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Gender Studies of Science and Science Education in Singapore

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Abstract

Singapore, in recent years, has seen increased efforts by individuals, social organizations, institutions, and private companies advocating for more women in science. However, as compared to many other places, such as the U.S. and Europe, gender studies of science and science education in Singapore are limited. Further, such studies are underrepresented in the local science and science education literature. In this paper, we review gender studies of science and science education in Singapore to show the status of this literature. We analyze the papers for the following: a) studies that examine gender as the main or auxiliary construct, b) the period of publication, c) topics in gender studies, d) the philosophical approach of the studies, e) research methods, and f) the type of participants. Our analysis of 39 empirical journal papers show the highest number of publications during the period 2011–2015. Gender is examined as an auxiliary construct in most papers. Most of the studies embody postpositivist worldviews, where the use of quantitative research methods to compare cognitive and affective differences between the two genders are common. The most frequently targeted group of research participants are students aged 13–16 (Grades 7–10). Based on this review, we suggest future research agendas for researchers, local and international, who may be interested to push for more studies in this field through local and/or international studies.

Key words

gender, science, science education, Singapore

Introduction

Recent years in Singapore have seen increased efforts by individuals, social organizations, institutions, and private companies advocating for more women in STEM (science, technology, engineering, and mathematics) fields.

Examples of recent local events (2014–2016) used to promote and attract more women to STEM fields include the *STEM Week* organized by the National University of Singapore, the Singapore University of Technology and Design *STEM Workshop for Women*, a panel discussion session hosted by the Singapore Committee for United Nations Women, and the *Women in Engineering, Science, and Technology* symposium organized by the Nanyang Technological University. These efforts are, in part, response to the nation's need to increase the size of the labor workforce so as to address the problem of a shrinking and ageing population (Ministry of Manpower, 2016). One strategy to address this issue is to bring more women back to the workforce (Singapore Tripartism Forum, 2011).

The situation is direr in the STEM field. Although the general proportion of males and females is almost equal in Singapore, less than 20% of students enrolled in engineering are female (Corinna Choong, cited in Lee, 2017). At the Nanyang Technological University in Singapore, about 40% of the undergraduates pursuing bachelors' degrees in science and engineering between 2009–2014 were female (Shiao, 2014). This number dropped to 30% at the post-graduate level. According to the 2014 statistics from the Agency of Science, Technology and Research (A*Star), a public-sector agency that hires many research scientists and engineers, about 30% of those in the science and engineering sectors were women (Seow, 2016). At the Singapore University of Technology and Design, women make up 38% of its cohort (Lee, 2017). Clearly, Singapore falls behind other OECD countries such as Norway and Finland in terms of the equality of gender representation in STEM fields. There is much untapped potential for greater diversity of ideas to be injected into the traditionally male-dominated STEM field.

With the above knowledge about the state of gender issues in STEM fields, we raise the question as science education researchers: What insights does research in science education offer that can inform science educators, science education researchers, and policy makers about the state of science and science education in Singapore so that they can change practices and develop policies that bring about greater gender equality? This paper presents a review of journal articles to show the current state of gender studies in science and science education in Singapore. The purposes of this review are two-fold. First, this review offers an overview of the topics of concern to science education researchers. It can help to identify gaps in the liter-

ature, and recommendations for future research agendas in this field may be suggested. These recommendations may be undertaken by science education researchers to inform their future projects. Second, it illustrates a structured approach to reviewing the literature. The same or similar categories of analysis may be used to analyze the literature for comparative reviews across contexts.

In what follows, we explain how we conducted the literature search, identified the relevant papers for review, and analyzed the literature. Then we discuss the findings and suggest future research agendas for local and international researchers.

Methods

Literature Search and Selection Criteria

This review focuses on peer-reviewed journal articles published about Singapore and/or Singaporean participants, specifically in science or science education contexts. A total of 39 relevant journal articles published before mid-2016 were found. The literature search was conducted in a systematic manner using a set of selection criteria, various search engines, and keywords. To make the review more manageable, the scope was limited to peer-reviewed journal research articles. As such, book chapters and non-empirical journal articles (e.g., commentaries, reviews, and theoretical papers) were excluded from the analysis. Dissertations and conference papers were also excluded as some of these were rewritten and published in journal articles.

