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Female Secondary Students' and Their Teachers' Perceptions of Science Learning Environments Within the Context of Science Education Reform in Saudi Arabia

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Abstract
This mixed methods study explored how Saudi Arabia's science education reform is functioning in 2 public girls' secondary schools located in Dammam, 1 of the main cities in Saudi Arabia. Saudi Arabia recently launched a new initiative to promote science education innovation by providing science curriculum change, professional development for science teachers, and progress towards a new educational system. This study examined Saudi secondary girls' perceptions regarding science learning environments and the metacognitive science learning orientation within the context of science education reform in Saudi Arabia (N = 202). Further, 3 science teacher participants were interviewed in order to ascertain their perceptions of their current science teaching environments and their science teaching. Particular emphasis was placed on examining differences between the Course System, which is a new system designed to facilitate science experiments and constructivist teaching and learning, and the regular system in terms of students' perceptions about science learning environments and their metacognitive science learning orientation. Results and findings indicate that teachers supported the constructivist pedagogy, and science education reform efforts may gradually change Saudi science education environments and improve Saudi girls' science metacognitive learning orientation.

Keywords Female secondary students · Saudi Arabia · Science education reform · Science learning environment · Metacognitive orientation

Introduction

The context and processes of the Saudi education system are focused on the teachings of Islam and the Prophet Muhammad, "Peace be upon him," as the ultimate guide for all

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Muslims (Alsuwaida, 2016). Over the last 40 years, the government has built an educational infrastructure leading to a steady increase in school and university enrollment and a steady reduction in illiteracy. These underlying conditions have a significant influence on education policy, school organization, and schooling and education in general.

The Saudi government has placed a high priority on free education for all of its citizens. Even though there are many efforts to improve education, the teaching methods employed in science instruction in the Kingdom of Saudi Arabia (KSA), regrettably, continue to place a heavy emphasis on memorization and rote learning. There is a strong tendency to avoid using the available classroom equipment and laboratories, and teachers are given broad discretion to decide whether to employ active-learning methodologies and thus engage their students in the processes of science inquiry. This situation is a reflection of the fact that Saudi Arabia's approach to science education continues to rely heavily on traditional teaching methodologies that involve the inculcation of information by teachers based entirely on the contents of officially approved textbooks (Alhammad, 2015; Hamdan, 2006).

In the KSA, education faces many challenges including students' low test marks. To illustrate, Saudi Arabia's results in the Trends in International Mathematics and Science Study (TIMSS) show that the country received a total score of 329 in 2007 and 394 in 2011 for eight grade students and 410 in 2011 for fourth grade students (National Center for Education Statistics, n.d.). These scores were significantly lower than the average score of 500 among the participating countries and rank among the lowest achievement scores for the TIMSS-listed countries. In addition, the majority of fourth and eighth grade KSA students (93% and 80%, respectively) were unable to solve math and science problems compared to about 72% and 50% of the fourth and eighth grade students internationally, respectively (see National Center for Education Statistics, n.d.). Largely for this reason, there has been a renewed interest in science and mathematics education in the KSA in recent years.

Women's Education in Saudi Arabia

Alsuwaida (2016) explains that the KSA follows an education model based on the following: "(1) a dual system of male and female education; (2) a gender-specific educational policy that emphasizes women's domestic function; (3) gender-segregated schools and colleges; and (4) curriculum differentiation at the various educational levels" (p. 115). Until 1956, women in the KSA were not allowed to be educated (Alsuwaida, 2016) and, for some years thereafter, course contents were minimally developed for girls and women (Mills, 2009). Although the curricula designed for female students have typically been similar to those designed for males, the course material is usually much less extensive for females than for males (Mills, 2009). Fortunately, this disparity is gradually being reduced.

