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High School Students' Stereotypic Images of Scientists in South Korea

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This study explored stereotypical images of scientists held by tenth-grade students at three different gender organized institutions. The three institutions included an all-male, an all-female, and a co-educational high school located in South Korea. A total of 393 tenth-grade students from these three respective schools participated in a Draw-A-Scientist-Test (DAST), which was designed to reveal students' perceptions about what scientists look like. After initial assessment of the DAST results, small numbers of students from each school were selected for follow-up focus group interviews. A mixed methods technique was used in order to analyse the DAST scores and data from the transcribed interviews. Quantitative results indicated that the groups from the three different types of schools were significantly different in terms of their stereotypical images of scientists in that the male and female students from the co-ed school had significantly fewer stereotypical images of scientists versus students in the all-male school. Qualitative results from analysis of selected students at the all-male, the all-female, and the co-ed schools corroborated the quantitative findings. Additional discussions address possible ways to improve equitable learning opportunities in South Korea.

Introduction

Culture, gender, and society in relation to science learning are positioned as some of the most important core research strands in the field of science education (Abell & Lederman, 2010). Research on culture, gender, and society within science education has been studied from various angles, but this study is primarily concerned with equitable learning opportunities, gender, and the masculine nature of science. This study is also aligned with the view of pluralism, in that understanding science knowledge is a product of its culture (McKinley, 2010). The working definitions of terms in this study are as follows:

- An equitable learning opportunity is defined as addressing "the needs of both girls and boys, rather than questioning whether each receives the same thing" (Banks, 2001, p 260).

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- The masculine nature of science is constructed and reproduced by “the boy-orientated curriculum packaging and the classroom interactions, whereby gender is re-contextualized” (Kelly, 1985, p. 133).
- Gender is defined as “a social construction, usually based upon the biology of one’s body” (Scantlebury & Baker, 2010, p.258). Social construction is defined as “a process through which a given community assigns, institutionalizes and legitimizes gender roles” (Mlama et al., 2005, p. 2).
- Gender stereotype is defined as “the constant portrayal, such as in the media, conversation, jokes, or books, of women and men occupying social roles, according to traditional gender roles or division of labor” (Mlama et al., 2005, p.1).
- Gender responsiveness is defined as “taking action to correct gender bias and discrimination so as to ensure gender equality and equity” (Mlama et al., 2005, p. 2).

During 1989-1990, there was a controversial debate among researchers over whether the differences in school type, namely, single sex schools vs. co-educational (co-ed) schools, affected girls’ or boys’ performance, achievement, and self-esteem (Bang & Baker, 2013). Although researchers have mixed opinions about the benefits of single-sex schools and co-ed schools, advocates of single-sex schools have the following assertions: 1) they fear coeducation would shatter family values, because they would erase the differences between males and females; 2) girls in single-sex schools have higher self-esteem, are more interested in non-traditional subjects such as science and math, and are less likely to form stereotypes about jobs and careers; 3) single sex schools offer more opportunities for students to find role-models and mentors; 4) in single-sex schools, girls can be educational players rather than spectators; 5) girls are more likely to believe that there is nothing unusual about girls being leaders; and 6) all-girl schools let students be themselves, without worrying about how they look, and without being pressured and embarrassed by guys (Sadker & Sadker, 1995).

On the other hand, promoters of coeducation put forth the following claims; 1) boys and girls learning together is a more natural, realistic situation—and therefore a better preparation for functioning successfully within a democratic society; and, by extension, 2) single-sex schools prepare students poorly for a sexually unsegregated world (as cited in Bang & Baker, 2013).

Due to the concerns of whether the types of school impacts student learning, it is important to reconsider how school types, namely all-male, all-female, and co-ed, play a role in the formation of high school girls’ and boys’ stereotypical images of scientists. Furthermore, when evaluating educational elements in a place like South Korea, where this study was conducted, the following factors need to be considered: 1) there is essentially one relatively homogenous ethnic group; 2) the educational system has a very nationalized, teacher-centred curriculum—which means most science classroom situations lack diversity; 4) the lives of most high school students are focused on preparing for college entrance exams; 5) students learn science with a mastery test book or through rote memorization; 6) the line of gender roles is more apparent than in Western schools due, in part, to the influence of Confucianism and Neo-Confucianism; and 7) this study’s findings can be significant with regards to the future evolution of science education in South Korea.

Purpose of the Study

The purpose of the study is to unpack differences and similarities in perceptions of scientists among high school students from different school types in South Korea using a mixed methodology (Creswell & Plano Clark, 2007). The authors of this study postulate that the results of the study will help galvanize dialogue among science educators in regards to providing equitable learning opportunities for both male and female students, and the ramifications of the perceived masculine nature of science.

Research Questions

1. Do students who have been taught in all-male, all-female, and co-educational school settings have different stereotypical images of scientists?
2. How do high school students in South Korea describe an image of a scientist coming from these three different school settings?