As the review mainly focused on gender studies in science and science education, we conducted the search in selected peer-reviewed science education journals, including the *Journal of Research in Science Teaching, Science Education, International Journal of Science Education, Research in Science Education, Cultural Studies in Science Education, International Journal of Science and Mathematics Education, Research in Science and Technological Education, School Science Review, and Journal of Science Education and Technology.* Although we did not limit the search period, few papers were found. Hence, we expanded the search to include journals in gender education. However, this search yielded no relevant results. Then, we searched for papers in the *Asia Pacific Journal of Education* (APJE), which was formerly known as the *Singapore*

Journal of Education (SJE). The journals are managed by the National Institute of Education—an institution of the Nanyang Technological University, Singapore—responsible for inservice and preservice teacher education. Nonetheless, these searches did not yield many more relevant papers. Subsequently, we conducted a search of the authors' library search engine (NIE LibDiscover!) and Google Scholar. These search engines yielded a few more papers in science and non-science education journals. All the papers reviewed here were published in international journals.

The search terms used for the literature consisted of the words: a) "Singapore", b) science-related keywords including "science," "physics," "chemistry," and "biology", and c) gender-related keywords such as "female," "male," "woman," "man," "girl," "boy," "sex," "gender," and "feminist." To reduce irrelevant search results, only articles that contained at least one keyword from each of the three search categories (i.e., mentioning "Singapore," at least one science-related keyword, and at least one gender-related keyword) were included. This was done using the search syntax, which differed according to various search engines. For search engines that utilized Boolean search operators (e.g., NIE LibDiscover!, Taylor and Francis Online, Wiley Online Library, Springerlink), the syntax "(gender OR sex OR boy OR girl OR wom?n OR female OR male OR femini*) AND (science OR physics OR chemistry OR biology) AND Singapore" was used. If the wildcard function was not supported (e.g., ERIC database), "(gender OR sex OR boy OR girl OR woman OR women OR female OR male OR feminist OR feminine) AND (science OR physics OR chemistry OR biology) AND Singapore" was used instead. For Google Scholar, "gender OR sex OR boy OR girl OR woman OR female OR male OR feminist + science OR physics OR chemistry OR biology + Singapore" was used.

Analysis

The researchers deliberated on the categories of the review and identified six of them: 1) gender focus or auxiliary, 2) period of publication, 3) worldviews, 4) research topics, 5) research methods, and 6) research participants. When searching and sieving out the relevant papers, the researchers noticed that gender could either be one of the multiple variables under study or form the focus of the study. Hence, it would be useful to find out how

many of these papers foregrounded gender and contributed significantly to the field. Trends in the period of publication alluded to the growth or decline of the field. The worldviews and methods adopted illuminated the paradigm in which the research was carried out and the perspectives represented. In examining the topics and group of participants involved in the study, we could identify gaps in the literature and voices (under) represented.

The analysis involved close reading of each article and the identification of emergent codes (Saldana, 2015) for each category by a researcher. Another researcher then independently coded all the papers using the same set of codes identified by the first researcher. Any discrepancies in the coding were discussed and deliberated until they were completely resolved. The findings of the analysis are presented in the next section.

Findings

Gender Focus or Auxiliary

Two broad categories of papers were identified: a) studies which foregrounded gender as the main theoretical construct under study and b) studies that examined gender as an auxiliary factor—meaning that gender was one of a few factors examined amongst other variables such as age, ethnicity, race, and so on. The analysis showed that 26% of the papers focused on gender as the main construct of study (see Figure 1). For example, in Goh, Chan, and Chia's (1995) paper, students' gender differences were examined to understand how different genders understood science concepts, and how each gender responded to different teaching strategies. Another such study was by Hoh (2009a), where he described a workshop conducted for high school biology teachers. The workshop was purposed to dispel the typical stereotype of engineers as male Caucasians. Through the activities, participants learned about notable female engineers and their contributions, and became more aware of their personal stereotypes.

On the other hand, 74% of the papers studied gender as an auxiliary construct (see Figure 1). For example, Caleon and Subramaniam's (2008) study mainly focused on investigating students' attitudes toward science, but included an analysis of the relationship between gender and attitudes toward science, and found boys to have more positive attitudes toward sci-

ence than girls. Another example of research that examined gender as an auxiliary construct is the study conducted by Zhai, Jocz, and Tan (2014). The research was conducted on primary school students to understand their views of the science classroom. Gender was discussed when students commented about science careers as dangerous, and a female student commented that a scientist had to be brave. They noted similar findings from past research (Osborne & Collins, 2001), and commented that perceptions of science work as masculine could be discouraging for girls.