Notwithstanding the apparent barriers to the advancement of women's education, the Saudi government, especially over the last decade, has demonstrated a strong commitment to moving forward at all levels, in particular by both increasing the number of higher education institutions and distributing them throughout the country in order to ensure that all women can easily access them (Alhareth, Al Dighrir, & Al Alhareth, 2015; Hamdan, 2005). In one of the signature policies of the Women's Golden Era of Saudi Arabia, King Abdullah bin Abdulaziz established a host of post-secondary institutions for both genders—namely 24 public universities, eight private universities, and 494 colleges in 76 cities across the Kingdom (Alsuwaida, 2016). Moreover, the King Abdullah Sponsorship Program (KASP), now named "The Custodian of the Two Holy Mosques Scholarship Program" at the time of its launch in 2005, has sent a substantial number of Saudi students to overseas universities, largely to institutions in the USA, the UK, Canada, and Australia. This program is open to Saudi students of both genders (Taylor & Albasri, 2014).

Multiple developments have occurred recently within the KSA's education system. One of the most notable events was the 2009 founding of the King Abdullah University of Science and Technology, an event that confirmed that the country is placing a stronger emphasis on science and technology (Jamjoom & Kelly, 2013). An equally important development was the recent launch of Vision 2030 (King Abdullah University of Science and Technology, 2018), a comprehensive national strategy that reflects the objective of expanding the KSA's investment and stake in the global digital economy while also inspiring and empowering Saudi citizens and women to play a more active role in the processes of national economic development. These changes can potentially increase the level of demand for graduates who have skills and knowledge in the science, technology, engineering, and mathematics (STEM) disciplines (Albadi, O'Toole, & Harkins, 2017; Cavacini, 2016).

Science Education Reform Efforts in Saudi Arabia

Some recent studies indicate that demand for higher-quality education has increased in Saudi Arabia (Alrushaid, 2010; Faiz, 2002; Hamdan & Al-Salouli, 2013). There is also a growing desire to change the curriculum and context for science education. Curriculum change recently emerged as a central issue in the KSA. The Saudi Ministry of Education (MOE) has centralized curriculum development, using a top-down approach to curriculum implementation (Hamdan & Al-Salouli, 2013). Furthermore, Hamdan & Al-Salouli (2013) indicate that, in 2008, "the Saudi Ministry of Education, which oversees all curricula from kindergarten to grade 12, introduced a new science curriculum in collaboration with the *Obeikan Research Development Company*. The new curriculum is partly based on a translation of science textbooks produced by Macmillan and McGraw-Hill, which are British and American publishing companies respectively" (p. 211).

The new Saudi science curriculum places a heavy emphasis on understanding concepts rather than only memorizing them and it attempts to make meaningful connections to students' lives and experiences. The Saudi MOE (as cited in Smith & Abouammoh, 2013) has been promoting student-centered education under its drive for current curriculum reform. Accordingly, the new curricula adopt a teaching approach based on the constructivist theory of learning, which is student-centered and places an emphasis on critical thinking and problem solving. This approach is highly emphasized in the new methods of teaching across the science discipline.

Science Teacher Education Reform in Saudi Arabia

Recent studies, such as Alturki (2016), have highlighted the need to shift science education towards inquiry-based learning, which involves teachers encouraging students to inquire and explore scientific concepts as much as possible on their own rather than continuing to teach them in a didactic manner that encourages students to memorize and learn in accordance with the "banking system" of education. This approach is characterized by students simply storing information and then withdrawing it in order to answer tests and exams (Freire, 2003). In this type of system, the teaching is didactic and the students are mere passive recipients of information. The *Quran* is based on invitations to inquire and explore. Prophet Muhammad of Islam implemented the *Quran*'s stance of invitation to inquire knowledge. For example, Alturki (2016) noted that "the *Quran* talks to the reader; look at the sky, look at the mountains, look at the people who came before you" (p. 23). One might therefore question why Saudi Muslim teachers, who implicitly accept Islam's encouragement of the application of inquiry and a sense of wonder to all aspects of life, generally do not encourage inquiry in their classrooms? Confounding this issue is the fact that Saudi teachers are not constantly monitored by the administrator or the principal meaning they have some degree of freedom in their classrooms. Although inquiry-based learning would generate more student-posed questions and deeper engagement with learning, it would be more challenging for educators to implement.

