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SECONDARY SCHOOL STUDENTS' PERCEPTIONS OF SCIENCE LEARNING ENVIRONMENT AND SELF-EFFICACY IN SOUTH KOREA: GENDER DIFFERENCES

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Abstract. *This study examined students' perceptions of their science learning environment and how it relates to their metacognition and self-efficacy. An exploratory study (N=186 South Korean secondary science students from a large-city urban school) used two instruments: Outcomes-Based Education Learning Environment Questionnaire [OBLEQ]; Self-Efficacy and Metacognition Learning Inventory-Science [SEMLI-S]). Descriptive and inferential statistics revealed that that Korean students' mean score of science learning environment was 2.98, representing male students scored highest on Involvement (M=3.24), while female students scored highest on Cooperation (M=3.00). In addition, regarding students' perceptions on their self-efficacy and metacognition learning in science, the mean score of SEMLI-S was 3.16, with both male and female students' highest score on Learning Risks Awareness (3.34 and 3.25 respectively). Further, the students' perceptions on science learning environment predicted students' metacognition and self-efficacy. The Investigation subscale, which emphasizes processes of inquiry, was the dominant predictive factor for both male and female students' self-efficacy and metacognition. The subscale Involvement was the next best significant predictor of male students' metacognitive orientation. Personal Relevance, Responsibility for Own Learning, and Differentiation filled that role for female students.*
Keywords: *constructivist pedagogy, science learning environment, secondary students, self-efficacy, students' metacognition*

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Introduction

An effective and stimulating learning environment is crucial to quality education, across all subjects and all grades. The challenge is finding the right pieces to cultivate an effective learning environment, especially for science education. Some researchers have focused on how introducing metacognitive skills and self-efficacy competency into science teaching and learning can benefit both learners and educators. They are also interested in gender differences regarding these competencies (e.g., Boz et al., 2016). The study herein continues this trend by analyzing Korean students' perceptions of their general science learning environment, constructivist pedagogy, and metacognition and self-efficacy along with gender differences. Results are crucial to both keeping up with the evolving science education system and understanding how to improve it.

The Korean MOE (2015) strived to reflect on the needs of the school environment and to strengthen basic literacy education, adopt a student-centered pedagogy, optimize the number of instructional hours at school, and ensure consistency of content, teaching, learning, and evaluation. Regarding the science curriculum in particular, the Korean MOE's 2015 Revised National Science Curriculum targeted the following scientific competencies (again, an innovation from the previous science curriculum): scientific thinking, inquiry, problem solving, communication, and engagement and lifelong learning with science.

Subsequent scholarship has revealed that even though the new curriculum brought positive change in Korean science learning environments, there were still teacher-centered classes, and students did not have sufficient inquiry-related learning activities – change is slow to come (Lee, 2016). Kim and Koo (2019) studied the actual science instruction situation in Korea reflected in 2015 Programme for International Student Assessment (PISA) results. Learning activities to explain students' ideas during science class had increased significantly compared to PISA 2006, but activities related

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to practices of scientific exploration were consistently less frequent (e.g., experimental practice, experimental design, discussions, and drawing conclusions).

The study herein was interested in students' perceptions of science learning environment and their metacognition and self-efficacy in science learning. Given the ongoing trend of linking science learning environments with metacognition and self-efficacy (Boz et al., 2016), the authors were also interested in exploring these traits in Korean secondary students as they engaged with the new science curriculum predicated on student-centered learning (Korean MOE, 2015).

Literature Review

Science Learning Environment and Constructivist Learning

Science education and science learning environments must shift from product-focused to process-focused teaching, that is, to a more inquiry-based, constructivist learning approach (Fensham et al., 1994) (i.e., students are involved in constructing knowledge). They further argued that using a constructivist approach in science education would contribute to (a) reconceptualizing science learning to be applicable to practical knowledge and action and (b) integrating students' own science experiences with science knowledge. Science teachers are strongly encouraged to support the constructivist approach and take issue with competition-based learning experiences favoring instead collaboration and cooperation (Kim & Alghamdi, 2019).

As a caveat, a constructivist, inquiry-based approach may be more feasible for certain learning environments than others. A recent Turkish study using the Assessing a Constructivist Learning Environment questionnaire reported that middle school students who attended rural schools and were in smaller classes tended to have more positive perceptions of their science learning environment than urban, larger-class students. Said another way, larger science classes tended to have limited collaborative interactions, which led to less positive perceptions of the overall learning environment (Yigit et al., 2017). Factors measured in this questionnaire included thought provoking content, collaboration, life relevance, concurrent learning and assessment, and integration of different viewpoints (Yigit et al., 2017).