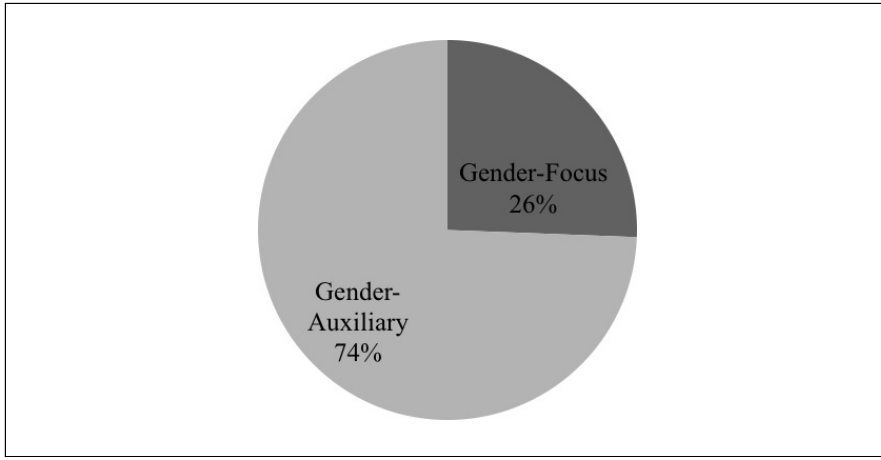

Figure 1. Papers with gender as focus or auxiliary topic.

Period of Publication

The period of publication was analyzed to identify changes in publication frequency over the years (see Figure 2). Overall, there was an upward trend in the number of publications. Relatively larger increase in the number of publications between the periods; a) 1986–1990 and 1991–1995 (3 papers or a 296% increase), b) 2001–2005 and 2006–2010 (5 papers or a 166% increase), and c) 2006–2010 and 2011–2015 (12 papers or a 150% increase) were observed.

The oldest paper, published by Thomas in 1984, aimed at understanding and comparing Singaporean primary school boys' and girls' conceptual development using Piaget's development theory. The author found that girls did better on the class and number relationships task, and conservation of

area task. On the other hand, boys did better on the conservation of liquid substance task, the geometrical area task, and the horizontality task.

Before 1997, the papers were published in general education journals and not in science education journals. During the period 2011–2015, 12 out of 20 papers were published in science education journals. Oon and Subramaniam (2011, 2013, 2015) contributed three papers in the *International Journal of Science Education* in this period, all of which were related to school students' interest in science. In the 2011 paper, they examined physics teachers' views on factors contributing to interest in physics among school students. Based on the survey from 135 secondary schools and junior colleges, they found that teachers perceived boys to be more likely to become involved in physics in the future. The paper published in 2013 focused on aspects of physics that school students perceived would be influential when choosing physics as an advanced field of study. Conducted in 16 secondary schools, this study found no significant difference between the genders when responding to the survey items, suggesting that the male and female respondents held similar views of physics. Finally, the 2015 paper studied students from 16 secondary and junior colleges that took physical science subjects, and the university programs that they were likely to consider. They found that secondary male students were more like-