Two recent projects, a Secondary Professional Development (PD) Program and the Tatweer Project (Tatweer, 2014a, b), are aimed at mathematics and science teachers with the objective of encouraging them to implement new constructivist teaching approaches and thus create inquiry-based, student-centered science and mathematics learning environments. In more detail, in 2009, as part of the Project of Mathematics and Natural Sciences (PMNS), the Secondary PD Program was developed and aimed at all mathematics and science teachers. The PMNS trains mathematics and science supervisors so that they can then train mathematics and science teachers. The goals of this program are to identify both teachers' competencies and the required skills (El-Deghaidy, Mansour, & Alshamrani, 2015; Mansour, Alshamrani, Aldahmash, & Alqudah, 2013). The Tatweer Project (Tatweer, 2014a, b), which is mainly focused on mathematics and science teachers' development needs, produced a set of goals that involve improving (a) the learning capacity for both teachers and supervisors, (b) general education outcomes by developing basic teaching skills, and (c) teachers' leadership of their classrooms. However, no evidence of outcome results or success has yet been provided. The main precursor of this significant increase in governmental support was the aforementioned weak performance of Saudi science students in the TIMSS results (Mullis, Martin, & Foy, 2008).

Secondary School System Reform in Saudi Arabia

The Course System, in which some of the teachers participating in this study teach, is a new Saudi system of teaching whose most prominent feature is the opportunity for students to finish secondary school in 2.5 years instead of 3 years, achieved by adding two summer classes. In terms of science teaching and learning, the Course System is based on inquiry-based, constructivist, and student-centered learning. Each lower-level course is a prerequisite for higher-level courses. There is no repetition of a course, but when a student does not pass a course, it has to be carried into the next summer semester. Conversion from the Course System to the traditional system is provided so that no failure in certain courses is permitted (Ministry of Education, 2018). Through the Course System, seven courses are studied in each semester except in the third grade.

Six courses are taught in each semester of the final year with a total of 40 courses during the 3 years. The quarterly average is calculated by dividing the student's score in the courses by the total number of courses where each course is 100 points. For example, if a student's result in the first semester is 680 and this total is divided by 700, the result is 97.14%. The result in level 2 is added to the first result and divided by the total number of courses recorded in the following level multiplied by 100 to calculate the annual rate. This system has been introduced and is being applied in a sample of schools across the KSA (Ministry of Education, 2018).

The difference between the regular system and the Course System is that the latter is more focused on the quality (affected by teaching strategies) not on the quantity of students' learning. Course System students are fully engaged in the learning and inquiry processes of constructing their own learning. Attending classes, visiting the laboratory to check on experiments, watching educational movies, engaging in flipped classroom activities, and then presenting learning in their classes make students move to an advantage stage compared to other students exposed to traditional lecture-like methods of learning (Hamdan & Hassan, In press). In addition, Course System students are evaluated based on their oral presentation, public speaking, written reports, visits to educational sites, and portfolios, along with their exams. In the traditional system, assessment is based on finals and midterms. Learning in the Course System is based on inquiry and constructing meaning by themselves so that each student grows and learns on his or her base, whereas for traditional system students, learning is based on rote memorization of subject content knowledge (Hamdan & Hassan, In press).

Within the context of science education reform, very few studies have discussed Saudi female students' perceptions about science learning environments and science learning orientation (see examples at Alghamdi, 2017; Alshmemri, 2014; Alzahrani, 2012; Hamdan, 2014; Mansour & Al-Shamrani, 2015). This study addresses that gap. This research further discusses the differentiation between the Course System and the traditional system using a mixed-methods research design.

Conceptual Framework

As described above, since 2008, the KSA has placed a top priority on the improvement of its educational infrastructure. Unfortunately, reforms and systemic planned changes in various contexts are not well documented and understood. Thus, this study aims to explore the current status of science teaching and learning within the context of contemporary KSA science education reform efforts.

To that end, this study adopted two constructs: (a) outcome-based learning environments in science classrooms and (b) students' metacognition in science learning. These were used as parameters for evaluating the current science reform efforts in Saudi Arabia. Outcome-based learning environments require a radical shift in the learning environment towards a constructivist and student-centered learning environment, an approach currently being adopted by a number of school systems around the world (Aldridge, Laugksch, Seopa, & Frase, 2006). Students' perceptions of their outcome-based learning environment provide insights into the ways in which Saudi Arabia's educational reform efforts are functioning for science educators and teachers. Pamuk, Sungur, and Oztekin (2016) found that this perception was a significant predictor of students' science achievement and learning success.