Chang and Tsai (2005) reported that Taiwanese students preferred the teacher-centered more so than the constructivist, learner-centered approach, but they also acknowledged that computer assisted instruction (CAI) may have been a confounding factor leading students to prefer teacher-centered instruction; access to computer technology may have skewed the results. Indeed, Doppelt (2004) was interested in how specific constructivist characteristics of a science-technology learning environment could impact Israelis students' science learning outcomes: class discussions, concept mapping, laboratory experiments, team projects, self-assessment activities, and computer usage. Problem-based learning, portfolios, the design process, and an integrated curriculum were employed. Both the cognitive and affective domains of learning were affected with students respectively scoring high on understanding the science content, being curious, and using critical thinking as well as on self-confidence, and an interest in and desire to learn science (in effect – self-directed and self-motivated learning that are the hallmark of the constructivist approach).

South African scholars designed, implemented, and measured the validity of their Social Constructivist Learning Environment Survey (SCLES) (Luckay & Laugksch, 2015) using a mixed methods research design. The validated instrument focused on six specific pillars of the learning environment: working with ideas (later combined with metacognition), personal relevance, collaboration, critical voice, respect for differences, and uncertainty in science. Of relevance to the study herein is their recommendation that studies designed specifically to measure gender differences in science learning environments are deserving of their own analyses.

Gender Perceptions of Science Learning Environments

Studies that specifically focus on gender differences in science learning environments provide insights that contribute valuable understandings to the overall cultivation of effective science education models. Attendant results can inform efforts to reform science curriculum and teaching. Koul et al. (2012) reported that Thai female secondary science students excelled in biology while male students excelled in physics. However, males exhibited higher performance avoidance goals in both physics and biology than females (i.e., students' fear of evaluation

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of their competency in a specific subject). Results suggested gender differences with female students excelling in biology instead of more math-oriented subjects like physics (Koul et al., 2012).

Doppelt (2004) reported no significant gender differences in perceptions of a science learning environment that employed a constructivist approach. However, because males scored higher than females in proficiency of computer usage, a gender difference seemed probable along other variables and merits further investigation. Kim and Alghamdi (2019) reported that Saudi female secondary science students generally had a positive perception of their science learning environment.

Metacognition and Self-Efficacy in Science Learning

Constructivist teaching methods that encourage students to draw on their own experiences to help advance their science learning benefit students (Luckay & Laugksch, 2015). However, what teaching methods are most effective for science students in terms of advancing metacognition and self-efficacy? Although the definition of metacognition and its role in education is somewhat fuzzy, metacognition is essentially the process by which one thinks about the way one thinks (Hsu et al., 2016). Self-efficacy is the belief in one's ability to (a) influence events that affect one's life and (b) exert control over the way these events are experienced (Bandura, 1994). Metacognition and self-efficacy are related in the sense that self-efficacy is how people regulate their own metacognitive skills.

Researchers have argued for more research on learners' self-regulation in science education and science learning environments (Schraw et al., 2006) as opposed to teacher-regulated instruction. Schraw et al. (2006) focused specifically on six constructivist-oriented instructional strategies: inquiry-based learning, collaborative support, problem-solving strategy, construction of mental models, using technology to support learning, and the role of personal beliefs. They concluded that emphasis on inquiry-based learning is prevalent throughout the literature, but more research into learners' self-regulation is imperative to a positive science learning environment.

It is important to be as specific as possible when researching metacognition and its role in education. Because different academic subjects can be taught differently, metacognition will need to be understood through those different methods. Science learning itself requires specific cognitive processes: reading text, problem solving, inquiry learning, and scientific writing. Metacognitive-specific instruction improves reading skills and academic achievement (Zohar & Dori, 2011). However, to take advantage of metacognitive teaching and instruction, it is important to fully understand its scope: awareness and executive control (Hsu et al., 2016). Helping students appreciate these two factors aids them in staying motivated and being engaged in and agents of their own learning. They would be aware of how they think, which in turn helps them control how they think, two traits that embolden science learning (Zohar & Dori, 2011).

Gender Differences in Metacognition and Self-Efficacy in Science Learning

Research on this gendered relationship is thin. That said, to help understand gender differences in the science learning environment, studies have shown that gender, self-efficacy, and positive academic science achievement are related. To illustrate, Boz et al. (2016) found that females were more understanding of their metacognitive and self-efficacy skills than males and therefore more successful in their overall academic performance. Conversely, Coll et al. (2002) reported that female students often perceived an overall more positive learning environment than male students, but they were uncertain about whether this was because of female's higher understandings of metacognitive and self-efficacy skills or a combination of other factors. These and other studies demonstrate the importance of aiding all students in mastering their metacognitive and self-efficacy skills so they can improve their overall academic science performance.