Related Literature

History of Draw-A-Scientist-Test (DAST)

For over fifty years, numerous studies have focused on elementary and secondary school students' images of science and scientists. In their famous study with U.S. high school students, Mead and Metraux (1957) found that the popular perception of the scientist was that of a white male with facial hair, wearing eyeglasses and a laboratory coat, working alone in a lab and using chemicals and test tubes. The following citation generalizes the stereotypical images of the scientist:

> The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses. He is small, sometimes small and stout, or tall and thin. He may be bald. He may wear a beard, may be unshaven and unkempt. He may be stooped and tired. He is surrounded by equipment: test tubes, Bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials. The sparkling white laboratory is full of sounds: the bubbling of liquids in test tubes and flasks, the squeaks and squeals of laboratory animals, and the muttering voice of the scientist. He spends his days doing experiments. He pours chemicals from one test tube into another. He peers raptly through microscopes. He scans the heavens through a telescope, or a microscope. He experiments with plants and animals, cutting them apart, injecting serum into animals. He writes neatly in black notebooks (Mead & Metraux, 1957, pp. 126-127).

In addition, one of Holland and Eisenhart's (1990) study participants, named Paula, described the following image of science students when she tried to get advice about getting into medical school:

> I need to talk to somebody who knows what's going on…all the people I know are business majors…except, I guess, the people in chemistry class. And I don't want to get into a detailed conversation [with them]…half the people in chemistry are weird…they could be mad scientists…hunchbacks, running around with their lab coats on (Holland and Eisenhart, 1990, p 165).

Such images of scientists were prevalent in the Western world regardless of age or country

(Song & Kim, 1999). Further research conducted in the 1960's and 1970's continued to utilize written instruments to study people's stereotypical images of scientists, and these works confirmed Mead and Metraux's (1957) findings that many students held sterotypical images of scientists (as cited in Painter, Jones, Tretter, & Kubasko, 2006).

Decades later, Chambers (1983) created the Draw-a-Scientist Test (DAST), and administered it to 4,708 students in grades K-5 to determine at what age children first developed distinct images of scientists. He also studied the impact of variables such as gender and socioeconomic class on the formation of these images (Painter et al., 2006). Chamber (1983) found that children held similar images of scientists when compared to the American high school students studied by Mead and Metraux (1957). He reported that stereotypic items as "lab coats, eyeglasses, growth of facial hair, and laboratory equipment that began to appear in the drawings of the youngest children" (Chamber, 1983, p259). Interestingly, he found that only girls drew women scientists. Chamber (1983), however, warned us that when using the DAST, a number of interpretive difficulties may arise which implies the test is more useful in *identifying* rather than *measuring* attitudes.

Mason, Kahle, and Gardner (1991) state that classroom learning environments can change these pervasive social stereotypic images of scientists. In their study, they used the DAST as a tool for sensitizing both teachers and students. Results indicated that when used in this manner, the DAST modified the stereotypic image of scientists held by many students and teachers. For instance, teachers tried to avoid sex-role stereotyping by using non-sexist language to refer to scientists and their activities. Also, teachers presented equitable numbers of men and women who have been successful within the scientific community (Mason, Kahle & Gardner, 1991).

The DAST has been shown to enable science education researchers to obtain data from students with limited written or verbal skills; however, the instrument was criticized because the criteria for scoring were not explicit. Therefore, Finson, Beaver, and Cramond (1995) redeveloped Chambers' original DAST instrument, to produce an enhanced version called the Draw-a-Scientist Checklist (DAST-C). The checklist provides researchers with a list of stereotypical descriptors likely to be found in the illustrations submitted by students.

Stereotypical Images of Scientists

In Korea, researchers have explored the differences between male and female students' images of science. These stereotypical images of scientists were also held by teachers (Song, 1993). Song (1993) also found that kindergarten teachers had more stereotyped images than secondary science teachers did. About 86% depicted scientists as male. Only 5% depicted scientists as women, and they were drawn by mostly female teachers (75%). Noh and Choi (1996) found that students held more masculine associations with scientists and more feminine characteristics in their own self-images. The perceived differences between the images of scientists and self-images were greater for female students than male students. Also, the differences between the perceived images were negatively correlated with negative science-related attitudes. Jeon, Yeo, and Woo (2002) found that after the designed instrument was administered, students were able to successfully cast away the stereotyped images of scientists. Also, there were significant differences between the experimental group and the control group in the perceived gender of a scientist. Namely, more students in the experimental group had drawn pictures of female scientists than those in the control group.

