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# Experts' Opinions on the High Achievement of Scientific Literacy in PISA 2003: A Comparative Study in Finland and Korea

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Despite the breadth of coverage and collaboration, few empirical studies have concerned educational background and its implementation in order for scrutinising the reasons for students' high scientific literacy in Program for International Student Assessment (PISA) 2003 at international level. Rather, many report the data as evidence of successful accountability in a country. In order to illuminate reasons for the high achievement, experts from Finland and Korea participated in a web-based survey. Their opinions revealed heterogeneous contributors: Korean parental support and private education, and Finnish policy involving educational equality; Finnish and Korean teacher education; and Korean centralisation, and Finnish devolution of curriculum and its implementation. Because of the reasons which are irrelevant to the policy orientation of PISA, careful analysis of the educational background and implementation ought to be recognised in advance of reporting the students' achievement as evidence of national accountability.

*Keywords*: PISA 2003, private education, public education, comparative study, Finland, Korea

## INTRODUCTION

According to the Organization for Economic Co-operation and Development (OECD) documents, the Program for International Student Assessment (PISA) examines to what extent students at the end of compulsory education have acquired knowledge and skills that are essential for their full participation in society. Skill refers to the ability to analyse, reason, communicate, solve and interpret problems in a variety of situations. They are included in the PISA as a part of *literacy* and are relevant to lifelong learning in domains of reading, mathematical, and scientific literacy. In the science section, scientific literacy does not merely refer to the mastery of the science curriculum, but also "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (OECD, 2004, p. 286).

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Based on its assessment aims, the comparative findings in PISA scientific literacy have been interpreted as indicating how successfully an educational policy in a country has been implemented for promoting the improvement of the public education (Aydagül, 2006; Ertl, 2006; Gorard & Smith, 2004; Harlen, 2003; Schleicher, 2006; Schwager, 2005).

Over the last two decades, there has been an international trend in science education policies and reforms which have aimed at improving science education quality and eventually at raising student achievement. This trend assumes that "a country's economic development and wellbeing depend upon a work force strong in its scientific conceptual knowledge" (Aikenhead, 2008, p. 47). For the political reason, the outcome-based reform led to standards-based education polices, which prescribed performance standards for schools, teachers, and pupils (Hargreaves, Earl, Moore, & Manning, 2001; Sahlberg, 2004). For example, Finnish and Korean 15-year-old students ranked first and third highest among the OECD countries in the international PISA 2003 scientific literacy assessment; this was far above the overall average (Finnish mean value = 548.2, Korean = 538.4, overall average = 500). Analysing the statistical data from OECD, many national reports in Finland and Korea (e.g., Korea Institute of Curriculum & Evaluation [KICE], and Korean Educational Development Institute [KEDI]) conclude that their PISA results are evidence of successful national accountability where many foresee future development of the nations (KEDI, 2005; KICE, 2004, 2005; Välijärvi, Linnakylä, Kupari, Reinikainen, & Arffman, 2002). Especially in Korea, the government is keen about students' performance in science: when Korea had slightly decreased its performance during 2000 and 2003, the national report was published concerning how to recapture the world-top performance in science (KICE, 2004).

However, other comparative studies which examine educational implementation as well as students' achievement have contradicted these positive national reports. According to International Institute for Management Development in Switzerland (IMD) study 2005, Finland and Korea were ranked 1st and 40th out of 60 countries on the criteria of public education (IMD, 2005). Even though the latter study focuses mostly on the national competitiveness of education as an infrastructure of international enterprises, the inconsistent data imply that students' high achievement in scientific literacy in some nations (e.g. Korea, Japan, and Hong Kong) might not exclusively be due to the public education on which PISA gives feedback. OECD reported other questionable data; the Gross Domestic Product (GDP) proportion of private expenditure on education was highest in Korea (3.41%) and the second lowest in Finland (0.10%) among the participant countries, while the GDP proportion of public expenditure in Korea was lower than its OECD average (OECD, 2005). Korea is thus perceived to be a country where private education matters more than public education both by students and parents (Kim & Kim, 2002). The national study discovered the high reliance on private education for students' school achievement. In Korea, 70.3% of sample students and 58.6% of their parents believe that students can achieve better grades in major school subjects such as science through their *cram schools,* which are prevalent as a type of private evening school that offer after-school classes for enhancing students' school achievement in Asian nations (Tsai & Kuo, 2008), or through private tuition better than through their public education. In the nations where there exists a robust system of private education, the credence toward the formal school education and the degree of teachers' confidence in their career are also examined as being lower than in other OECD countries (e.g. KICE, 2004).

## RESEARCH QUESTIONS

The literature has questioned the results from international assessments as a national criterion of public education in some nations, especially when relating Asian students' achievement to their public education. For example, private education (shadow education) is examined prevalent to support students in such schooling institutions to advance to higher education in Japan (Stevenson & Baker, 1992); the Korean government has tolerated private education and consequently contributed to its prevalence over public education (Kim, 2000); the private tutoring accounts for a significant proportion of school achievement in Korea and Japan (Sahlberg, 2007); cram schools are examined to influence Taiwanese students' conceptions of learning and learning science (Tsai & Kuo, 2008). However, few empirical studies have concerned both public education, which consists of educational policy and its implementation, and private education through which we may scrutinise the high achievement in the international assessment. Examining educational background and the implementation of education in Finland and Korea (the 1st and 3rd highest ranked nations in PISA 2003 science, the former being Western, the latter Asian), our research questions are set as follows:

1. *What are the reasons suggested by science education experts in Finland and Korea for the success of students in PISA 2003 scientific literacy?*
2. *Which of these reasons relate to public educational policy and its implementation?*
3. *Which of these reasons involve the private education of science?*

For empirical comparison of the two education systems, we organised an expert survey in Korea and Finland through a web-based survey system. Experts were requested to evaluate how much the given items had contributed to the students' success in PISA 2003 science literacy.