The previous studies examined either students' perceptions of the science learning environment (i.e., Chang & Tsai, 2005; Doppelt, 2004; Luckay & Laugksch, 2015; Yigit et al., 2017) or metacognition (i.e., Boz et al, 2016; Coll et al., 2002; Kiran & Sungur, 2012) but not both. This study explored both variables (science learning environment and metacognition) along with gender differences. Through examining how science learning environments impact students' metacognition and self-efficacy, this study can link the science learning environment with metacognition in one Asia country, South Korea.

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Research Questions

A constructivist approach to science education requires emphasis on understanding how positive and effective learning environments fit into fostering metacognition and self-efficacy. However, any focus on gender differences among metacognitive and self-efficacy skills relative to students' perceptions of science learning environment is not readily evident in the literature with that essential missing piece further explored in this study. Three research questions thus guided this study:

1. How do these South Korean secondary students perceive their science learning environment? Are there gender differences?
2. How do these South Korean secondary students perceive their metacognition and self-efficacy? Are there gender differences?
3. How do these South Korean secondary students' views of their science learning environment impact their metacognition and self-efficacy? Are there gender differences?

Research Methodology

This exploratory, quantitative research design employed two instruments to collect empirical data about Korean science students' perceptions of their science learning environment, their self-efficacy and metacognition, and how they are related. Exploratory research advances a discipline's knowledge base by affirming that there are grounds for future studies about the phenomenon (Dudovskiy, 2016; McGregor, 2018). This descriptive research was carried out in Autumn 2018. The classes were chosen using convenience sampling.

Sample

The convenience sample for this exploratory study comprised 90 male and 96 female South Korean secondary science students (N = 186) from one public, urban school (six classes) (averaging 32 students per class) located in one of South Korea's largest cities. Six classes were in 8th grades and were purely parallel classes. The sample size parameter of this study exceeds that required for exploratory research (i.e., 150 respondents) (Daniel, 2012). To control the compounding variable of teacher (McGregor, 2018), all six classes were taught by the same science teacher who had a master's degree in biology education, and had taught science for five years. Data were collected in 2018 after obtaining permission and ethical approval. The teacher hand distributed the two instruments during the science classes allotting about 40 minutes for completion. Anonymity was ensured. The teacher securely returned the completed instruments to the lead author for analysis.

Instruments

Two instruments were used to collect quantitative data: (a) the Outcome-Based Learning Environment Questionnaire (OBLEQ) (Aldridge et al., 2006a) in order to explore students' perceptions of science learning environments and (b) the Self-Efficacy and Metacognition Learning Inventory-Science (SEMLI-S) instrument (Thomas et al., 2008) to examine students' perceptions of self-efficacy and metacognition in their science learning.

Outcome-Based Learning Environment Questionnaire (OBLEQ)

In this study, the OBLEQ was used to explore students' perceptions of science learning environments. It comprises 56 questions organized within seven subscales (eight items each): *Involvement, Investigation, Cooperation, Equity, Differentiation, Personal Relevance, and Responsibility for Own Learning* (see Table 1). The OBLEQ uses 5-point Likert scale of always, often, sometimes, seldom, and never. The 56 English-language items were first translated to Korean by a bilingual Korean science educator and then back-translated to ensure accuracy and quality (Edunov et al., 2018; Postan, 2021).

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Table 1
Outcome-Based Learning Environment Questionnaire's (OBLEQ) Subscales and Cronbach's α

Subscales	Descriptions: The extent to which…	*n* of items	Cronbach's *α*
Involvement	students have attentive interest, participate in discussions, do additional work, and enjoy the class	8	.892
Investigation	emphasis is placed on the skills and processes of inquiry and their use in problem solving and investigation	8	.881
Cooperation	students cooperate rather than compete with one another on learning tasks	8	.819
Equity	students are treated equally and fairly by the teacher	8	.893
Differentiation	teachers cater to students differently on the basis of ability, rates of learning, and interests	8	.765
Personal Relevance	teachers relate science to students' out-of-school experiences	8	.781
Responsibility for Own Learning	students perceive themselves as being in charge of their learning process, and motivated by constant feedback and affirmation	8	.920

Self-Efficacy and Metacognition Learning Inventory-Science (SEMLI-S)

SEMLI-S (Thomas et al., 2008) was used to explore South Korean secondary students' metacognition and self-efficacy in their science learning. The 30-item instrument has five subscales: Constructivist Connectivity (CC); Monitoring, Evaluation & Planning (MEP); Science Learning Self-Efficacy (SE); Learning Risks Awareness (AW); and Control of Concentration (CO) (see Table 2 for descriptions and Cronbach's α). The .69α level for the CO subscale essentially falls within the acceptable limits of Cronbach's alpha (Tavakol & Dennick, 2011). The SEMLI-S uses 5-point Likert scale: always, often, sometimes, seldom, and never. As with the OBLEQ instrument, the SEMLI-S was back-translated (Edunov et al., 2018).