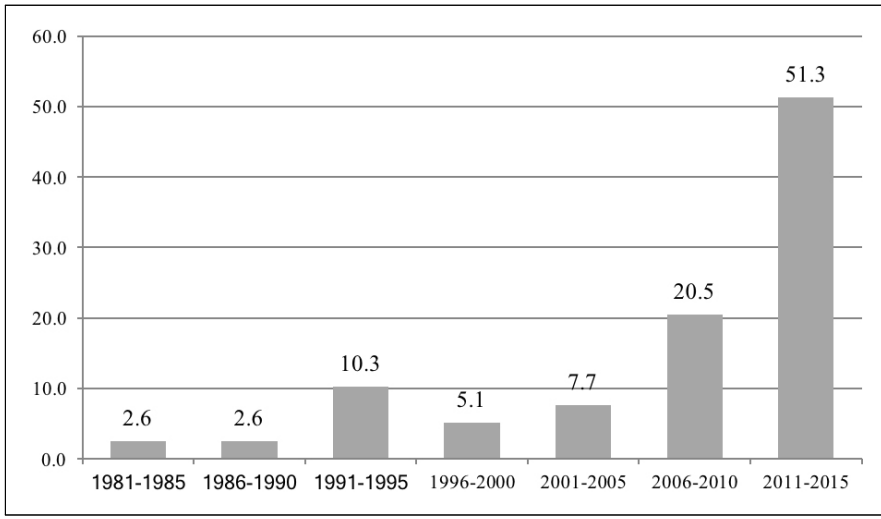

Figure 2. Percentage vs. period of publication of gender papers.

ly to choose Engineering and Mathematics programs, while the female students were likely to consider Arts and Social Sciences, and Medicine programs. Secondary female students were reported to be more likely than males to consider their own ability as a factor influencing their decision. Junior college male students were more likely to consider Engineering programs, while female students were more likely to choose Arts and Social Sciences. As compared to the junior college male students, career aspirations and parental advice were important factors for the junior college female students.

Worldviews

The term worldviews refers to "a basic set of beliefs that guide action" (Guba, 1990, p. 17). The papers were coded according to the four philosophical worldviews (see Figure 3)—postpositivist, constructivist, transformative, and pragmatist (Creswell & Plano Clark, 2011). Typically, the authors did not explicitly articulate the worldviews which undergirded their research designs. Hence, these were elicited by examining the data collection methods, analysis, and representation.

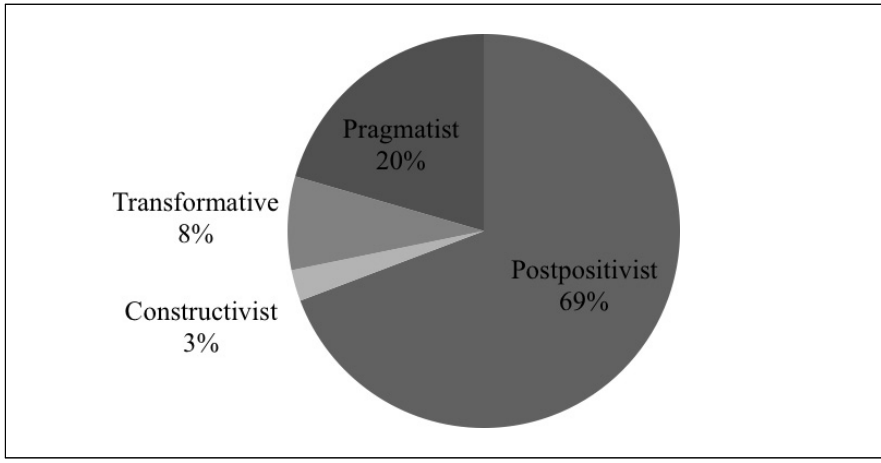

Figure 3. Philosophical worldviews of gender papers.

Postpositivist worldviews were reflected in the approaches that resembled the scientific method (Creswell & Plano Clark, 2011). Studies that examined

the causal effect or outcomes of a phenomenon were typically postpositivist in nature. These studies usually adopted quantitative approaches such as surveys, pre-tests, and post-tests with prescribed options. In our analysis, it was found that the majority (69%) of the papers reported on studies that adopted postpositivist approaches. For example, Lin, Tsai, Chai, and Lee (2013) followed the framework of technological pedagogical content knowledge (TPACK) to assess teachers' perception of their own ability to effectively implement lessons with ICT. The authors modified a survey instrument to measure seven factors based on the model, and collected demographic data, including gender, for correlation analysis. The analysis suggested that female teachers were more confident with pedagogical knowledge, while male teachers were more confident with technological knowledge. Another example of a postpositivist study was by Kaya and Rice (2010), who studied TIMSS (Trends in International Mathematics and Science Study) results from five countries to identify student and classroom factors associated with achievement. Their analysis of the Singapore sample found significant gender differences in achievement not present in the Japan, USA, and Australia samples.