 

## THEORETICAL BACKGROUND OF QUESTIONNAIRE

Figure 1 presents the structure of our questionnaire containing 69 items. Its upper part, concerning public education (b1, c1-6), outlines how every factor is eventually interrelated and how students develop scientific literacy. While assessing students' scientific literacy and comparing its quantitative data over nations, PISA provides feedback to participant governments, which in turn relates to each policy (b1) and its implementation (c1-6) in national science education (OECD, 2004). According to National Research Council (NRC), its base presumption is that such international or national assessments lead to constructional change in national (public) education of science by advising students how close they satisfy the extrinsic expectations of their achievement, informing local communities about the effectiveness of their curriculum and school teaching, and counselling policy makers about how far education policies achieve their aims (NRC, 1996). Since they expect high scores in those international assessments to play a robust role in their economic development, governments assimilate the results of PISA as a criteria for developing infrastructure toward national development and for reforming various aspects of education: an educational policy standardises its public education (b1), encouraging teacher education (c3) and local school management (c5) (Aikenhead, 2008; Hargreaves, Earl, Moore, & Manning, 2001). Under the influence of an educational policy, much literature has been documented to report that teacher education (c3) and local school management (c5) could be the critical facilitators in pupils' performance. The former produces quality science teachers as facilitators of the educational policy in Finland where teaching is perceived as a high-state career and parents are satisfied with the education in school (Alamäki, 2000; Simola, 2005). The latter is referred to as school autonomy in setting education standards, school budget, and personnel management, connecting the educational policy and students' performance (Maslowski, 2007; Wossmann, 2003).

In particular, the national curriculum (c1) practices the code of educational policy by manipulating teaching material (c4) and individualised education (c6). According to the analysis of the reasons for students' performance, the detailed curriculum and textbooks

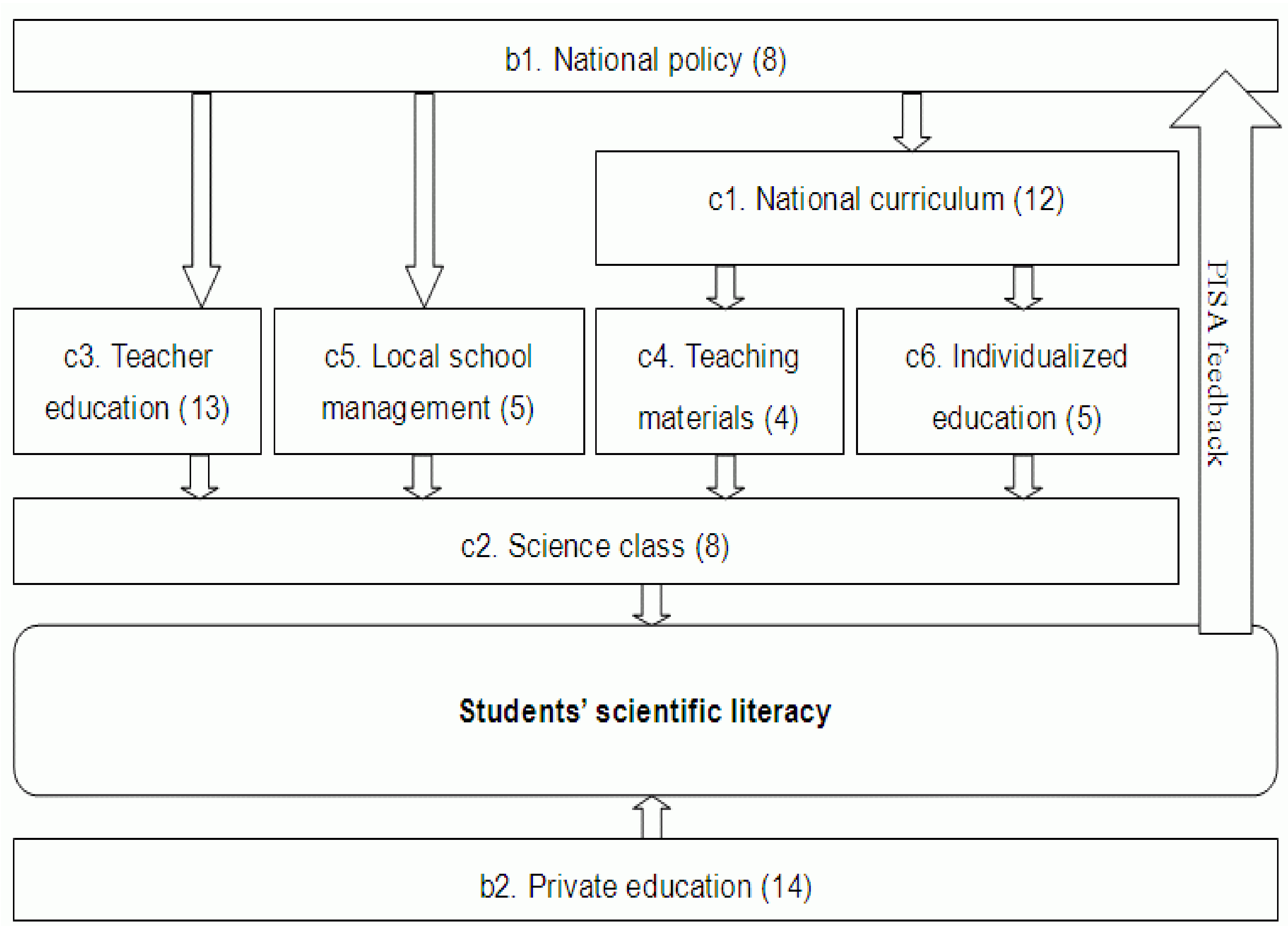


**Figure 1. Structure of the questionnaire and its theoretical background illustrating how public and private education influence students' scientific literacy (the figures in parentheses refer to the number of items)**

approved by centralised educational policy positively relate to the students' performance of science and mathematics (Wossmann, 2003). Such control over teaching material for deriving students' performance has been grounded in the perspective of outcome-based reform, and has been prevalent among curriculum makers for the last two decades (Barton, 2007). For example, a recent national report on PISA science issued by the Korea Institute of Curriculum & Evaluation (KICE) suggests that the curriculum makers should make note of the science content on which the higher-ranked nations (where students have performed better than Koreans) place importance, and should consider including them in upcoming curriculum and textbook revisions in order to attain better results in PISA (KICE, 2007). Lastly, it has also been found to be significant that individualised education (c6) contributes to students' better performance in PISA scientific literacy. In fact, in Finland there are fewer low achievers than in any other country participating in PISA. Kivirauma (2007) asserts that the equality of Finnish education focusing on part-time special education (where low performing students receive an additional two-hour class per week) has implemented the individualised education, and thus contributed to the overall high performance in the nation. All of these influences are set to be enacted in the science class (c2) which illustrates physical or situational environments such as students' behaviour and attitude, and teachers' instructional strategies.