Table 2
Self-Efficacy and Metacognition Learning Inventory-Science's (SEMLI-S) Subscales and Cronbach α

Subscales	Descriptions	n of items	Cronbach's α
Constructivist Connectivity (CC)	Whether students construct connections between information and knowledge across various science learning locations (i.e., view science beyond the classroom)	7	.847
Monitoring, Evaluation & Planning (MEP)	Related to metacognition: students' inclination to assess, evaluate, and adjust their learning process (progress and interim success)	9	.840
Science Learning Self-Efficacy (SE)	Students' perceptions of their orientation to organizing and executing actions required for attaining science learning goals	6	.863
Learning Risks Awareness (AW)	Students' perceptions of their levels of awareness in relation to situations that may prove detrimental to their learning	5	.792
Control of Concentration (CO)	Students' ability to adjust level of concentration depending on learning situation, task difficulty, and subject matter	3	.690

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Data Analysis

Data were analyzed using descriptive and inferential statistics. Means, range, and Standard Deviation (SD) were calculated for each instrument's subscales. An independent samples *t*-test was performed to examine gender differences for students' perceptions of both science learning environments (as measured by OBLEQ) and self-efficacy and metacognition in science (as measured by SEMLI-S). A Stepwise multiple regression was calculated to determine which OBLEQ variables (see Table 1) predicted students' metacognition and self-efficacy (see Table 2) by gender.

Research Results

South Korean Secondary Students' Perception of Their Science Learning Environment: Gender Differences

South Korean secondary science students perceived their overall science learning environment as sometimes (*M* = 2.98) being able to provide the seven elements of science learning environments as measured by the OBLEQ. In descending order, overall, respondents said they sometimes were treated equally and fairly by their teacher (*Equity*), able to collaborate and learn together in groups (*Cooperation*), learned meaningful and relevant science content (*Personal Relevance*), and actively participated in the learning process (*Involvement*). To a nominally lesser degree, they said they sometimes received *differentiated* instruction, took *responsibility for their own learning*, and engaged in inquiry and *investigation*.

Table 3
Gender Differences for Seven OBLEQ Subscales

OBLEQ Subscales	*M* overall	Male		Female				
		M	*SD*	*M*	*SD*	*t*	*df*	*p*
Involvement	3.04	3.24	1.015	2.83	0.811	2.970	167	.003**
Investigation	2.76	2.97	0.940	2.54	0.825	3.174	167	.002**
Cooperation	3.07	3.16	0.804	3.00	0.750	1.330	167	.185
Equity	3.08	3.19	0.798	2.97	0.617	1.978	167	.050
Differentiation	3.01	3.11	0.778	2.91	0.521	1.950	167	.053
Personal relevance	3.05	3.17	0.687	2.93	0.614	2.426	167	.016*
Responsibility for own learning	2.83	3.01	0.830	2.66	0.713	2.918	167	.004**
Total	2.98	3.12	0.720	2.83	0.527	2.984	167	.003**

*$p < .05$; **$p < .01$

The male students represented the highest score in the *Involvement*, while the female students represented the highest score in the *Cooperation*. Notedly, both male and female students had the lowest score in the *Investigation*. The independent samples *t*-test determined a significant difference in the OBLEQ scores for male (*M* = 3.12, *SD* = 0.720) versus female students (*M* = 2.83, *SD* = 0.527); *t*(167) = .984, *p* = .003. Male students scored higher than female students on all OBLEQ subscales. There were statistically significant gender differences for four subscales: *Involvement, Investigation, Personal Relevance, and Responsibility for Own Learning*. There were no statistically significant gender differences for *Equity, Cooperation, or Differentiations* (see Table 3).

Korean Secondary Students Perceptions of Metacognition and Self-Efficacy: Gender Differences

South Korean secondary students perceived their metacognition and self-efficacy in science learning as sometimes (*M* = 3.16) being met as measured by the SEMLI-S instrument (see Table 4). Respondents scored highest on *Learning Risks Awareness* (AW)(*M* = 3.29) and *Control of Concentration*(CO) (*M* = 3.27) followed by *Constructivist Connectivity*(CC) (*M* = 3.15), *Monitoring, Evaluation & Planning*(MEP) (*M* = 3.10), and *Science Learning Self Efficacy*(SE)

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(M = 3.09). Respectfully, they sometimes felt aware of situations when both their learning and concentration were compromised, their science learning was related to beyond the classroom, they could adapt their learning, and they would succeed in the course. Compared to female students, male students received the higher scores albeit only a midpoint score (sometimes) on the 5-point Likert scale.