Constructivist worldviews are reflected in studies that provide an interpretive understanding of the participants' thinking or sense-making through social interactions (Stake, 2010). Most of these studies adopt qualitative approaches to draw an in-depth understanding of the participants' experiences and understanding of the world. In our analysis, only one study adopted a constructivist approach. The paper by Zhai et al. (2014) analyzed how primary school students viewed their science lessons, and how it compared to the work of real-life scientists. The students drew pictures of themselves as scientists doing science, and were subsequently interviewed. During their analysis, they attempted to compare students' responses by gender, but found few differences between them.

Transformative worldviews were embodied in studies that questioned taken-for-granted assumptions to empower the marginalized to have a voice and for the oppressor to develop critical consciousness for change to happen (Mertens, 2007). Participants may actively be included in such studies as collaborators. Our review found that three papers (representing 8%) reported on studies that adopted transformative approaches. For example, Teo (2015) wrote a case study of two female science teachers. The paper described their political positionality derived from social and cultural back-

grounds, the inequitable structures they faced as teachers, and how it shaped their science curriculum making.

Pragmatist worldviews were concerned with applications by asking the question *what works* and looking for solutions to address the research problem (Creswell, 2009). As such, these studies typically adopt diverse quantitative and qualitative (mixed) methods to address the research question. From the review, it was found that eight papers (representing 20%) reported on studies that adopted transformative approaches. Studies that were categorized as having a pragmatist worldview included Hoh (2009b), who described a workshop organized to change science teachers' stereotypical perception of engineers. The workshop consisted of the *Draw-an-engineer* activity, participants researching and presenting about notable female environmental engineers, a post-activity survey, and a follow-up survey administered six months later. Jocz, Zhai, and Tan (2014) also used a combination of student surveys and student interviews to understand primary students' interest in school science. The authors explained that the deliberate use of questionnaires and interviews was intended to capture the complex and multi-faceted nature of students' perceptions about their interest in science.

Research Topics

Five topics were identified in the coding process (see Figure 4): a) gender differences in cognitive aspects, b) gender differences in affective aspects, c) gender differences in perspectives on career conditions, d) peoples' perceptions of gender differences, and e) gender equity. Three papers covered both topics a) and b) and hence, were coded twice. Notably, the majority of the papers were focused on studying the differences between female and male participants in the cognitive (12 out of 39 papers) and affective (27 out of 39 papers) aspects.

Studies that examined gender differences in the cognitive aspects focused on areas such as achievement results or conceptual understanding. Amongst 12 papers, two papers examined Grade 8 students' science results from TIMSS 2007, and analyzed various factors associated with achievement. Mohammadpour's (2013) analysis was aimed at measuring proportions of variances in Grade 8 students' performance that were associated with school-related, classroom-related, or student-related factors. Using multilevel

analysis, Mohammadpour found that for student-related factors, gender was found to be a significant predictor of achievement, where male students outperformed female students. On the contrary, Ng, Lay, Areepattamannil, Treagust, and Chandrasegaran (2012) studied the results of Malaysian and Singaporean Grade 8 students to find associations between affective variables and achievement. They used factor analysis and principal component analysis to analyze the data but, unlike Mohammadpour, they found no significant relations between gender and science achievement.

Papers that examined gender differences in the affective aspects focused on areas such as interests or perspectives. For example, Caleon and Subramaniam (2005) studied how an enrichment program would affect each gender's attitude towards science and the enjoyment of science. Similarly, Wong and Fraser (1997) developed and validated the Chemistry Laboratory Environment Inventory (CLEI). Using this instrument, they found female secondary students as generally having more favorable perceptions of chemistry lessons than males. Studies that focused on comparing genders through such methods were categorized as examining gender differences in the affective aspects.

The study categorized as gender differences in career conditions was by Sidhu, Yeoh, and Chang (2015), where they surveyed and interviewed scientists who were foreigners employed in Singapore by public research institutes and universities. They noted that female scientists originating from Western Europe and North America felt that Singapore had a less family-friendly working environment. However, participants originating from Asia found that with help from employing domestic helpers, they could focus more attention on their scientific careers.

Three studies examined individuals' perceptions of gender differences. For example, Hoh (2009c) focused on stereotypical gender perceptions in his study. Noting the general image that people had about engineers and scientists as Caucasian men, he conducted a workshop aimed at letting participants become more aware of their own stereotypes through discussing the achievements of notable female engineers.