Metacognition is a construct that indicates improvement in students' learning processes, self-awareness of their learning, and consequently, their learning outcomes (Thomas, Anderson, & Nashon, 2008). Metacognition is defined as one's knowledge, regulation, and awareness of one's own learning processes (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Metacognition is context-related and interplays between the context of teaching and that of learning that reflects the classroom learning environment (Thomas et al., 2008). Ernest (1995) suggests that constructivism, which derives from both the radical and social perspectives, focuses attention on metacognition and strategic self-regulation by learners. Honebein (1996) further argues that constructivist learning environments encourage "ownership and voice in the learning process" (p. 20) and "self-awareness of the knowledge construction process" (p. 12), elements that are parallel to the concept of metacognition.

Research Purpose and Questions

This present study aims to explore Saudi secondary girls' perceptions of science learning environments and their metacognitive science learning orientation within the context of science education reform in Saudi Arabia. More specifically, this study compared the Course System with the regular, traditional system in terms of girls' perceptions of science learning environments and their metacognitive science learning orientation. Then, the researchers explored science teachers' perceptions of their science classes' learning environments and their science teaching. The research questions are as follows:

1. What are Saudi secondary girls' perceptions of their science learning environment and metacognitive science learning orientation?
2. What are the differences between the Course System and the regular, traditional system in regard to the science learning environment and metacognitive science learning orientation?
3. What are the science teachers' perceptions of their science classes' learning environments?

Research Methodology

This study used the mixed-methods research design comprising both quantitative and qualitative data. The quantitative strand explored Saudi female students' perceptions of science learning environments and metacognitive orientation, while the qualitative strand focused on science teachers' perceptions of their science classes' learning environment.

Participants and Study Context

The sample comprised 202 female students enrolled in secondary grade 10, 11, and 12 science classes in two public schools. Both schools are in the urban part of the main city located on the Eastern Province of the KSA. The school contexts are very similar at the students' achievement level, school learning environment, as well as parents' socioeconomic status. In addition, both are girls' schools as the Saudi education system continues to be segregated by gender. The number of Course System students totaled 63, enrolled in two classes. The grade 10 students were involved in the Course System for about 1 year and the grade 12 students for about 2 years. There were 139 regular-system grade 11 students, enrolled in three classes. The classes were chosen using convenience sampling. Pseudonyms were used to ensure confidentiality.

In the qualitative strand of this mixed-methods study, three teachers from the same schools whose students were study participants were interviewed about their science classes' learning environment. The minimum amount of time that each teacher had spent teaching in her school was 5 years. All three teachers hold a B.Ed. degree. To ensure confidentiality and privacy, each participant was assigned a pseudonym. Teacher LA has a physics background. She had 24 years of experience at the high school level and had been given an award for best science teacher by the board. Teacher FK has a chemistry degree and 17 years of experience. Teacher SS has a master's degree in biology teaching and 12 years of teaching experience. FK and LA had taught in the Course System for 4 years and SS for 2 years. They all voluntarily participated in the study.

Data Collection and Measures

Two instruments, the *Outcome-Based Learning Environment Questionnaire* (OBLEQ) and the *Self-Efficacy and Metacognition Learning Inventory-Science* (SEMLI-S), were chosen to investigate students' perceptions of science learning environments, and their science learning efficacy and self-regulation for their learning and metacognition, respectively. The science classroom teachers administered both instruments during week 5 of the first semester in 2017. Students were given 40 min to complete them.

Outcome-Based Learning Environment Questionnaire

To explore Saudi secondary girls' perceptions of the learning environment in their science classes, the OBLEQ (Aldridge et al., 2006) was used. The OBLEQ consists of 56 items with seven scales measuring involvement, investigation, cooperation, equity, differentiation, personal relevance, and responsibility for own learning. Each subscale has eight items. The response format consists of a five-point Likert scale comprising always, often, sometimes, seldom, and never. The instrument items were translated by a Saudi Arabian science educator who used both English and Arabic and then back-translated to ensure accuracy. All six subscales of Cronbach's alpha were above 0.765 (Table 1), ensuring the reliability of the instrument.