Table 4
Gender Differences for Five SEMLI-S Subscales

SEMLI-S Subscales	*M* overall	Male		Female				
		M	*SD*	*M*	*SD*	*t*	*df*	*p*
CC	3.15	3.32	.700	2.98	.650	3.257	167	.001**
MEP	3.10	3.23	.557	2.97	.537	3.090	167	.002**
SE	3.09	3.27	.702	2.92	.599	3.475	167	.001**
AW	3.29	3.34	.653	3.25	.519	.952	167	.343
CO	3.27	3.33	.648	3.21	.546	1.260	167	.209
Total	3.16	3.29	.591	3.03	.488	3.035	167	.003**

Note. CC: Constructivist Connectivity; MEP: Monitoring, Evaluation & Planning; SE: Science Learning Self-Efficacy; AW: Learning Risks Awareness; CO: Control of Concentration; $^{**}p < .01$

Both male and female students represented the highest score in *Learning risk awareness*. The male students had the lowest mean score in the *Monitoring, Evaluation & Planning*, while the female students had the lowest mean score in the *Science Learning Self-efficacy*. Gender differences were exemplified in the results of the independent samples *t*-test, $t(167) = 3.035$, $p < .01$. There was a significant gender difference for CC between male ($M = 3.32$, $SD = 0.700$) and female students ($M = 2.98$, $SD = 0.650$); $t(167) = 3.257$, $p < .01$. Male students also scored significantly higher on SE ($M = 3.27$, $SD = 0.702$); ($t(167) = 3.475$, $p < .01$) and MEP ($M = 3.23$, $SD = 0.557$); ($t(167) = 3.090$, $p < .01$) than female students ($M = 2.92$ for SE and $M = 2.97$ for MEP respectively) (see Table 4).

Impacts of Science Learning Environment to Metacognition and Self-Efficacy: Gender Differences

A stepwise multiple regression was performed to predict how students' perceptions of their science learning environment (see OBLEQ subscales in Table 1) impacted their metacognition and self-efficacy as measured using the SEMLI-S instrument. Stepwise multiple regressions culminate in variables that best explain the distribution. In this case, those variables were *Investigation* and *Involvement* and, to a lesser extent, *Personal Relevance*. Respectfully, these relate to learner-centered inquiry, active participants in learning, and science learning that is meaningful beyond the classroom. Results are presented using five subscales of the SEMLI-S (such as Constructivist Connectivity (CC); Monitoring, Evaluation & Planning (MEP); Science Learning Self-Efficacy (SE); Learning Risks Awareness (AW); and Control of Concentration (CO)).

Constructivist Connectivity

A multiple linear regression was calculated to predict students' *Constructivist Connectivity* (i.e., connecting learned material to existing knowledge or beyond the classroom to other disciplines and the larger world) relative to the OBLEQ's five subscales of science learning environments (such as Involvement, Investigation, Cooperation, Equity, Differentiation, Personal Relevance, and Responsibility for Own Learning; see Table 5). A significant regression equation was found for male students ($F(1, 79) = 79.933$, $p < .01$) with an R^2 of .531. CC was equal to 11.462 +.295 (Investigation) and +.185 (Involvement) for male students. A weaker but significant regression equation was found for females ($F(1, 82) = 33.165$, $p < .01$) with an R^2 of .357. CC equaled 7.465+ .291 (Investigation) and +.310 (Personal Relevance) for female students. Investigation, which emphasizes processes of inquiry, problem solving, and investigation, affected both male and female students' *Constructivist Connectivity*. For male students, *Involvement* was the next best predictor of *Constructivist Connectivity* compared to *Personal Relevance* for females.

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Table 5
Stepwise Multiple Regression Predicting Korean Secondary Students' Constructivist Connectivity relative to Science Learning Environment [OBLEQ Instrument]

Model		Unstandardized Coefficients		Standardized Coefficient		
		B	*SE B*	*β*	*t*	*p*
Male	Constant	11.462	1.313		8.732	.000
	Investigation	.295	.093	.452	3.176	.002**
	Involvement	.185	.086	.307	2.153	.034*
Female	Constant	7.465	2.290		3.260	.002
	Investigation	.291	.072	.404	4.046	.000**
	Personal Relevance	.310	.105	.293	2.937	.004**