Newer studies are also contributing to a growing body of evidence that sociocultural influences and traditions are deeply connected to students' perceptions of science and their views of scientists. Koren and Bar (2009) have posited that in industrialized countries, the image of the scientist is stereotypical with a certain percentage perceiving scientists as "mad." On the other hand, in undeveloped countries, the scientist is perceived as heroic, brave and intelligent, helping other people, curing the sick, and improving the standard of living. For example, Medina-Jerez, Middleton, and Orihuela-Rabaza (2011) administered the DAST-C to 1,017 Colombian and Bolivian students in grades 5-11 to find out how these students pictured scientists and science. Medina-Jerez et al. (2011) found that Colombian and Bolivian students produced stereotypical images of the scientist, which were revealed in previous studies, via images of white males, conducting experiments indoors, and wearing lab coats and glasses. However, there were some differences in how students perceived scientists based on nationality, grade, and school type. For example, in regards to the gender of a depicted scientist, 85% of Bolivian students included male scientists, while 78% of Colombian students chose male characters to represent scientists. In addition, 9.5% of Colombian students drew female scientists, while 6% of Bolivian students depicted scientists as females (Medina-Jerez et al., 2011).

Laubach, Crofford, and Marek (2012) examined the perceptions of scientists of 133 Native American high school students in grades 9-12 by using the DAST instrument to see if differences existed between grade level, gender, and level of cultural tradition. They found that Native American students who practiced native cultural traditions at home were more able to successfully integrate indigenous knowledge and modern western science than their non-practicing counterparts. In one study of 1,137 Korean students from three different age groups (11, 13 and 15), Song and Kim (1999) found that students' stereotypical views of scientists were influenced more by affective and ethical personal characteristics of scientists than by their cognitive abilities.

Along the same vein, Miller, Blessing, and Schwartz (2006) examined gender differences in 79 U.S. high-school students' perceptions of science and scientists. They found that males liked mathematics and science courses more than females did, and that females tended to find science uninteresting and scientists' lifestyles unattractive. The study also presented several implications for institutional changes regarding science education, and several pedagogical techniques for attracting females to the science, technology, engineering, and math (STEM) fields.

Despite the wealth of information from many years of study, there is still a lack of research on images held by students in non-western countries, specifically in South Korea. Students' conceptions of science and their perceptions of scientists are related to their views of scientific knowledge and practice and to their attitudes towards science and career aspirations (Christidou, 2011). Investigating Korean students' stereotypical views of scientists may be the first step in getting students in western and non-western countries to consider future careers in the STEM fields (Painter et al., 2006). Hence, the purpose of this study is to explore the stereotypical images of scientists held by Korean high school students in an effort to improve inquiry-based science teaching and learning and educational policies in South Korea.

Methods

Data collection

Participants and Contexts

Participants for this study were from 10th grade high schools. They lived in one of the big suburban cities named Suwon, which is 30 minutes from the capital city of Seoul, South Korea. The first author of the study and one of the earth science teachers from an all-male school, Mr. Namu (pseudonym), met to select schools in which to conduct the research. The science teacher had already been informed about the study's purposes and characters via e-mail correspondence with the first author. The science teacher and the first author selected three schools, and its students, based on similarities in socio-economic status and school rankings based on standardized tests.

Before the researcher visited and interviewed each school and its students, (1) the principals and the science teachers were informed through a letter by the researcher about this study's purposes and aims; 2) the science teachers were informed that the participants of this study were to be chosen by a cluster sampling method, in which intact groups were randomly selected (Gay & Airasian, 2003), the researcher chose interviewees by the same method and; 3) the teachers and interviewees were informed that there would be assistants present during the interview phase in order to video-record sessions.

Contexts: Women, South Korean Society, and the Influence of Confucian Virtues

In traditional Korean society, women were largely confined to the home. From a young age, women were required to learn the Confucian virtues of subordination and endurance to prepare for their future roles as wives and mothers. Their roles were limited to the management of the large extended family, and the production of a male heir so that the family line could continue unbroken (Korean Women's Studies Institute [KWSI], 2002). This situation began to improve, however, thanks to the education of women, which followed the opening of the country to the outside world during the late 19th century. With the establishment of the Korean Republic in 1948, women achieved the clear constitutional rights to equal education, job opportunities, and participation in public life (KWSI, 2002).

Today, in compliance with the changing social environment, the government established the Ministry of Political Affairs to handle women's issues in 1988. In addition, in 1991, the Family Welfare Division—with female chiefs in towns, counties, and wards—was also founded to deal with women's welfare issues. On June 25, 1994, a Special Committee on Women was established at the National Assembly as a permanent body to discuss and legislate laws related to women. With the launch of the Government of the People in 1998, the Presidential Commission on Women's Affairs was established to handle women's issues. Despite these efforts, the number of women holding policy-making positions in administration and management remained very small (Elizabeth, 1998). Table 1 depicts a brief summary of women's lives in South Korea reported by the Korea National Statistical Office (KNSO) in 2013.