Other than the public education, much literature has reported that private education is another non-negligible influence in Asian countries (e.g. Japan, Taiwan, and Korea). Families in Asian nations are not only expected to support students' education by taxes but also to make a financial contribution to cram schools (Guo, 2005). Together with the regional tradition of educational enthusiasm and the high desire toward higher education, private education is considered to contribute to students' performance in science (Tsai & Kuo, 2008). The questionnaire thus contains items examining private education (b2) considering such important issues such as parental endeavour toward children's education (George & Kaplan, 1998; Han, 2004), its consequential effect toward the competitive school culture (Kim, 2003; Lee & Kim, 2003), and the cram schools or private tutoring (Kim & Kim, 2002; Stevenson & Baker, 1992).

## OVERVIEW OF EDUCATION IN KOREA AND FINLAND

The statistical data presented in Table 1 and 2 provides a general overview of education in Korea and Finland. The Korean compulsory education system consists of kindergartens, primary schools, middle schools (lower secondary schools), high schools (upper secondary schools), vocational high schools, and higher education. Korea had approximately 6 million students in 2006, with 99.7 % of middle school graduates advancing to high school. What distinguishes Korean education among the data is that a Korean school tends to educate more students than its Finnish counterpart (only a quarter of the Korean); and student/teaching staff ratios are higher in Korean (22.2) than in Finnish schools (13.0). These school factors are regarded as

**Table 1. Number of students, teachers, and schools in compulsory (elementary and lower secondary) education in Korea and Finland**

| | Students (A) | Teachers (B) | Schools (C) | (A) / (B) | (A) / (C) | Advancer § |
|---|---|---|---|---|---|---|
| Korea* | 6,000,000 | 270,000 | 8,700 | 22.2 | 690 | 99.7% |
| Finland** | 580,000 | 45,000 | 3,400 | 13.0 | 170 | 95.1% |

* (MOE&HRD, 2006); ** (Tilastokeskus, 2007); § those who advanced to schools of a higher grade

**Table 2. Allocation of school science in Korea and Finland (figures in parentheses present number of classes per week per academic year)**

<table>
<tr><td>Grade</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td><td>5th</td><td>6th</td><td>7th</td><td>8th</td><td>9th</td></tr>
<tr><td>Age</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td></tr>
<tr><td>Level</td><td colspan="6">Primary school (Basic comprehensive school)</td><td colspan="3">Lower secondary School</td></tr>
<tr><td rowspan="2">Korea*</td><td colspan="2" rowspan="2"></td><td colspan="4" rowspan="2">integrated physics, chemistry, biology, & earth science (3)</td><td colspan="3">integrated physics, chemistry, biology, & earth science</td></tr>
<tr><td>(3)</td><td>(4)</td><td>(4)</td></tr>
<tr><td>Finland**</td><td colspan="4">integrated biology, geography, physics, chemistry, & health education (2.25)</td><td colspan="2">integrated biology & geography (1.5),<br>integrated physics & chemistry (1)</td><td colspan="3">biology (1.2), geography (1.2), physics (1.2), chemistry (1.2), & health education (1)</td></tr>
</table>

* (MOE&HRD, 1997); ** (NBE, 2004)

multilevel variables in the PISA study, and are considered to have an impact on students' performance (OECD, 2007a). The Finnish education system consists of comprehensive school, post-comprehensive general (upper secondary school) and vocational education, higher education and adult education. In 2006, there were 3,400 comprehensive schools and 0.58 million pupils in compulsory schools. About 53.3% of the students continued their studies in upper secondary school and 41.8% in vocational schools, which meets the total 95.1%. The vocational schools are vocationally oriented but still allow students to continue their studies in polytechnics and universities. The Finnish school system differs from the Korean in terms of the small-size classes and schools (13.0 students per teacher, and 171 students per school).

Along with the statistical comparison of the school factors, our second discussion of the overall education in the two countries involves the allocation of school science over 1st to 9th grades in comprehensive school (see Table 2). Koreans commence their first school science (*Kwahak*) when they are in the 3rd grade. During 34 academic weeks, elementary students take three 40-minute classes per week, while lower secondary students take three or four 45-minute classes. The contents in all science textbooks are authorised by the government, and they are evenly divided into 4 distinct subjects for 3rd to 9th graders: each of the 4 subjects occupies the identical amount of concepts in a textbook. As long as every 4 science sectors (physics, chemistry, biology, and earth science) nominate each curriculum makers, sectarianism appears to acquire more/even amount of each in school science (Kwon, 2001).

School science in Finland is schemed with more complexity as is presented in the bottom row of Table 2. As students advance to higher grades, the number of science classes increases, i.e. 2.25 classes for 1st – 4th graders, 2.5 classes for 5th – 6th, and 5.8 classes for 7th – 9th graders. In Finland there are on the whole 190 schooldays in an academic year which is equal to 38 weeks; one lesson is 45 minutes at all levels. Science subjects are taught as early as possible, even from grade 5. At grades 7 to 9, specialised physics, chemistry, biology, geography and health education teachers separately teach each science subject.