Self-Efficacy and Metacognition Learning Inventory-Science

The SEMLI-S tool (Thomas et al., 2008) was used to explore Saudi secondary girls' metacognition, self-efficacy, and learning processes in science. The SEMLI-S comprises 30 items with five subscales: Constructivist Connectivity (CC); Monitoring, Evaluation & Planning (MEP); Science Learning Self-Efficacy (SE); Learning Risk Awareness (AW); and Control of Concentration (CO). Each subscale comprises from three to nine items (see Table 2). The SEMLI-S consists of a five-point Likert scale of

Table 1 Subscales of the OBLEQ and their Cronbach's α

Subscales	Descriptions	n of items	Cronbach's α
Involvement	The extent to which students have attentive interest, participate in discussions, do additional work, and enjoy the class	8	0.892
Investigation	The extent to which emphasis is placed on the skills and processes of inquiry and on their use in problem solving and investigation	8	0.881
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks	8	0.819
Equity	The extent to which students are treated equally and fairly by the teacher	8	0.893
Differentiation	The extent to which teachers cater to students differently on the basis of ability, rates of learning, and interest	8	0.765
Personal Relevance	The extent to which teachers relate science to students' out-of-school experiences	8	0.781
Responsibility for Own Learning	The extent to which students perceive themselves as being in charge of their learning process, motivated by constant feedback and affirmation	8	0.920

always, often, sometimes, seldom, and never. The instrument items were translated by a Saudi science educator who uses both English and Arabic and then were back-translated to ensure accuracy. Table 2 indicates the descriptions of subscales and their Cronbach's alpha, ensuring the reliability of the instrument.

Teacher Interviews

During 2016 – 2017, the two authors conducted 50-min individual, semi-structured interviews, asking about teachers' science class environments, which are equivalent with the seven OBLEQ subscales (see Table 1 and the Appendix). The two remaining questions pertained to their classroom learning environment and teaching style and the Course

Table 2 Subscales of SEMLI-S and their Cronbach's α

Subscales	Descriptions	n of items	Cronbach's α
CC	Whether they construct connections between information and knowledge across various science learning locations	7	0.847
MEP	Related to metacognition (awareness of one's own learning and thinking)	9	0.840
SE	Students' perceptions of their orientation to organize and execute actions that are needed to attain science learning goals	6	0.863
AW	Students' perceptions of their levels of awareness in relation to situations that may prove to be detrimental to their learning	5	0.792
CO	Relationship with monitoring and evaluation of learning	3	0.690

CC Constructivist Connectivity; *MEP* Monitoring, Evaluation & Planning; *SE* Science Learning Self-Efficacy; *AW* Learning Risk Awareness; *CO* Control of Concentration

System. Each interview was conducted in Arabic, recorded, transcribed, and then translated into English. Two Arab English professors checked the accuracy of the translations.

Data Analysis

Descriptive statistics were used to indicate the mean scores of each subscale of both instruments. Pearson correlation coefficients were used to examine the associations among the variables of the OBLEQ and the SEMLI-S. Finally, the independent-samples *t* test was used to detect any differences in the Saudi girls' perceptions of their science learning environment and metacognitive science learning orientation between the Course System and the regular system. For the qualitative data, we carefully read each transcript, organized by questions reflecting the seven OBLEQ subscales (see Table 1 and the Appendix), and developed a profile of teachers' perceptions of their outcome-based learning environment, students' learning within this classroom, and the Course System.

Results and Findings

Research Question 1: Saudi Secondary Girls' Perceptions of Their Science Learning Environments and Metacognitive Science Learning Orientation

Saudi Secondary Girls' Perceptions of Their Science Learning Environments in Science Classes

Saudi secondary girls' perceptions of their science learning environments were depicted using descriptive statistics based on responses to the OBLEQ. Table 3 presents the average means per item. The total mean score of the OBLEQ was 3.63 (SD = 0.52). The average item mean for the science learning environment ranged from 3.23 to 4.05. The highest mean score was 4.05 (SD = 0.68) in "Cooperation," and the lowest mean score was 3.23 (SD = 1.07) in "Responsibility for Own Learning." The mean score for every subscale was higher than three points within the five-point scales.