Table 1: Women's Lives in South Korea (June, 2013)

Items	Female
Female population	50.0%
Female house holders	27.4%
Marriage	29.4 years (first marriages)
Life expectancy	84.5 years
College enrolment rate	74.3% of the total female high school graduates
Labour force participation rate	49.9% (the participation rate for females aged 25 to 29 recorded the highest figure)
Opinions on housework sharing	57.0% of females thought that wives should do house work)
Wage gap between males and females	68.0% of the wages of males
Medical sector (esp. pharmacists)	64%
Lawmakers	15.7%
Local council members	20.3%
Government employees	7.3%
Victims of violent crimes	83.8%
Emergency call for counselling	Domestic violence is the largest share

Methods of Data Collection

DAST (Draw-A-Scientist-Test)

The study followed Mason, Kahle, and Gardner's (1991) DAST. At this phase of data collection, the researcher emphasized that all processes would be administered anonymously for the survey and confidentiality would be maintained for the follow-up interview. The researcher and the assistants handed out coloured pencils to the students and asked them to draw pictures of scientists. The researcher told students that they could write comments about their drawings. Besides that, the researcher did not give the participants any other directions. The DAST sessions lasted 15 minutes.

Focus group interviews

As a follow-up to the DAST, the first author conducted focus group interviews with 11 students who came from the three differing school environments. All interviewees obtained parental consent for video-recording of their interviews, and were notified that pseudonyms would be used throughout the study. All of the interview citations in the study are worked in translation, as it were, from Korean to English. Each focus group interview, which was conducted outside of the school setting, took approximately one to one and one-half hours. Interview questions were adapted from the Mason et al. study (1991) and were revised with feedback from researchers in the area of the nature of science. The main interview questions are listed below:

1. Tell me about your picture (Draw-a-Scientist-Test)
2. Can you describe your image of scientists, what they do and what kind of people they are?
3. What is the scientist's nationality? Why do you think the scientist is from that particular country?

4. From where did you get your image?
5. Do you think more scientists today are men or women? Why do you think this is the case? Do you think this is changing? Do you think this change is good for science?

Data Analysis

This study used a mixed model, in which the researcher used both a quantitative method and a qualitative method for in-depth analysis (Creswell & Plano Clark, 2007). For the quantitative method, the following steps were administered: 1) The DAST drawings from the participants were scored and coded using Microsoft EXCEL; 2) After data entry and coding, the researcher rechecked 30% of the scores for data processing 3) The results of the scored data were transferred to data summary sheets for further uses; and 4) a One-Way analysis of variance (ANOVA, F-test, α=. 05) followed by a Post Hoc test were performed on the stereotypic DAST scores, to test the statistical significance of the differences using Microsoft SPSS 10.0. Any p-value less than or equal to .05 was considered significant.

As for the qualitative method, the first author transcribed the recorded interviews in Korean and English, then used the constant comparison analysis method to find the important themes or issues in the data (Gay & Airasian, 2003). Approximately 516, 10th graders were selected by cluster sampling for the stereotypic images of the scientists. Only 393 out of 516 (76.16%) students from each school participated in a 15-minute Draw-A-Scientist-Test (DAST) for the stereotypic images of scientists.

The Draw-A-Scientist-Test (DAST) rubric that was adapted from Mason et al.'s (1991) study was modified by the researchers and checked by nature of science researchers to make it more applicable to this study. See table 1 for the rubric. One of the modifications to the rubric included adding questions to check whether participants drew a Korean scientist or a Westerner. Each of the 14 items that represents the stereotypic images of scientists was given 1 point. For this study, inclusion of multiple images of the same type in a single drawing counted as one image. For example, if a drawing contained televisions, telephones, and computers—which are images of technology, only one point would be given. Below are the indicators for the stereotypic images of the scientist. Finally, 23 % of the total DAST data were eliminated from the study when the drawings were defined as "unrecognizable" (e.g. stick figures without any comments or notes).

Table 2: Indicators for the Stereotypic Images of Scientists

Stereotypic Image	Score	Note
Lab coat	1	Usually but not necessarily white.
Eyeglasses	1	Wearing eyeglasses.
Facial hair	1	Beard, moustache, abnormally long sideburns.
Symbols of research	1	Scientific instruments, lab equipment of any kind, Types of scientific instruments / equipment.
Symbols of knowledge	1	Books, filing cabinets, clipboards, pens in pockets, and so on.
Technology represented	1	Televisions, telephones, missiles, computers, and so on.

Relevant captions	1	Formulae, taxonomic classification, the "eureka!" syndrome, Why? Fail and so on.
Male gender only	1	
Western or Caucasian only		Taken off when was analysed.
Middle-aged or Elderly scientist**		Taken off when was analysed.
Mythic stereotypes	1	Frankenstein creatures, Jekyll/Hyde figures, etc.
Indications of secrecy	1	Signs or warnings that read "Private," "Keep Out," "Do Not Enter," "Go Away," "Top Secret," and so on.
Scientist working indoors	1	Scientist working indoors
Indications of danger	1	Mask, protective gloves, and glasses etc.