According to OECD's (2007a) multilevel analysis, the socio-economic differences at school level such as school size, student/teacher ratios, and learning time at school have an impact on students' performance in science. The overview of the educational system shows that those school factors in Korea are considered to be disadvantageous to pupils' performance, when compared to the ones in Finland. For example, a school has 4 times as many students in Korea than in Finland. Since a school shares a common curriculum, textbooks, and teachers (Reinikainen & Isozaki, 2007), it is expected that schools in Korea support less individualised education than in Finland. Even so, PISA 2003 reports that students from both countries achieved high results well above the OECD average of 500 in science. As our discussion above indicates, the PISA 2003 results do not coincide with other research findings, and empirical studies are called for in order to examine the research question: "what are the reasons for the success in PISA 2003 scientific literacy?"

## METHODOLOGY

### Expert survey

Historically, experts in science education are perceived to play the role of a facilitator who coordinates various opinions from students, parents, teachers, policy-makers, and scientists (Ogawa, 2008). Zembylas (2005) regards them (researchers) as those whom policy-makers and the general public consult with to understand the Eurocentric science: "Researchers in science education can help policymakers and the general public to understand Western science as well as other types of science, and the limits, advantages, and ethics involved around scientific advances in the 21st century" (p. 720).

For instance, expert opinion provided information for deciding whether an emerging element in science education should be included in the compulsory curriculum (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). Osborne and his colleagues conducted Delphi study of 3-stage questionnaire and revealed that 5 key concepts about the nature of science (or ideas-about-science) should be considered as essential components in secondary science. Furthermore, what the experts in community of science education and science communication agreed about the issue gave clear measure of the unbalance between teaching about the science and teaching the nature of science. In Korea, expert opinion was examined to explore a consensus of aims of laboratory activities in secondary science (Yang, Cho, Jeong, Hur, & Kim 2006). The sample experts comprised scientists, science educators, teachers in elementary school, and science teachers in secondary school. The Korean study suggested that the most requisite aims in school laboratory is to acquire skills of scientific process for elementary and secondary science and to develop ability for scientific discovery of regularity by interpreting natural phenomenon for university science. The expert opinion was supposed to provide the timely guideline of laboratory activities as the Korea national curriculum commenced focusing on science inquiry in school laboratory.

**Table 3. Likert scales values**

| *Analytic Value* | *Description of scale on the survey* |
|---|---|
| N/A = 0 | This factor does not exist at all in my country or I totally disagree with it. |
| 0 | This factor does not affect students' high achievement of PISA 2003 in my country. |
| 1 | |
| 2 | |
| 3 | This factor strongly affects students' high achievement of PISA 2003 in my country. |

This study, as well, expects the respective consensuses of each items over the two countries could provide empirical discussion of the national science curriculum and educational policy. For the purpose, the authors surveyed 82 experts from Finland and Korea by a web-based surveying system. Having approved the code of research agreement, experts from each country were asked to scale the degree of their acceptances of the 69 possible reasons behind 15-year-old students' success in PISA 2003 scientific literacy.

### Items and scale

Our rationale model described in Figure 1 was employed to develop the 69 items. The survey includes, in addition to the respondents' background information section, two main categories: "*B. Educational background*" where (b1) national policies of science education and (b2) out-of-school influences were identified; and "*C. Implementation of science education in comprehensive school at grades 7-9*" questioning factors such as (c1) national science curriculum, (c2) science teaching and learning, (c3) science teacher education, (c4) teaching / learning materials, (c5) school management, and (c6) special education. The authors of this study discussed how to allot the most relevant items into each category. There were more than ten iteration revisions of the questionnaire among the authors. The socio-cultural and linguistic differences were also considered. For example, the expressions that contain degree of acceptability toward an item such as "very much", "much less", "strongly", or "poorly" were avoided.

The basic Likert scale is labelled only for experts' none and maximal acceptance (see Table 3). Its two medial choices remain empty for the purpose of resolving respondents' discordance among scale intervals. The experts answer the survey by clicking the appropriate box on a 4-choice Likert scale; its two extreme choices are *"this factor does not affect students' high achievement of PISA 2003 in my country"* and *"this factor strongly affects students' high achievement of PISA 2003 in my country"*. Their responses are then marked as 0, 1, 2 and 3. This marking strategy enables the authors to presume that the scale is a continuum, and thus its means and standard deviations can be analysed, although, strictly speaking, the scale is ordinal to each item (Jamieson, 2004). In fact, such a strategy has been employed in multiple-language surveys such as Relevance of Science Education (ROSE) to preclude respondents from linguistic misunderstandings that might occur in translating English into national languages, e.g. its scale illustrates only two extreme choices, "*1 disagree / 4 agree*" or "*1 not interested / 4 very interested*", without two medial choices (Schreiner & Sjøberg, 2004).

Since the two culturally and linguistically disparate groups of educational experts from Finland and Korea respond to one identical questionnaire, another issue of developing the scales occurs: *non-existence* of certain factors in a nation. For example, the literature concerning high reliance on family expenditure on students' private education predicts that the item, "*B2g. there are many private cram schools in my country*" might score high from Korean experts (Kim, 2000; Stevenson & Baker, 1992). On the other hand, in Finland where educational equality is highly respected through its public education, such educational symptoms might not exist. Since the most negative choice of our basic scale, *"this factor does not affect students' high achievement …"* still premises the existence of such an educational symptom (e.g. private education in Finland), a *non-existence* choice should be provided for participants' better understanding of the questionnaire. Therefore, the Likert scale includes an additional choice, "*N/A (not applicable); this factor does not exist at all in my country; or I totally disagree with it*" where respondents refuse to mark the irrelevant item reflecting their professional belief in science education. Since their refusals theoretically imply that the item does not influence students' performance in the nation, its analytic value is thus marked as zero in its later analysis (see Table 3). For the same purpose, s/he is not allowed to choose any other choices on the Likert-scale, if a respondent chooses the "N/A".