Three studies were concerned with gender equity issues. They included the study by Teh and Fraser (1994), where they developed a quantitative instrument to assess students' experience with computer-assisted learning (CAL) classrooms. Part of the dimension measured was the gender equity scale used to better detect gender effects. Another research study focusing

on gender equity was by Teo (2015). In her case study, she analyzed the political positionalities of two female science teachers. Through the study, she discussed the inequitable structures they experienced throughout their career, and how it shaped the teacher-student interactions.

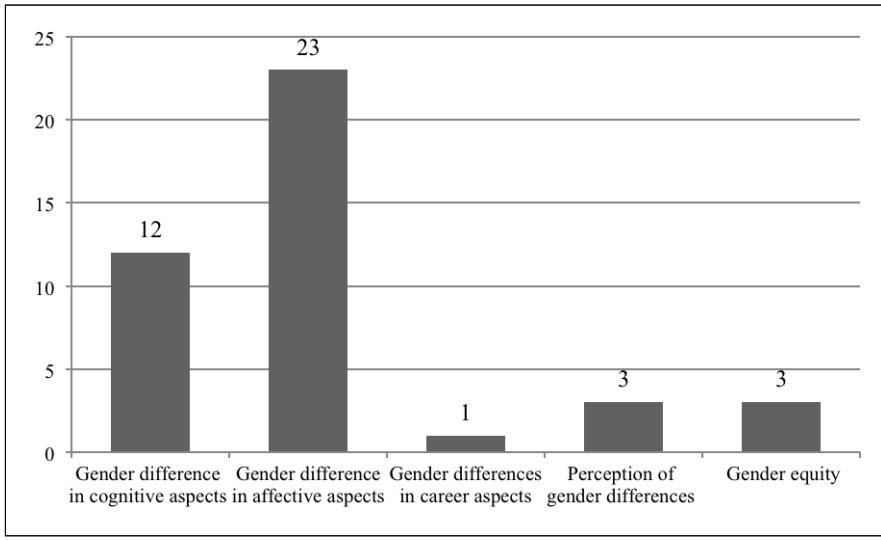

Figure 4. Number of papers vs. research topics.

Research Methods

The research methods—quantitative and/or qualitative—adopted by each study were analyzed (see Figure 5). The majority (67% or 26 papers) of the studies used quantitative data collection methods. One such example was the study by Foong (1994), where she administered survey questionnaires to 889 secondary school students to examine their attitudes toward science. Her review of the literature identified a need for further research on the cognitive and social differences in attitudes toward science among boys and girls, which formed the focus of her analysis. She found boys to have more positive attitudes toward science, science achievement, and home support, while girls had more positive attitudes toward their science teachers.

About 25% (10 papers) adopted both quantitative and qualitative methods. Yeo and Garces-Bacsal (2014), for example, used a combination

of questionnaires and interviews to understand the differences between the academic self-concepts of high-ability and mixed-ability female students. They investigated the students' self-concept quantitatively, and used interviews as a means of understanding students' thoughts on in-depth issues such as their feelings toward their results and how the comparison of academic abilities between themselves affected their self-concepts.

About 8% (3 papers) adopted only qualitative methods. For example, Teo and Tan (2011) used reflective narratives to examine issues faced by teachers during curriculum work. Four science teachers were recruited to write about their experiences with curriculum making and teaching, where they were prompted to reflect critically on issues such as gender and race. The authors found that none of the teachers considered the critical issues to be pertinent in curriculum work, and possibly avoided discussing controversial issues.