*$p < .05$; **$p < .01$

Monitoring, Evaluation & Planning

A significant regression equation was found for male students ($F(2, 78) = 47.892$, $p < .01$) with an R^2 of .551 (see Table 6) for MEP (i.e., students' inclination to assess, evaluate, and adjust their learning process). MEP was equal to 17.015+.311(*Investigation*)+.182 (*Involvement*) for male students. For female students, a significant regression equation was found ($F(2, 81) = 27.350$, $p < .01$) with an R^2 of .403. MEP equaled 13.280 +.417 (*Investigation*) and +.224 (*Responsibility for Own Learning*). *Investigation* and *Involvement* were significant predictors of male students' MEP, while *Investigation* and *Responsibility for Own Learning* were significant predictors of female students' MEP. *Investigation* affected both male and female students' MEP. *Involvement* was the next best predictor of male students' MEP compared to *Responsibility for Own Learning* for female students.

Table 6
Stepwise Multiple Regression Predicting Korean Secondary Students' Monitoring, Evaluation & Planning relative to Science Learning Environment [OBLEQ Instrument]

Model		Unstandardized Coefficients		Standardized Coefficient		
		B	*SE B*	*β*	*t*	*p*
Male	Constant	17.015	1.293		13.157	.0001
	Investigation	.311	.091	.474	3.401	.001**
	Involvement	.182	.085	.299	2.147	.035*
Female	Constant	13.280	2.045		6.495	.0001
	Investigation	.417	.066	.547	6.285	.0001**
	Responsibility for own learning	.224	.079	.246	2.824	.006**

*$p < .05$; **$p < .01$

Science Learning Self-efficacy

A significant regression equation was found for male students ($F(2, 78) = 44.604$, $p < .01$) for SE with an R^2 of .534 (see Table 7). SE was equal to 9.547+.217 (*Involvement*) +.189 (*Investigation*) for male students. A significant

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regression equation was also found for female students ($F(1, 82) = 26.519$, $p < .01$) with an R^2 of .244. SE equaled 11.712 +.281 (*Investigation*) for female students. *Involvement* and *Investigation* were both significant predictors of male students' SE, while just *Investigation* was a significant predictor of female students' SE.

Table 7
Stepwise Multiple Regression Predicting Korean Secondary Students' Science Learning Self-Efficacy relative to Science Learning Environment [OBLEQ Instrument]

Model		Unstandardized Coefficients		Standardized Coefficient		
		B	*SE B*	*β*	*t*	*p*
Male	Constant	9.547	1.118		8.541	.000
	Involvement	.217	.073	.422	2.971	.004**
	Investigation	.189	.079	.340	2.392	.019*
Female	Constant	11.712	1.171		10.004	.000
	Investigation	.281	.054	.494	5.150	.000**

*$p < .05$; **$p < .01$

Learning Risks Awareness

A significant regression equation was found for male students ($F(1 , 79) = 68.816$, $p < .01$) for AW with an R^2 of .466 (see Table 8). AW was equal to 9.631+.298 (*Investigation*) for male students. A significant regression equation was found for female students ($F(2, 81) = 15.834$, $p < .01$) with an R^2 of .281. AW equaled 9.023+.120 (*Investigation*) and +.201 (*Personal Relevance*). *Investigation* was a significant predictor of male students' AW, and *Investigation* and *Personal Relevance* were both significant predictors of female students' AW (see Table 8).

Table 8
Stepwise Multiple Regression Predicting Korean Secondary Students' Learning Risks Awareness relative to Science Learning Environment [OBLEQ Instrument]

Model		Unstandardized Coefficients		Standardized Coefficient		
		B	*SE B*	*β*	*t*	*p*
Male	Constant	9.631	.893		10.787	.0001
	Investigation	.298	.036	.682	8.296	.0001**
Female	Constant	9.023	1.390		6.490	.0001
	Investigation	.120	.044	.290	2.744	.007**
	Personal Relevance	.201	.064	.332	3.145	.002**

**$p < .01$

Control of Concentration

A significant regression equation was found for male students ($F(2 , 78) = 44.123$, $p < .01$) for CC with an R^2 of .531 (see Table 9). CC was equal to 5.321+.102 (*Investigation*) and +.086 (Involvement) for male students. For female students, a significant regression equation was found ($F(2, 81) = 22.438$, $p < .01$) with an R^2 of .357. CC equaled 3.038+.071 (*Investigation*) and +.217 (*Differentiation*). *Investigation* and *Involvement* were significant predictors of male students' CC, while *Investigation* and *Differentiation* were significant predictors of female students' CC.