The items were first developed in English and then translated into the two domestic languages–Korean and Finnish. Since there were subtle linguistic nuances that made a difference to national respondents, the questionnaire was required to undergo an elaborate validation process of its language and contents review. Socio-cultural differences were cautioned in the translation process. For example, the item "*B2h. fathers help their children with school homework*" could refer in Korean to "*there exist fathers who help their children with school homework*" or "*some percentage of fathers help their children with school homework*". Hence, the translations in the two languages contain counterpart expressions such as "*in general*". Through discussion with national researchers, translations of the English version into every other language were performed by retaining the identical meaning of the original version, and not done word-by-word.

**Validity**

Validity of our items commences with its framework where the rationale with the relevant literature is applied. A pilot test based on the framework targeting 6 Korean researchers in science education was conducted to obtain their professional comments on the items. Since the pilot sampling was limited in its quantity to employ statistical analysis, their comments and the mean values were examined only for validating the items. For example, some items that contain adverb expressions were amended to indicate national generalisations in science education in order not to narrow their nuances toward certain occasions (see the same discussion with item *B2h* on the preceding section).

In the second round of our validating procedure, face validity was adopted to scrutinise the items. The literature explains face validity (FV) as follows: "A direct measurement of FV is obtained by *asking* people to rate the validity of a test as it appears to them" (Nevo, 1985, p. 288). In the perspective, 6 science education researchers from Finland and Korea who are capable with English to a high level, as well as their mother tongue, reviewed the items. They were asked to validate the items by focusing on 1) whether every item examines what the survey is purposed to examine, 2) whether every item is understandable in the context of their national situation, and 3) whether every item possesses linguistic coincidence between the national language version and the original English version. Every additional comment on an item from a version was employed for amending its equivalent item in another version. For the synchronisation of language coincidence, the items were first validated in Korea, then in Finland.

**Sampling**

Since the distribution and number of students, teachers, and schools vary among the two countries, e.g. Finland has a relatively small-population with much social homogeneity (Simola, 2005), their academic contribution in science education was employed to be a criteria for selecting samples. In Korea, invitations were sent to the authors who had published one or more research articles in the domestic journal of science education, *Journal of the Korean Association for Research in Science Education* during 2004-2006. Among 143 email invitations requesting their participation in the web-based survey, 38 experts agreed with the ethical code of the web-based survey and responded to our items written in the Korean language. Likewise, experts in Finland were sampled among the members of the *Finnish Mathematics and Science Education Research Association* who had published their research papers in the proceedings of the annual meetings of the association (e.g., Laine, Lavonen, & Meisalo, 2004). Altogether 72 emails were sent to the selected experts with one additional reminder; 44 of them consented to the ethical code and collaborated with the survey. Tables 4 and 5 present the demographics of our sample experts.

**Table 4. Distribution of respondents' working place**

| A1. Where are you working (you can choose more than one)? | Korea | Finland | Tot. |
|---|---|---|---|
| In primary/secondary school | 10 | 1 | 11 |
| In a Department/Institute of Education/ Pedagogy/ Didactics etc. | 6 | 23 | 29 |
| In a Department/Institute of Physics/ Chemistry/ Biology/ Science etc. | 1 | 10 | 11 |
| In a Teacher Training College/ Training School/ etc. | 17 | 3 | 20 |
| In a department of administration | 0 | 0 | 0 |
| Other, please specify: | 4 | 7 | 11 |
| Total | 38 | 44 | 82 |

**Table 5. Distribution of respondents' position**

| A2. What is your position? | Korea | Finland | Tot. |
|---|---|---|---|
| Teacher in a school | 7 | 4 | 11 |
| Professor / Lecturer / Senior Lecturer / University Teacher | 20 | 26 | 46 |
| Pre/in-service teacher educator | 0 | 0 | 0 |
| Assistant, graduate student, Post-doc researcher | 1 | 6 | 7 |
| Researcher | 6 | 2 | 8 |
| Other, please specify: | 4 | 6 | 10 |
| Total | 38 | 44 | 82 |

**Table 6. Private education in Korea and educational policy in Finland**

| | Korea | | Finland | |
|---|---|---|---|---|
| **B. Educational background** | **M (S.D)** | **[Rank]** | **M (S.D)** | **[Rank]** |
| *B1. Educational policy* | | | | |
| b1a. knowledge-based society | 2.11 (0.83) | **[11]** | 1.95 (0.96) | [30] |
| b1e. educational equality | 1.37 (0.91) | [39] | 2.73 (0.59) | **[3]** |
| *B2. Private education* | | | | |
| b2a. educational enthusiasm | 2.39 (0.92) | **[2]** | 2.25 (0.58) | [18] |
| b2e. parental wish for education | 2.42 (0.92) | **[1]** | 1.70 (0.82) | [39] |
| b2f. high social status of schooling | 2.11 (0.98) | **[10]** | 1.66 (0.71) | [40] |
| b2g. private cram schools | 2.08 (1.09) | **[12]** | 0.11 (0.39) | [68] |
| b2i. mother's help with assignments | 1.92 (0.85) | **[15]** | 1.16 (0.81) | [55] |
| b2k. mother's advice on career | 2.18 (0.83) | **[6]** | 0.80 (0.88) | [58] |
| b2n. competitive culture in school | 2.16 (1.03) | **[8]** | 0.39 (0.62) | [61] |

With regards to the concern that some of the invitation receivers might not be specialised enough in the PISA 2003, the web-based survey contains the cover page. This provides them with our research aim, premises, and the significance of their proficiency (see *Cover page of the survey* in Appendix) in order to help them reflect on whether to participate or not. A relatively small proportion of receivers (27% in Korea; 61% in Finland), who self-evaluated their specialty in the issue, accepted our invitation, participated in the survey, and informed the authors about their participation via email. We also received a decline letter with the excuse that the particular expert lacked specialty in the area of PISA.

