific learning was found to have a positive relationship with the degree of scientific literacy achievement. Therefore the higher the students achievement, the stronger the motive for scientific learning in order to develop their ability to think scientifically or acquire science knowledge. Application ability in everyday life or enhancement of creativity was not an important learning motive, reflecting the situation in Korea's science education, which emphasized science knowledge and thinking ability rather than the diversity in applying science knowledge to real life or developing creativity.

Fourth, Korean students were shown to participate very little in out-of-school scientific activities other than watching TV programs related to science. Whatever the activities may be, the more actively involved students are in out-of-school scientific activities, the higher their scientific literacy achievement. Based on such observation, science education in Korea should place more focus on informal science education, such as excursions to science exhibitions and museums, nature trips, and subscriptions to science magazines and books.

Fifth, Korean girls were rather passive compared to boys in all areas, including science learning motive and out-of-school scientific activities. The gender difference was especially more pronounced in out-of-school scientific activities with wider gaps in such activities as reading scientific books or articles and visiting science-related web sites. In order to cultivate scientific literacy needed in everyday life, not science knowledge, it would be more effective to have individual and voluntary interest and participation in not only science classes at school but also out-of-school activities. Seen from this perspective, the gender difference in extracurricular scientific activities can be conjectured to have a direct effect on the gender difference in the scientific literacy achievement of PISA. The motives for science learning and out-of-school activities all point to students attitude toward science. The passivity of Korean girls toward science led to the largest gender difference in scientific achievement among all PISA participating countries, resulting in girls lagging far behind boys in science. Considering the fact that several studies show a close positive relationship between attitude and achievement (Stark, 1999; Tony-Purta, 1994; Watts & Aesop, 1997), one of the ways to overcome the gender gap among Korean students is to forge an educational environment that encourages girls to have an active attitude toward science.

V. Conclusion

In Korea, it is proved that students' home background such as parents' socio-economic

status, parents' educational attainment, family wealth, and cultural possession has less influence on students' scientific literacy achievement, comparing with other PISA participating countries. It is admitted that some differences exist between groups in parents' socio-economic status, reporting much lower score than OECD mean. That is, parents' socio-economic status is not so much as a powerful indicator of student performance as other OECD countries. The tendency, however, is same as other OECD countries, which shows that the higher parents' socio-economic status the better Korean students' scientific literacy achievement.

Students with strong science learning motives tend to perform better than those with slight science learning motives, supporting that positive attitude toward science results in higher science achievement. Similarly, students who participate frequent out-of-school science activities, such as watching TV science programs, reading science books or articles, and visiting science-related web sites, tend to perform better than those who do not. A prominent gender differences are also reported in science learning motives and out-of-school science activities, probably causing the largest gender differences in science achievement in all PISA participating countries.

In the field of Korean science education, few interests have so far been concentrated on international comparative assessment. One possible reason for it is that Korean students have made an excellent performance in most international science studies. However, a variety of problems and suggestions are drawing from very recent international results (Park *et al.*, 2000; Hong *et al.*, 2001; Kim *et al.*, 1999; Shin & Ro, in press; Shin *et al.*, in review) including this study, which should not be neglected. Any other results cannot be more objective than international results assessing representative samples of Korea, which can be generalized to Korean students' overall tendency. From this perspectives, the result of this study is expected to make an important role in developing science education of Korea.

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