Pearson correlations were computed among the seven OBLEQ subscales on data for 202 students (see Table 4). The highest correlation was between the variables "Involvement" and "Investigation" ($r = 0.575$; $p < 0.01$) with a moderate correlation. The total score of OBLEQ was most related to the variable Responsibility for Own Learning ($r = 0.708$; $p < 0.01$) indicating a strong correlation. The second highest correlation was found between the total scores of OBLEQ and the variable "Equity" ($r = 0.704$; $p < 0.01$) with a strong correlation.

Saudi Secondary Girls' Perceptions on Metacognitive Science Learning Orientation

The mean score of the Saudi girls' SEMLI-S was 3.84 (SD = 0.48) within a five-point Likert scale (see Table 5). The average item mean for SEMLI-S ranged from 3.71 to 4.02. The students' highest mean score was in "Learning Risk Awareness" ($M = 4.02$; SD = 0.65), and the lowest mean score was in "Constructivist Connectivity" ($M = 3.71$; SD = 0.72).

Table 3 Average item means and standard deviation for the Saudi secondary girls' perceptions of the outcome-based learning environments

Subscales	Subscale mean	Std. deviation	Skewness	Kurtosis
Involvement	3.66	0.69	− 0.417	− 0.142
Investigation	3.52	0.69	− 0.401	0.248
Cooperation	4.05	0.68	0.218	3.032
Equity	3.89	0.80	− 0.539	− 0.113
Differentiation	3.37	0.80	− 0.033	− 0.309
Relevance	3.71	0.72	− 0.315	− 0.353
Responsibility	3.23	1.07	− 0.275	− 0.337
OBL total	3.63	0.52	0.250	0.040

Table 6 represents the correlations among the SEMLI-S variables. The highest correlation was found between the total score of SEMLI-S and "Monitoring, Evaluation & Planning" ($r = 0.852$; $p < 0.01$), indicating a very strong correlation. The second highest correlation was found between the total score of SEMLI-S and "Science Learning Self-Efficacy" ($r = 0.733$; $p < 0.01$), representing a strong correlation.

Research Question 2: Differences Between the Course System and the Regular System in Terms of Science Learning Environments and Metacognitive Science Learning Orientation

Comparison of the Course System and the Regular System in Terms of Science Learning Environments

In order to compare the students' perceptions of science learning environments between the Course System and the regular system, the results of the OBLEQ were analyzed using the independent-samples *t* test (see Table 7). No significant differences were found between the two groups in terms of the students' perceptions of the outcome-

Table 4 Correlation among the variables of Saudi girls' outcome-based science learning environments (OBLEQ)

Variables	1	2	3	4	5	6	7
1. Involvement	1						
2. Investigation	0.575**						
3. Cooperation	0.425**	0.344**	1				
4. Equity	0.396**	0.345**	0.402**	1			
5. Differentiation	0.316**	0.330**	0.182**	0.349**	1		
6. Relevance	0.314**	0.369**	0.101	0.319**	0.319**	1	
7. Responsibility	0.337**	0.328**	0.228**	0.429**	0.296**	0.324**	1
Total	0.696**	0.685**	0.552**	0.704**	0.612**	0.591**	0.708**

**$p < 0.01$

Table 5 Average item means and standard deviation of Saudi secondary girls' perceptions of the metacognitive science learning orientation

Subscales	Subscale mean	Std. deviation	Skewness	Kurtosis
CC	3.71	0.72	−0.234	−0.383
MEP	3.80	0.56	−0.036	0.213
SE	3.84	0.77	−0.900	1.236
AW	4.02	0.65	−0.717	1.122
CO	3.94	0.80	−0.708	0.486
SEMLI-S total	3.84	0.48	−0.467	1.636

CC Constructivist Connectivity; *MEP* Monitoring, Evaluation & Planning; *SE* Science Learning Self-Efficacy; *AW* Learning Risk Awareness; *CO* Control of Concentration

based learning environments ($t(200) = -1.617$; $p > 0.05$). However, in the subscale Responsibility for Own Learning, there was a significant difference between the Course System ($M = 24.06$; SD = 8.59) and the regular system ($M = 26.69$; SD = 8.45) ($t(200) = -2.036$; $p < 0.05$).