## FINDINGS

The analytical processes are conducted according to the item structure consisting of two categories, "*B. Educational background*" and "*C. Implementation of science education in comprehensive school at grades 7-9*". The reliabilities of each category were examined to indicate Cronbach's Alpha = .74 ($N$ = 22) for category B and Cronbach's Alpha = .89 ($N$ = 47) for category C. Due to certain limitations of our comparative survey: 1) the responses from the two countries can not be standardised; and 2) Westerners (the Finnish) and Easterners (the Korean) are considered to represent what they believe toward identical objects in different modes (Nisbett, 2003), our discussion focuses on the 15-highest ranked items among 69 items by their mean values from both nations. Thus the number of items discussed in this section is 15 from the Finnish experts and 15 from the Korean experts, summing to 27 selected items listed in Table 6-8 (3 of them were overlapped).

### Korean parents and Finnish policy in educational background

Korean experts perceive that parental support of their children's education, especially from the side of the mother, (b2e, 1st; b2k, 6th), and the enthusiastic and competitive culture in education (b2a, 2nd; b2n, 8th) are important for students' scientific literacy in the educational background (see Table 6). In fact, the parental effects on Korean education also have an effect on education expenditure; this is also ranked highly by Korean experts (b2g, 12th). Such a social-cultural factor is considered as one of the most prominent factors in affecting school achievements as well as student attitude toward science (George & Kaplan, 1998). Relatively, with regards to the 69 items, educational policy aiming to encourage equality is not considered to contribute to students' performance (b1e, 39th).

Finnish experts rank their policy toward educational equality as important reason contributing to students' scientific literacy (b1e, 3rd). According to National Board of Education (NBE), the long-term objective of educational equality in Finland has been set to enhance the general standard of education since 1970s (NBE, 2004). What is similar with the educational background in Korea is that there also exists educational enthusiasm in Finland, which influences pupils' performance (b2a, $M$ = 2.25; non-influential at $M$ = 0.00 to strongly influential at $M$ = 3.00). However, private education, such as cram schools, is not considered to prevail in Finland (b2g, 68th). Rather, on the ground of educational equality, every student in Finland should finish their state comprehensive school education, regardless of their socio-economic differences (e.g. whether they are from urban or rural regions). Another evidence of the educational equity can be inferred by the fact that there exists little differentiation between schools (OECD, 2007a). That is, Finland has one of the lowest variations in students' achievement and also has small variations between schools.

**Science teacher education in Korea and in Finland**

Korean experts perceive science teacher education as another critical reason for the students' high scientific literacy (see Table 7). As in Finland, the 2-years of studies of physics, chemistry, biology, or earth-science at the subject department are perceived to have a very large impact, and are ranked high among the 69 items (c3i, 3rd). Since science teachers and the education system are expected to play critical roles in applying the national curriculum into school lessons (van Driel, Beijaard, & Verloop, 2001), it is not surprising that teacher education is of importance in the both nations. However, in Korea what differs from the Finnish teacher education is that the Master's degree is not considered to be compulsory and critical in teacher education and consequently does not account for students' scientific literacy (c3h, 43rd in Korea) as much as in Finland (2nd in Finland). Rather, Korean science teachers are perceived to be competent due to what they learn at university level (c3c, 14th), putting less relevance on the other teacher education examined in our questionnaire. For example, freedom in planning of teacher education and the management of classes in Korean universities is not considered to be of high importance (c3a, 49th; c3l, 35th in Korea).

Finnish experts responded that the 8 items concerning teacher education are the most relevant for pupils' performance in PISA 2003 science. To explain

**Table 7. Science teacher education in Korea and Finland**

| C. Educational implementation | Korea | | Finland | |
|---|---|---|---|---|
| | **M (S.D)** | **[Rank]** | **M (S.D)** | **[Rank]** |
| *C3. Teacher education* | | | | |
| c3a. freedom in planning PSTE* in universities | 1.13 (0.84) | [49] | 2.30 (0.73) | **[14]** |
| c3b. effective** combination of subject and pedagogical knowledge in PSTE | 1.71 (0.77) | [23] | 2.61 (0.65) | **[5]** |
| c3c. teachers' proficiency in subjects through PSTE | 1.97 (0.64) | **[14]** | 2.70 (0.59) | **[4]** |
| c3d. effective Master's courses in PSTE | 1.79 (0.81) | [21] | 2.41 (0.76) | **[9]** |
| c3f. self-reflection as a tool in improving oneself | 1.71 (0.77) | [22] | 2.30 (0.71) | **[13]** |
| c3h. Master's degree of teachers | 1.26 (1.06) | [43] | 2.81 (0.45) | **[2]** |
| c3i. 2-year studies in the subject (at subject dept.) | 2.29 (0.80) | **[3]** | 2.91 (0.29) | **[1]** |
| c3j. students learn to analyze SK, SP and C§ while they are planning science lessons | 1.84 (0.95) | [17] | 2.56 (0.63) | **[6]** |
| c3l. students learn to manage a class in PSTE | 1.50 (0.80) | [35] | 2.40 (0.62) | **[11]** |

* PSTE = pre-service teacher education

** *effective* refers to being useful for the teaching profession

§ SK = scientific knowledge; SP = science process; C = contexts

**Table 8. Korean centralisation and Finnish devolution in curriculum and its implementation**

| C. Educational implementation | Korea | | Finland | |
|---|---|---|---|---|
| | **M (S.D)** | **[Rank]** | **M (S.D)** | **[Rank]** |
| *C1. National curriculum* | | | | |
| c1a. general goals presented in NSC* | 2.24 (0.88) | **[4]** | 2.37 (0.82) | **[12]** |
| c1b. science concepts to be learned listed in NSC | 2.18 (0.80) | **[5]** | 1.84 (0.95) | [35] |
| *C2. Science class* | | | | |
| c2a. teachers organise practical work frequently | 1.05 (0.80) | [52] | 2.41 (0.73) | **[10]** |
| c2h. learning concepts is important | 2.11 (0.80) | **[9]** | 1.57 (0.93) | [45] |
| *C4. Teaching material* | | | | |
| c4a. science textbooks are important | 2.08 (0.88) | [13] | 2.44 (0.63) | **[8]** |
| c4c. national regulation of textbook | 2.16 (1.00) | **[7]** | 0.20 (0.70) | [64] |
| c4d. teachers have freedom in choice of textbooks | 1.55 (0.89) | [32] | 2.48 (0.82) | **[7]** |
| *etc* | | | | |
| c5d. schools are monitored by inspectors | 1.47 (0.89) | [36] | 0.21 (0.41) | [63] |
| c6a. support for low-achievers | 0.63 (0.79) | [68] | 2.28 (0.80) | **[15]** |