*Note: Several images of the same type in a single drawing counted as one image (for example, two scientists each with eyeglasses received only one check, not two).
**When the researcher tried to analyse this item, although many students drew scientists as very old, the reasons were not quite matched with this image. The most common reason was because they were working day and night, that they were just worn-out. Therefore, this image also had to be taken off.

Findings

All-male, all-female, males and females in co-ed situations were examined using ANOVA. An α level of .05 was used to test for significance between groups. The independent variable—the school type factor—included four levels: students in the all-male school, students in the all-female school, male students in the co-ed school, and female students in the co-ed school. The dependent variable was the stereotypic images of scientists. The results are shown in Table 3. The mean scores and standard deviation for DAST scores for the school types are also presented in Table 3.

Table 3: Analysis of Variance, Mean Scores, and Standard Deviations for DAST Scores

Variable	Source	df	SS	MS	F	p
DAST Scores	Between groups	3	26.29	8.76	4.28	.006
	Within groups	298	609.90	2.05		

	All-male		All-female		Male in co-ed		Female in co-ed	
	n = 73		n = 79		n = 78		n = 72	
	M	SD	M	SD	M	SD	M	SD
DAST Scores	**6.12**	1.57	**5.90**	1.56	**5.41**	1.07	**5.47**	1.47

DAST Scores

- Students from the all-male school vs. Students from the co-ed school – Sig.
- Male students from the co-ed school vs. Female students from the co-ed school – n.s.
- Students from the all-male school vs. Students from the all-female school – n.s.
- Students from the all-female school vs. Students from the co-ed school – n.s.

There was a significant difference in the means between the students from the all-male school and the students from the mixed school, but no significant differences between the male students in the co-ed school and the female students in the co-ed school. There were also no differences between the students from the all-female school and the students from the mixed school, or between the students from the all-male school and the students from the all-female school. Using a boxplot as the graphical method, Figure 1 shows the DAST scores for the school types.

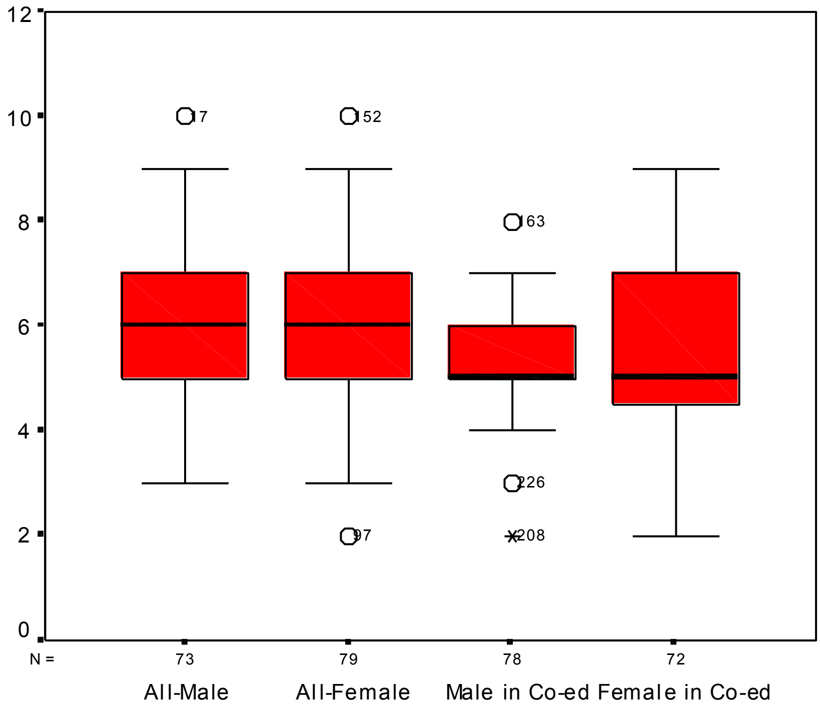

Figure 1: The Boxplot of DAST Scores

Draw-A-Scientist-Test (DAST) Drawings

The DAST data on stereotypic images of the scientist were drawn by 302 students (all-male = 73, all-female = 79, males in co-ed = 78, and females in co-ed = 72) from the same three schools. A close scrutiny of student drawings illustrates the very similar images that Mead and Metraux found from their American high school students in 1957. However, there were interesting drawings that mirrored Korean scientists' predicaments, contemporary science issues and technology, and group work.