Comparison of the Course System and the Regular System in Terms of Metacognitive Science Learning Orientation

The students' perceptions of the metacognitive science learning orientation of the Course System and the regular class were compared using the independent-samples t test. A significant difference was found between the two groups, with $t(200) = 2.066$ and $p < 0.05$. The sample means of the subcategories of metacognitive science learning orientation are displayed in Table 8, which shows that the students in the Course System scored significantly higher on MEP ($t(200) = 3.063$; $p < 0.01$) as well as on SE ($t(200) = 2.734$; $p < 0.01$) than the students in the regular system.

Table 6 Correlation among the variables of the Saudi girls' metacognitive science orientation

Subscales	CC	MEP	SE	AW	CO
CC	1				
MEP	0.490**	1			
SE	0.305**	0.512**	1		
AW	0.202**	0.391**	0.247**	1	
CO	0.249**	0.499**	0.449**	0.241**	1
Total	0.701**	0.852**	0.733**	0.549**	0.623**

CC Constructivist Connectivity; *MEP* Monitoring, Evaluation & Planning; *SE* Science Learning Self-Efficacy; *AW* Learning Risk Awareness; *CO* Control of Concentration

**$p < 0.01$

Table 7 Comparison of the perceptions of the science learning environment by the Course System and the regular system

Subscales	Couse system ($n = 63$)		Regular system ($n = 139$)		t	df	p
	Mean	SD	Mean	SD			
Involvement	28.48	4.93	29.69	5.74	− 1.452	200	0.148
Investigation	27.24	5.61	28.55	5.50	− 1.557	200	0.121
Cooperation	31.70	5.05	32.71	5.64	− 1.219	200	0.224
Equity	30.41	6.69	31.49	6.21	− 1.123	200	0.224
Differentiation	26.54	5.60	27.10	6.70	− .576	200	0.565
Personal Relevance	29.91	5.61	29.56	5.87	0.401	200	0.689
Responsibility for Own Learning	24.06	8.59	26.69	8.45	− 2.036	200	0.043*
Total	198.33	25.76	205.40	30.08	− 1.617	200	0.107

*$p < 0.05$

Research Question 3: Classroom Science Teachers' Perceptions of Their Science Classes' Learning Environments

Three teachers participated in the individual interview about their classes' science learning environments. The first question was about the students' level of involvement. All the teachers mentioned that they are making an effort to promote the students' involvement during the classes. FK mentioned the importance of "relevance to students' backgrounds." LA indicated that the content needs to be interesting to ensure the students' involvement in the classes. Finally, SS mentioned that science experiments are effective engagement strategies for students who are weak in terms of scientific language.

Table 8 Comparison of the perceptions of metacognitive science learning orientation of the students in the Course System and in the regular system

Subscales	Couse system ($n = 63$)		Regular system ($n = 139$)		t	df	p
	Mean	SD	Mean	SD			
CC	26.12	4.56	25.88	5.23	.311	200	0.756
MEP	35.76	4.47	33.47	5.11	3.063	200	0.002**
SE	24.33	3.89	22.44	4.80	2.734	200	0.007**
AW	20.05	3.24	20.14	3.27	− 0.175	200	0.861
CO	11.95	2.43	11.77	2.40	0.480	200	0.632
Total	118.20	13.36	113.70	14.77	2.066	200	0.040*

CC Constructivist Connectivity; *MEP* Monitoring, Evaluation & Planning; *SE* Science Learning Self-Efficacy; *AW* Learning Risk Awareness; *CO* Control of Concentration

*$p < 0.05$; **$p < 0.01$

> FK: They are involved if they feel and sense the relevance to their background. I work hard on that before coming to class.
> LA: The content is interesting when they [the students] engage. But without them it's too difficult for them to grasp some meanings.
> SS: Student involvement in class is there with those that understand the scientific language. However, I noticed that when we have science experiments, those that are weak in the [scientific] language tend to participate more and seem to be more engaged.