* NSC = national science curriculum

Finnish students' success in PISA 2003 scientific literacy, the experts consider the following items for teacher education as being most important: student teachers' 2-year studies in the subject (physics, chemistry, or biology) (c3i, 1st), Master's degree (c3h, 2nd), teachers' proficiency in subjects (what they teach) (c3c, 4th), student teachers' education in analysing scientific knowledge, the science process and contexts while planning science lessons (c3j, 6th), effective combination of subject and pedagogical knowledge in the teacher education program (c3b, 5th), preparation for managing classes (c3l, 11th), and self-reflection for their professional development (c3f, 13th). Regarding their robustness of perceived influences on the science education, the experts' opinions in Finland are the most convergent on the two items with the two least deviations .29 for item c3i (rank = 1st) and .45 for item c3h (rank = 2nd).

### Korean centralization and Finnish devolution in curriculum and its implementation

Korean experts nominate the centralisation of the science curriculum as having the other influence on students' high achievement in scientific literacy (see Table 8). Three pieces of evidence can be given for this: the Korean national curriculum is perceived as critical to students' performance in PISA 2003 science (c1a, 4th); the lists of science concepts in the national science curriculum is ranked high (c1b, 5th); and the national regulation of textbooks is perceived as being significant (c4c, 7th). Under the centralised curriculum, science classes in Korea focus on learning concepts more than organising practical work (c2h, 9th; c2a, 52nd). According to the aim of PISA (OECD, 2004), scientific literacy consists of students' integrated capacity in using scientific knowledge, identifying questions, and drawing evidence-based conclusions in order to decide nature-human issues. Hence, such emphasis on the conventional concept-centred curriculum in Korea lacks authority as a contributory factor toward the high achievement in PISA 2003 scientific literacy.

Finnish experts are examined to hold the different opinions that the devolution of the curriculum and its implementation are significant for students' high performance: the national regulation of textbooks in Finland is one of the least significant (c4c, 64th); the freedom with which teachers choose class materials is ranked to be important (c4d, 7th); monitoring of schools (c5d, 63rd) is ranked low. Another characteristic found in Finland is the practical work during science lessons (c2a, 10th), while the science concept itself is given smaller significance (c2h, 45th). Based on their responds, a premise can be derived from the findings in Finland—the flexible curriculum allows teacher autonomy and the practical work in the classroom, which results in pupils' high performance. This corresponds with the literature that under a robust curriculum exerting itself as a blueprint, not simply as a guide, teachers might feel deprofessionalised, less confident, cynically compliant, and increasingly stressed (DeBoer, 2000; Hargreaves, Earl, Moore, & Manning, 2001; van Driel, Beijaard, & Verloop, 2001). National standardisation and teachers' deprofessionalisation have been examined in such relation to each other.

## DISCUSSION

### Limitation

All the 69 items examined in this study have not been scrutinised in detail due to the broadness of the questions and the complexity of international comparison. Thus the authors focused on the 15-highest-ranked items, which enabled the different opinions in Finland and Korea to be more concise and apparent. Another issue in this study is that the sample size of experts is too limited to make any generalised assertion on science education in the two nations. Rather, our comprehensive analysis aims to compare the disparate reasons for the pupils' high performance in international assessments (e.g. PISA 2003 scientific literacy) which has been reported through a large quantity of literature (Guo, 2005; Kim & Kim, 2002; Sahlberg, 2007; Stevenson & Baker, 1992; Tsai & Kuo, 2008). Coinciding with the literature, the disparate reasons are perceived to account for their high performance among science pupils; only 3 reasons are ranked within the 15-highest over Korea and Finland (c3c, c3i, and c1a). Reflecting the consensus among the sample experts, as well as the limitations, we give more focused discussion of "*B. educational background*" and "*C. educational implementation*" in the following section.

### Private education and teacher education in Korea

Korean private education is perceived by the experts to account for the high achievement in PISA 2003 scientific literacy. In fact, the literature on this chronic issue in Korea reported that the educational policy has burdened pupils and their parents with educational expenditure, which is then employed to enhance Korean pupils' high achievement in international assessments (Kim, 2000). Compared to other developing countries, Korea has achieved the high growth in its economic development by combining private spending from families with public expenditure since the 1980s; private education in which parents are willing to make enormous sacrifice for their children's education has contributed to its rapid development (Hanson, 2006). The parental enthusiasm for education thus provokes consequential social issues. The private expenditure in Korea is the highest (3.41% of GDP, about 5 times higher than the OECD average of 0.65%) while its public educational expenditure is lower (4.79% of GDP) than the OECD average of 4.96% (OECD, 2005). Moreover, the national literature considers that the socio-economic growth among families which allows them to afford the high rate of private tuition is a trigger for social-economic inequality (Yang, 2006). Although the Korean government adheres to educational equality, the private educational expenditure has been understood to differentiate the quality of students' education which then influences their achievement in school work over the long term.