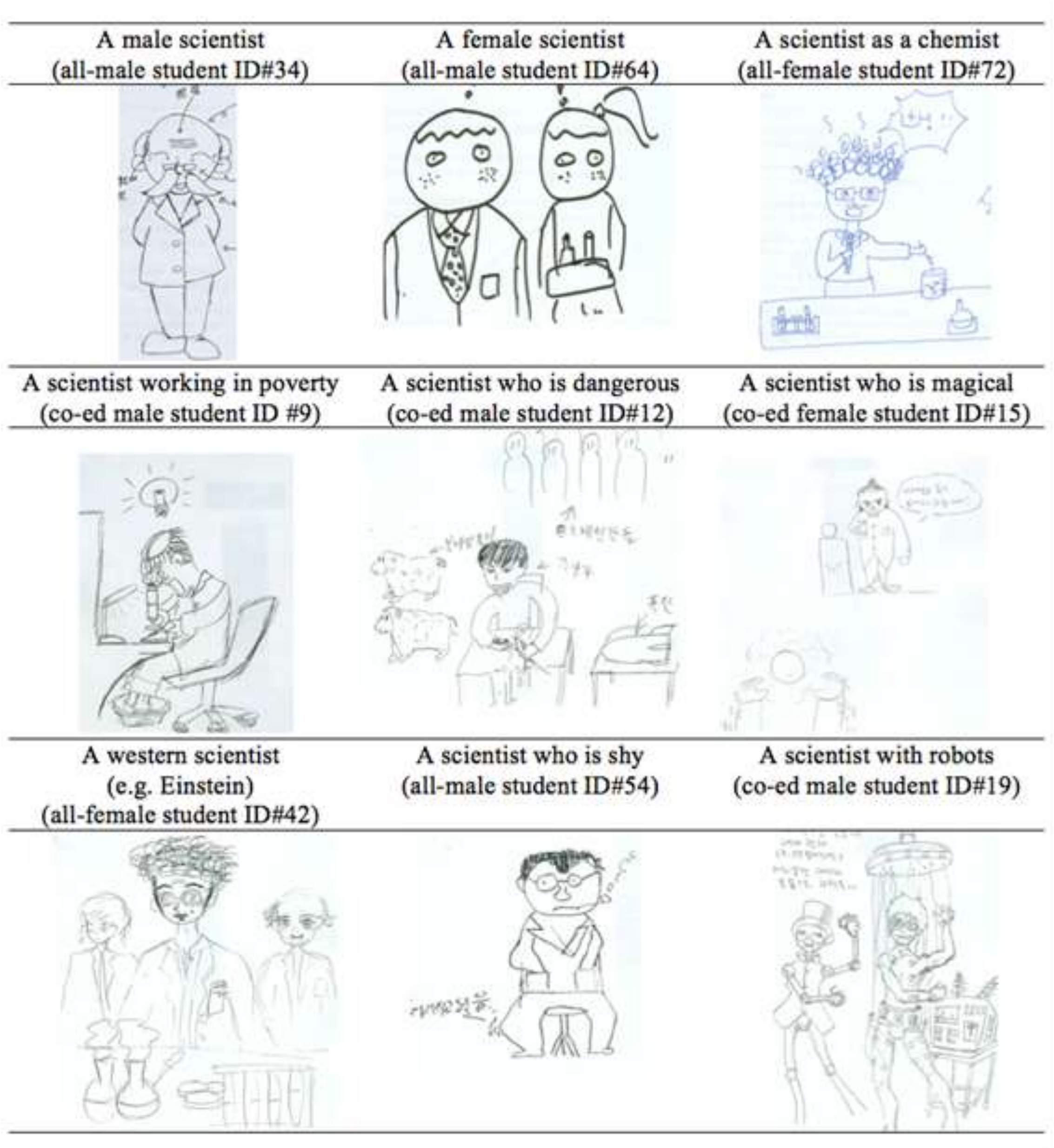

Figure 2: Examples of Students' Drawings

The researcher found ten common images of the scientists from the participants: 1) a scientist who has Mead and Metraux's (1957) standard stereotypic image; 2) a scientist who is in agony because of dated science equipment and poverty; 3) a chemist; 4) a female scientist; 5) a scientist who works with computers and robots; 6) a scientist who is wearing protective clothing; 7) a scientist who is evil or magical; 8) Western scientists; 9) scientists working in a group and; 10) a shy scientist. The images presented in Figure 2 are example drawings of scientists from some of these categories.

The Interviews

Images of Scientists

The interviewer (Int.) asked about the images of scientists, including details such as the kinds of people the scientists were, where the students got these images, and what the nationalities of the scientists were. The students had drawn stereotypic images of scientists that depicted men in white laboratory coats, worked in a laboratory, might be unshaven and unkempt, and and/or surrounded by equipment doing experiments.