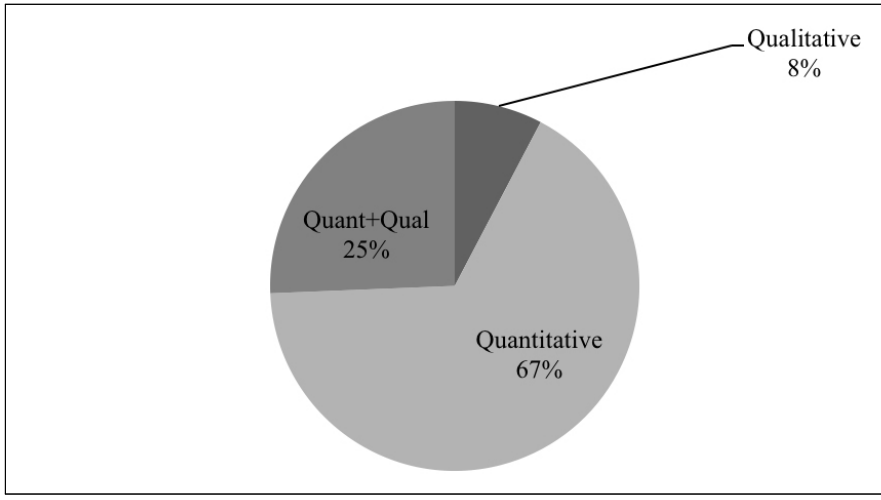

Figure 5. Research methods of gender papers.

Research Participants

The papers were reviewed for the group of research participants who took part in the gender studies (see Figure 6). Apparently, children aged six or below and educators in higher education were not included in the gender studies. Most the studies focused on students aged 13–16 (Grades

7–10). This was followed by students aged 7–12 (Grades 1–6), in-service teachers, and students aged 17–18 (Grades 11–12). To cite an example of a study of elementary students, Peer and Fraser (2015) used a survey instrument to look at classroom learning environments and student attitudes of Grade 4–6 school science classrooms. The authors chose to investigate the primary school science-learning environment because no previous studies had been conducted for this age group on this topic.

There was one study for each of the categories students aged 19 and above, pre-service teachers, and scientists. Specifically, these studies were Ynalvez, Garza-Gongora, Ynalvez, and Hara's (2014) study of doctoral students, Lin et al.'s (2013) study on teachers and pre-service teachers, and Sidhu et al.'s (2015) study about foreign scientists in Singapore.

Ynalvez et al. (2014) conducted their research on East Asian (Singaporean, Japanese, and Taiwanese) doctoral students to understand the mentoring practices and research experiences within the academic community. The sample recruited for the study in Singapore was more gender-balanced (51% of females, 49% of males) as compared to that in Japan and Taiwan (69% of males and 31% of females for both contexts). They attributed the higher proportions of Japanese and Taiwanese male doctoral students to the stronger patriarchal orientation of the two nations. Lin et al. (2013) recruited in-service and pre-service science teachers to examine their perception of their technological pedagogical content knowledge. The authors distributed online surveys to in-service and pre-service science teachers to measure their perceived TPACK through seven factors: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and synthesized knowledge of technology, pedagogy, and content (TPC). They found that female teachers were more confident in PK, but less so in TK. While in-service female teachers were found to have higher perceived PK and lower TK than in-service male teachers, this gender effect was not found with the pre-service teachers. Sidhu et al.'s (2015) study, based on Bourdieu's framework of capital accumulation, studied the geographic and professional mobility of foreign scientists in Singapore. Their sample consisted of foreign research scientists, who were surveyed and interviewed on various topics such as the pros and cons of living and working in Singapore. As described earlier, the female participants from Western Europe and North America

found Singapore's working environment less family-friendly, while the participants from Asia found that they could focus more attention on their scientific careers with the help of domestic helpers.

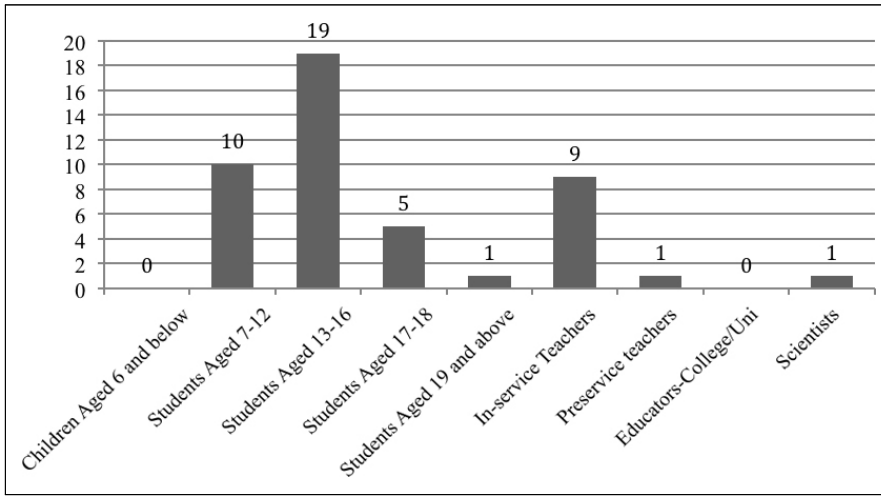

Figure 6. Number of papers vs. type of participants researched.