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Table 9

Stepwise Multiple Regression Predicting Korean Secondary Students' Control of Concentration relative to Science Learning Environment [OBLEQ Instrument]

	Model	Unstandardized Coefficients		Standardized Coefficient		
		B	*SE B*	*β*	*t*	*p*
Male	Constant	5.321	.526		10.118	.0001
	Investigation	.102	.037	.395	2.747	.007**
	Involvement	.086	.034	.358	2.493	.015*
Female	Constant	3.038	1.070		2.839	.006
	Investigation	.071	.025	.270	2.859	.005**
	Differentiation	.217	.046	.444	4.697	.0001**

$^{*}p < .05$; $^{**}p < .01$

Discussion

This study explored Korean secondary students' perceptions of science learning environment and their metacognition and self-efficacy in science learning. Further, multiple regression analyses were conducted to determine which science learning environment, measured by OBLEQ variables (refer back to Table 1), best predicted science students' metacognition and self-efficacy as measured by SEMLI-S (see Table 2).

Science Learning Environment

Korean students' perceptions of 'sometimes' experiencing a positive learning environment as measured by the OBLEQ suggests that they felt that they 'sometimes' had chances to benefit from constructivist teaching, which can augment both cognitive and affective domains of learning (Doppelt, 2004) and benefit students' academic achievement (Luckay & Laughksch, 2015). Desired learning that happens only sometimes does not bode well for Korean secondary science students' academic success and achievement. And, in a competency-based context like Korea, it means that achievement of learning outcomes and science competencies and skills are compromised. A preferred result would be often (regularly) but mean scores did not reach 4 or higher for any of the science learning environment subscales (measured by OBLEQ).

Regarding students' perceptions of their science learning environment, male students scored highest on *Involvement* (M = 3.24), while female students scored highest on *Cooperation* (M = 3.00) (see Table 3). Both male and female students indicated the lowest score on *Investigation* (Male = 2.97, Female = 2.54). Respectively, male students enjoyed their involvement in the class, while female students valued working with other students to achieve learning tasks. To benefit most from the science learning environment, male students needed to connect with participation in works, while female students needed to connect with their peers. More emphasis on *Investigation*, such as skills and processes of inquiry, are needed in science learning environments for both male and female students.

Statistically significant gender differences were recorded for four subscales of science learning environment: *Involvement, Investigation, Personal Relevance,* and *Responsibility for Own Learning* with males scoring higher than females on all four (refer back to Table 3). More than chance, these results suggest that the science learning environment resonated with male students along these dimensions – girls, much less so. To better ensure that all students in the future score higher on these aspects of science learning environment than just sometimes, it is important to (a) offer authentic learning experiences (personal relevance), (b) provide opportunities for scientific inquiry (both take responsibility for own learning and investigate) and (c) make the content as interesting as possible according to students' interest and ability. Lower mean scores on the other science learning environment dimensions further challenge teachers to differentiate their science instruction, and provide constant feedback and affirmation so students can perceive themselves in charge of their learning (Aldridge et al., 2006a,b).

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Metacognition and Self-efficacy

The Korean secondary students' metacognition (thinking about one's own thinking) and self-efficacy (ability to control and influence events impacting one's life) in science learning were explored using SEMLI-S instrument. Of specific interest was Korean science students' perceptions of these two factors on their science learning. Male students' mean scores were higher than females on all SEMLI-S subscales registering at the midpoint (sometimes) (see Table 4) (overall $M = 3.16$; male $M = 3.29$; female $M = 3.03$). This midpoint score suggests that Korean science teachers should focus on helping students appreciate the full scope of metacognition: awareness of one's own thinking and control of it (Hsu et al., 2016; Zohar & Dori, 2011). Similarly, Schraw et al. (2006) urged science educators to be concerned with student self-regulation (self-directed, self-efficacious learners), which is imperative for a positive science learning environment.

Statistically significant gender differences were found for three SEMLI-S subscales: *Constructivist Connectivity* (CC), *Monitoring, Evaluation & Planning* (MEP), and *Science Learning Self-Efficacy* (SE) with males scoring higher than the females. These results suggest that the science learning environment in this study resonated more with boys than girls (overall and for CC, MEP, and SE in particular) with two subscales not gendered: *Learning Risk Awareness* (AW) and *Control of Concentration* (CO). The lowest mean score for the females was the *Science Learning Self-Efficacy* (SE), while the male students represented the lowest score in the *Monitoring, Evaluation & Planning* (MEP).

The overall SEMLI-S mean score results (sometimes, $M = 3.16$) suggest that if they want to foster metacognition and self-efficacy, Korean science teachers must engage in instructional strategies that enable students to track their learning and make adjustments (MEP) and become more aware of things that are detrimental to their learning (AW) and affect their control of their concentration (CO) (i.e., metacognition). Regarding self-efficacy (controlling events impacting one's life), students need help gleaning insights into how they organize and execute actions to achieve science learning goals (SE). Teachers must also ensure that science content is relevant to life beyond the classroom so students can make authentic connections with the subject matter (CC) (Thomas et al., 2008).