DeaShik's (am S2) ideas and description of a scientist were perfectly matched with Mead and Metraux's (1957) findings. JeeSun (af S2), who was from the all-female school, consistently described what scientists were doing, and said that science was very difficult and complicated. However, most of the students from the co-ed school thought that scientists were not that different from normal people, that they simply had science-related jobs. These students' verbal responses correlated with the results of the students' DAST scores, but the students from the all-male school had the most stereotypical images of scientists:

> Q 1. Int.: "Can you describe your image of scientists, what they do and what kind of people they are?"
>
> --all-male--
>
> DeaShik (am S2): "…white hair, because scientists think and do experiments too much, blowing things up or exploding something. Because they are so into their experiments, their eyes are getting bad, so they wear black-rimmed glasses. They always stay inside the lab, so their shoulders become smaller…they are always holding a flask, mixing something, blowing something up. They are always sitting, so their legs are so short. They are worn out. They always work 24 hours…they are thinking about their experiments even while they are eating. When they succeed, then they come out to see the sun…"
>
> --all-female--
>
> JeeSun (af S2): "Of a scientist? Well, the first thing that cames to my mind is an image from a cartoon book. I think scientists are not just doing experiments; for instance a teacher who teaches science is also a scientist. I think I might have been narrow-minded when I drew this [she looks at her drawing]. I drew this because science is very complicated and difficult; therefore, when you study it, you will change into or become a stranger person. Studying science is too hard. Also, scientists are the people who do lots of experiments and who have a lot of curiosity…and who always pick apart anything, because they want to know the reason for everything. So, from a layperson's point of view, they seem invasive."
>
> --co-ed male-
>
> YoungTae (com S2): "I don't think they always wear a white coat and do experiments. In my mind, scientists would vary; like they can invent something new to improve our lives or they can build a spaceship. There are no big differences between normal people and scientists. However they are interested in very tiny, trivial things that are related to science."
>
> --co-ed female-
>
> Sook (cof S1): "They are just doing experiments or doing science-related works in their lab. I think they are just like normal people. I don't think they are that much different."

In terms of the nationality of scientists, most of the students from the three schools imagined them as Westerners, like Einstein. Only two students, SuSup (am S1) and Sunny (cof S2), envisioned them as a Korean.

> Q2. Int.: "What is the scientist's nationality?"
>
> --all-male--
>
> DeaShik (am S2): "When I heard the word scientist a Westerner's image came to me… Especially white people…Einstein's image is very strong."

SuSup (am S1): "Off the top of my head, the image of scientist is Korean. Look, I drew his nose very small."

--co-ed male--
JunHyuck (com S1): "I also thought of scientist as foreigners, especially the Japanese scientist who got the Nobel Prize."
YoungTae (com S2): "…as Edison or Einstein. So to speak, white people…I think white people…"

--co-ed female--
Sook (cof S1): "Of course the Westerners, especially Einstein who is really famous… There are many foreigners in the books that I had read when I was a child. So…"
Sunny (cof S2): "Korean scientists came to my mind first."

The students learned these images mostly from the media, cartoons, photographs, video games, and science-related books. SuSup (am S1) admitted that he had to rely on his imagination because, for him, scientists were so distant. Also, SeoungMin (am S3) indicated that he had never met a scientist before:

Q3. Int.: "From where did you get your image?"
--all-male--
SuSup (am S1): "When I drew this, I used half of my imagination and half of my experience…Media and cartoons are the sources that I have about scientists…Envisioning their characteristics are so difficult because they are so far from us…"
SeoundMin (am S3): "…but I've never met a scientist at all…"

--all-female--
SoonHee (af Sl): "…TV shows scientists who are conducting experiments…When I was in elementary school, I saw many boys who wanted to be scientists."

--co-ed male--
ByungChan (com S3): "Probably science books…"

--co-ed female--
Sook (cof S1): "I've thought this since I was young or I got it from the TV…just learned naturally."

To summarize, both quantitative and qualitative findings indicate that the students from the all-male school had a higher likelihood of maintaining their stereotypic images of scientists than the students from the co-ed school. The focus group interviews indicated that the students at three different gender organized institutions held slightly different degrees of stereotypic images of scientists.

Conclusions

In this study we explored stereotypic images of scientists, as perceived by high school students from three different types of schools in South Korea. These stereotypical images of scientists were captured and reported in the form of drawings and verbal follow-up interviews. The study revealed that the students from the all-male school showed the highest DAST scores, which was significantly different from the students from the co-ed school. This suggests that the students from the all-male school had a more limited and stereotypical understanding of scientists. The students from the co-ed school had the lowest DAST scores and were thus less likely to hold stereotypical images of scientists.

Generally, a scientist was perceived as a Western male wearing a lab coat and eyeglasses, and had facial hair. Symbols of research and knowledge were represented by the following: (1) A female assistant holding a beaker or flask tray, following a male scientist (2) A male scientist holding cylinders or stirring chemicals in a beaker, situated within a laboratory (3) A male scientist looking through a microscope apparently "discovering" something (4) A male scientist surrounded by the results of his scientific work—such as cloned humans, the first cloned sheep, "Dolly," or an atomic bomb.