In the educational implementation sector, although the 2-year study of the subject at university level is perceived highly relevant to students' high scientific literacy, the freedom that universities hold for planning teacher education and teacher training at Master's level is not considered as significant for students' scientific literacy. This paradoxical finding is believed to originate from the teacher education issues in Korea. The concern of teacher proficiency which has been referred to as *non-proficiency* in pre-service science teacher education programs and *incongruity* in the national examination for the teacher appointment (Cho, Lee, Cho, & Han, 1989; Kim, Pak, & Kim, 1994). Science-teacher candidates are required to obtain 42 credits in their major subject of the nature sciences (i.e., physics, chemistry, biology, earth science, or science for lower secondary students), 14 credits in general education, 4 credits in PCK (Pedagogical Content Knowledge) related courses, including a mere 2 credits of 4-week teaching internship[1]. In Korean universities of teacher education, 80% of professors in science education departments have a degree in the nature sciences; their research has mainly focused on natural science, overlooking the science education aspect, or science teacher education; the pre-service teacher education programs consequently lack pedagogical content knowledge and practical teaching experience (Kim, Pak, & Kim, 1994). The second issue is *incongruity* in the national examination of teacher appointments. It originated from the belief that a well devised pencil-and-paper test could determine teachers' proficiency well enough to qualify them. Because the applicants' credits in university are not monitored properly, private cram schools (not for the secondary students but for the teacher candidates) where they cram science contents and teaching knowledge are also prevalent among the science-teacher examinees. This in turn threatens their proficiency in school practice (Jeong, 2003).

[1] The 14-4-2 credit system (20 credits in total) varies depending on each particular curriculum, e.g., 8-9-3 at Seoul National University.

**Equality and trust toward teachers in Finland**

This expert survey has confirmed the prevalence of Finnish educational policy exerting on equality and devolution of decision making powers in curriculum implementation. The equality is assured by the policy on the practical level. Finnish young people complete the same 9-year comprehensive school education which is provided free of charge, including school books, meals, transport, and health care. For the curriculum devolution, Finnish educational policy values teachers' professionalism for deciding what is appropriate to students and in reporting on the progress of their learning. Local level experts from primary education to universities are not regarded as mere implementers of educational decisions but partners in decision making, giving feedback on the national strategies and framework curriculum from their early development process. Likewise, the number of Finnish schools where they use accountability data in evaluating teachers is less than 20%, while the OECD average is 43% (OECD, 2007b). The culture of trust toward the education system is said to be prevalent in Finland (Simola, 2005).

The distinction revealed in the implementation of science education is that the Finnish background of education is most supported by the teacher education, which coincides with the literature (Lavonen, Krzywacki-Vainio, Aksela, Krokfors, Oikkonen et al., 2007). Finnish teachers are committed to planning the processes of the local curriculum and their science classes with much freedom. The findings in this survey have further reassured this statement, in terms of teacher education as the most contributory factor to Finnish high achievement in scientific literacy. During the 2-year teacher education program and the Master's course, student teachers perform academic research; they become familiar with the terminology and didactics of the subject, and social, psychological development of pupils (Alamäki, 2000). This practical knowledge matters at school, when a teacher guides students to different aspects of scientific literacy. The highest score, small standard deviation (the high scores of low achievers), and small regional differences in PISA 2003 scientific literacy could be inferred to as evidences of the effective teacher education implemented from the educational policy (Simola, 2005).

**PISA scientific literacy as a comparative assessment**

It is common for countries to formulate education policies and to implement them to achieve desirable educational goals, and educational policies are regarded as the power that controls the education system including the teacher education program (Ball, 1993). In the light of robust educational policy and reform, Anglo-Saxon countries invented the performance standards that teachers and students are required to observe through comparative assessments, e.g., Hargreaves et al. (2001) refers to the last two decades as the era of outcome-based education reform. A Map of PISA 2003 illustrates that the participant OECD countries in the comparative assessment mostly covers the Anglo-Saxon where the popular evaluation of policies has long been esteemed.

However, due to our finding that 1) Korea, the new participating country, has achieved high results in scientific literacy from PISA 2003 through disparate reasons (private education, centralisation in policy and curriculum, and teacher education at university level) from Finland (educational equality, trust in education, and teacher education at Master's course level), and due to the fact that 2) PISA initially emerged to assess national policies and to give feedback to the governments of non-Asian countries, careful analysis concerning their educational background and its implementation ought to be recognised in advance of reporting any of its comparative interpretation. According to Sahlberg's (2007) assertions below, the comparative assessments such as PISA should consider student performance attained by certain types of private education as well as public education; they do not represent the national accountability.

> *How student achievement is defined deserves more attention when the educational performance of nations is compared. In most instances achievement indicates what students have gained, not necessarily learned. Moreover, student achievement may be a result of activities not only in school but also out of school. For example, in well-performing education nations such as Korea and Japan, a significant proportion of students' achievement measured by typical school tests is a result of private tutoring, and not school alone. (p. 163)*

Although international assessments might be attributed to various reasons (public or private education), the national reports focusing on the ranks of students' achievement among participant nations have overlooked the latent, robust reasons for pupil's high performance (e.g., KEDI, 2005; KICE, 2004, 2005). The finding in this study that collates experts' opinions empirically compares the disparate reasons for the high achievement among Finnish and Korean students, which could be regarded as a disproof against the national accountability reports. A closer consideration of educational background and its implementation is hence required for interpreting students' performance of the international assessment.

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## Appendix

*Cover page of the survey*

*Educational environment and Science results of PISA2003 at grades 7 - 9 in Finland, Japan and Korea*

Finnish, Japanese and Korean 15-year-old students attained the highest scores of all OECD countries in the international PISA 2003 scientific literacy assessment. The aim of this survey is to analyse the reasons behind this success. This survey, written in your language, concerns only 7 - 9th graders (students aged from 13 to 15) and their science education in your country. We, the authors point to three reasons that affect such high achievement in scientific literacy. They are 1) public educational policy visions, 2) its implementation strategies, such as teacher education and national science curriculum, and 3) other private support for science learning.

Based on your profession, we ask you kindly as an expert of science education to evaluate the influence of each item on students' scientific literacy. The Likert-scale that is uniformly used throughout this survey is listed as below …

According to PISA official documents, scientific literacy refers to the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. Since this questionnaire is used in different countries, there might be some questions that are unfamiliar to you. We promise that any comments you make in the questionnaire can not be identified in the final report. Thank you for your co-operation.