Prediction of Students' Metacognition and Self-efficacy related to Science Learning Environment

Not all metacognition and self-efficacy in science earning subscales were impacted by science learning environment variables but the one constant and best predictor was *Investigation* (predicted CC, MEP, SE, AW, and CO), a result that held true for males and females (see Tables 5-9) (Fensham et al., 1994). This result implicated that the science learning environment, *Investigation, which* is the extent to which teachers emphasize problem solving and inquiry-based learning to teach science, help the improvement of these Korean students' metacognition. The next best predictor for males was their *Involvement* during the science classes – the extent to which they were interested, attentive, and actively participated in discussions. In contrast, the next best predictor for female students was *Personal Relevance* (predicted CC and AW) – teachers related science to students' out-of-school experiences. This was followed by *Responsibility for Own Learning* (predicted MEP) and *Differentiated* instruction (predicted CO).

These gendered results imply that Korean teachers should tailor their science instruction to the different needs of females and males (Luckay & Laughksch, 2015). Females needed personal relevance, differentiated instruction, and the chance to be in charge of their own learning, but boys needed a learning environment that let them get involved, remain interested and actively take part in class discussions in order to improve students' metacognition and self-efficacy in science learning.

Female students scored noticeably lower on aspects of metacognition and self-efficacy (ranging from $M = 2.92$ to $M = 3.25$ with averaging $M = 3.03$) compared to averaging $M = 3.29$ for male students ($p < .01$; see Table 4). This result contradicts Boz et al.'s (2016) finding that female students were more understanding of their metacognitive and self-efficacy skills than males. Results herein suggest that further research is needed about this gender aspect of Korean science education because an appreciation for one's own thinking and a belief in being able to influence things that impact one's science learning are central to achieving the goals of the revised Korean science curriculum. This recommendation is compounded with the midpoint mean score of sometimes, which can be interpreted as a true reflection of respondents' perceptions rather than them sitting on the fence with no opinion (Lam et al., 2010).

The subscale of Differentiation, which teachers teach differently based on students' ability and interests, only predicted one aspect, Control of Concentration, of female metacognition and self-efficacy with no influence on males. Overall, students scored this variable at $M = 3.01$, meaning they perceived it as sometimes happening in their science learning environment. Differentiated instruction improves science learning and achievement of learning outcomes because individual learning styles and preferences are accommodated (Tobin & Tippet, 2014).

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Limitations

Results herein are limited in their generalization, but their exploratory nature can augment the knowledge base through exploring South Korea context, where the competency-based curriculum is implementing. This study added the knowledge about South Korean secondary students' perceptions of science learning environment and self-efficacy, and further studying gender differences. Gendered comparisons should continue, and cross-national studies including other Asian nations and beyond are recommended. Mixed methods research designs are encouraged because they provide qualitative and quantitative insights into the research problem.

Conclusions and Implications

Promoting metacognition and self-efficacy is crucial to science learning. Results herein were conclusive in that the male and female students in this study differently perceived the science learning environment and their metacognition and self-efficacy. The male students most perceived *Involvement* of the science learning environment, while the female students most perceived *Cooperation*. Further, *Investigation* was the main predictor of both male and female students' metacognition and self-efficacy: *Constructivist connectivity, Monitoring evaluation & planning, Science learning self-efficacy, and Control of concentration*. This study found that science learning environments affected South Korean students' metacognition and self-efficacy. Guided by the new student-oriented Korean science curriculum, Korean science teachers can make an effort to provide a constructivist science learning environment that bolsters students' metacognition and self-efficacy in science learning.

The implementation of Korea's revised competency-based science curriculum requires a learner-centered pedagogy that respects students' current perceptions of their learning environment and its impact on their thinking about their thinking and their sense of being in control of their science learning. South Korean secondary science students felt they sometimes experienced an outcomes-based science learning. A pervasive overall result of not all the time, not regularly, speaks to an opportunity for pedagogical innovation in the science learning context. Within a competency-based context like South Korea, this study further implicated that constructivist learning environment, such as inquiry, problem solving activities, would better help both male and female students' metacognition and self-efficacy. Korean science curriculum architects respect the imperative to reflect on the needs of the school environment (which can be reflected through students' perceptions) and to implement a student-centered pedagogy. To that end, researchers, educators, curriculum planners, and policy makers should heed the results of this exploratory, and any future descriptive and explanatory-related, studies.

Declaration of Interest

The authors declare no competing interest.

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