In terms of stereotypes regarding the character of scientists, students perceived scientists as magical, shy, dangerous, and secretive people who generally worked alone in a laboratory. The follow-up interviews indicated that these images of scientists were garnered from the amalgam of images in mass media (e.g. TV, cartoon books, science books). Finally, this study supports the notion that the images of scientists from students in the all-male school aligned with the findings and descriptions from Mead and Metraux's (1957) study.

Equitable learning opportunity

The results of the study indicated that attending the co-ed school accounted for a few positive effects on both male and female students. This is not to imply, however, that the students' experiences of science in the single-sex schools were unimportant. Taking into account that all three of the schools' environments were the same—in terms of the centrality of the college entrance exam (Ann, 2003; Kim, 2001)—schools should provide enhanced curricula by providing multiple opportunities for students to participate in science fairs, or various out-of-school science activities, such as science camps and field trips to well known laboratories. Another noteworthy finding was that students from the all-male high school held increasingly more stereotypical ideas of women's and men's roles as scientists than male students from coeducational schools. Therefore, having male and female students participate in various science fairs and out-of-school science activities together can encourage the development of more gender-equitable and supportive environments for all students.

Curriculum and classroom interactions

Barton's (2010) description of composite culture offers insights on which learning environments and factors best support the process of students successfully developing an egalitarian view of science and scientists. As she summarized, "science learning, when viewed as enculturation, can be understood as mediated by the intersections of the experiences that students bring to the classroom, the pedagogical ideals of the teacher, and the teacher's explicit understanding of how to bring together the dimensions of professional science practice and pedagogical ideals" (Barton, 2010, p. 332).

Through this lens, science is seen as a collective enterprise, and the role of science teachers is positioned as critical and important—especially their skills in negotiating different or conflicting perspectives and capabilities (Hogan & Corey, 2001). For many science educators in South Korea, this may sound impractical due to the current educational policy and the long tradition of teacher-centered, textbook-centered, and lecture-style science teaching and learning methods (Ann, 2003; Kim, 2001). Yet, creating a classroom culture or even a school support system that respects experiences and perspectives from all involved is worth further investigation.

Certain pedagogical interventions in school can also mitigate the masculine nature of science. For instance, gender responsive pedagogy (Mlama et al., 2005) furnishes several elements such as (1) raising awareness of involved individuals, (2) training students, teachers, and the school community, (3) empowering female and male students to accept gender equity in a positive light, (4) providing scholarships and support—as well as gender responsive infrastructures, (5) designing and teaching activities to promote the participation of girls in STEM fields, and other issues.

Gender Roles and Science

The study sheds light on the fact that gender that was socially constructed affected high school students' access to science learning via somewhat insidious mechanisms of culture. According to Geertz (1973), culture is defined as "an historically transmitted pattern of meanings embodied in symbols—and a system of inherited conceptions expressed in symbolic forms, by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life" (p. 89). Through the lens of Geertz's (1973) concept of culture, it is not surprising to find that gender inequity is still prevalent in some of the results informed by the KNSO, on women's lives in South Korea. Moreover, the results of the study depict societal and culture expectations of what it means to be scientists—for students in South Korean high schools, where gender roles are so clearly drawn. The results also reinforce the masculine nature of science (Kelly, 1985).

Yet, living in a technology-intensive world, it is time for South Korean policy makers to join the dialogues initiated by countries like Australia and New Zealand, in terms of sexism within schools (Scantlebury & Baker, 2010). This daunting job can be initiated by investigating the factors influencing the reproduction of traditional gender roles in the context of current educational policies in South Korea.

Last, but not least, it is not unusual to hear in a conversation between Koreans the assertion that, "the biggest problem in Korea's education is the college entrance exam" (Ann, 2003). Students learn science through textbooks, and concentrate on mastery books—in school and in private institutions—called "Hakwon"—to learn subjects like Korean, English, Mathematics, and Science. Many mothers who are housewives have to find extra work just to pay their children's expensive private lesson fees. When possible, some affluent parents send their children to the United States and Canada to study. According to the KNSO report in 2012, 69.4 % of the total student population in South Korea takes lessons in private institutions, lessons averaging approximately 340 U.S. dollars a month per student.

Considering all the cultural and contextual factors described in this section, the authors of the study urge policy makers to develop stronger foundations that more effectively nurture educational policies and science education, rather than stifle school administrators, teachers, and students. Furthermore, it is suggested that science educators and educational planners in South Korea broaden their perspectives and endeavor to incorporate a variety of workable measures and activities to improve science education in Korea. The most effective first step may be to revise teacher education programs in a way that allows future science teachers an ample opportunity to explore the complex relationships among culture, gender, and society—in relation to science learning and teaching. To conclude, policy makers need to *listen* to the voices of students, teachers, administrators, parents, teacher-educators, and pay closer attention to researchers' findings to accelerate advancements in education.

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