Discussion

The findings of the review of 39 empirical journal papers showed that most of the studies adopted the postpositivist worldview and used quantitative methods to compare differences between male and female research participants in, for example, science achievements, attitudes, and interests. A few observations can be made based on the analysis of these studies. First, gender was referred to as a biological construct (sex) and not a social construct (Glenn, 2000). While *gender* referred to the construction of one's identity, *sex* was a label of the human anatomy (Delphy, 1993). These studies embodied objective, reductionist, and authoritative views of science. As such, gender was not viewed as a constitutive and contextualized construct. In these studies, the research participants were not positioned as empowered agents as their gender identity was predetermined by their physical traits.

Second, the studies resembled those found in the first feminist wave during which studies focused on factors that constrained the learning out-

comes of males and females (Barton, 1998). As mentioned earlier, gender (or rather, sex) was one of the many factors examined. Relatively fewer studies foregrounded gender to examine girls' or women's experiences and their ways of knowing, which can become valuable resources for understanding diverse social phenomena associated with those who had been marginalized (Roychoudhury, Tippins, & Nichols, 1995). This could potentially limit educators' knowledge about women and girls, specifically strategies and approaches that can help to address issues that confront them.

Over a span of more than 30 years, only 39 empirical journal papers were found. Further, most of the papers were published between 2011 and 2015. Although the trend in publication looks promising, the numbers illuminate the dearth of gender studies conducted in the local context. The implication for science educators is that female and male learners may have traditionally been regarded as a homogenous group with unquestioned assumptions about the needs and opportunities given to boys and girls.

Possible Future Research Agenda

Brotman and Moore (2008) conducted a review of 107 gender studies in science education published between 1995 to 2006 and identified four themes—equity and access, curriculum and pedagogy, the nature and culture of science, and identity. Although research in science education in Singapore started in the 1970s, gender studies in science and science education remain limited in quantity and scope. This is probably due to the lack of awareness among educators about the sociocultural aspects of science education that may lead to certain biased outcomes. Related to this point is the common thinking among science educators that science teaching and learning are gender-neutral (Teo, 2015). Notably, the current literature was characterized by studies that adopted a postpositivist lens using quantitative measures to study the differences between males and females. While such studies may be used for generalizing between males and females, they could reinforce simplistic and dichotomized understandings of sex and gender. However, educational phenomena are not always clear cut. From the earlier discussion, studies comparing male and female students' dispositions, interests, and competencies in science-related areas provided mixed results, with no clear indication of any one gender having an advantage over the other. From a review of only one gender study on female researchers (scientists)

in this paper, little generalizable knowledge can be inferred.

Based on the reviewed studies, we suggest two areas of research that can potentially expand the frontiers of gender studies in science and science education in Singapore. First, a large-scale survey on various gender- and science-related topics could be conducted. In writing about the context of this review, we noted a lack of empirical data that offer insights about the state of gender representation and equity in science-related fields. Most of the information gathered was anecdotal or from non-empirical sources (e.g., news articles with quotes from experts). A systematic and large-scale survey (e.g., on salaries of women in STEM-related careers, STEM degrees, career advancements, retention) would provide empirical information that offers a better overview of the status of gender equity to set the context or background to support work in this area. Second, researchers could critically examine the science curriculum which contains embedded Eurocentric and androcentric ideas. Due to the emphasis on achievement scores in the national examinations, science teaching was primarily objective (noun + adjective) in nature. By *objective*, we mean that it was implemented with the goal to complete all the learning objectives specified in the syllabus, and to teach science as a collection of facts that are values-free (Kuhn, 1970). Therefore, it is of interest to us, as educators, to critically examine how students deconstruct their own gender identity when they are voicing their viewpoints in a non-objective-based curriculum. The same study could be conducted across different sociocultural and sociopolitical contexts and age groups to understand the complex relationship between gender and science. By using a *process lens* in examining the curriculum, science educators can gain better insights into *how* girls and women experience their science endeavors so that the necessary resources may be afforded to them to harness and build their capital for better participation in science.

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