The second question was about students' investigation in their science classes. FK said that "giving some hints" promotes students' curiosity and thus encourages them to explore new things. LA mentioned the difficulties of maintaining the same level of student interest in engaging in investigation, but she had confidence in her ability to instill interest in the students and thus encourage investigation. SS mentioned that students' investigation happens in the context of science experiments, rather than lectures.

> FK: Some of my students are curious to explore new things, and I promote curiosity by giving some hints.
> LA: It's hard to maintain the same level of interest in investigation but I know that I succeeded in instilling that in my students …. It's a must for future scientists.
> SS: It's possible especially when I teach my students to investigate use of scientific concepts …. When engaging in science experiments, the students are open to investigation. However, if it is a lectured style class, then they will not be open.

The third question was with respect to the students' level of cooperation in their science classes. FK mentioned that she often uses games to promote cooperation. LA commented that she dislikes competition-based motivation and instead asks students to cooperate to find meanings. SS mentioned that she supports a cooperative learning environment that emphasizes group learning rather than competition so that each student has a role in the various groups.

> FK: When I use games I see lots of cooperation in my classes … gaming is effective and attractive and instills cooperation.
> LA: My students cooperate to find meanings, and I don't like to support competition in science class.
> SS: Students come to my classes eager to learn, and I have supported learning through cooperation in my years...as students have too much competition …. When students are in cooperative learning environments, they tend to cooperate with each other and the teacher. They all have a role in their group and know what is expected of them.

The fourth question was about equity in their science classes, and the fifth question was about differentiation. All three teachers mentioned that they treat students in different ways in accordance with the individual level of ability. FK mentioned that she always takes into consideration the fact that students have different abilities. LA said that equity and differentiation should be given equal priority so that no one is left behind. SS mentioned that equity ensured that opportunities are provided to every student, while differentiation supports students who have learning disabilities or language issues.

> FK: I don't treat all students in the same way …. I have to differentiate between equity and justice …. This is why differentiation and considering students' different abilities are significant practices for science teachers...By differentiation I am seeing all my students are engaged … excellent and average students.
> LA: Equity is not possible in its literal sense …. I have to equate with or by using differentiation...Differentiation is allowing students to fit in all are part of the lessons and no one left out. I try to use differentiation in my classes but sometimes it is hard to manage my time. Differentiation would entail that I tailor my teaching, assessment and evaluation according to students' needs.
> SS: Equity in science classes means giving opportunities to every student to learn and make a difference, and I am influencing that in my teaching...Differentiation is giving the students confidence …. In my classroom, we have a co-teacher who sits with those that have difficulty learning either because of language issues or learning disabilities.

The sixth question was about personal relevance for students in their science classes. FK mentioned the importance of "enthusiastic teachers" who are able to relate science to students' lives. LA stated that she used examples drawn from everyday experiences. SS also mentioned using real-world experiences to connect science with "what is happening now in the world."

> FK: Science is relevant to students' lives and it takes an enthusiastic teacher to instill that.
> LA: Science is personal...I bring examples from the kitchen, make up and cosmetics. Students can see that, and reach an understanding of science relevance.
> SS: I could see students' faces full of curiosity in discovering the themes and moral values of learning science in its context …. We have adopted the IB curriculum, which makes sure the students have real-world experiences in their learning. We try to adapt lessons where they can have that connection between what happens or is happening now in the world along with science situations, skills, and concepts.

The last question of science learning environment was about taking responsibility for one's own learning. FK stated that students are able to take responsibility for inspiring other students regarding career prospects in science. LA mentioned the importance of connecting science to students' experiences in order to stimulate their interest. Finally, SS mentioned that students assume responsibility for their own learning when they demonstrate scientific curiosity and motivation to conduct research or experiments or when they explain why and how something happens.

> FK: Inspiring students and raising their expectations for the scientific sections in terms of career prospects and university majors available.

LA: Connecting science learning to students' immediate experience raises their interest, and thus their responsibility for their learning.

SS: My science class consists of reading, experiments, and phenomena or situations that the students have to figure out. We don't have consistent access to labs in school, so sometimes I do an experiment and the students have to explain what is happening. Or I give them a situation, and they [the students] have to explain, why and how it happened in that way. When we read, it is usually the beginning of the unit and at the end. After we read, we sometimes do a Thinking Routine.

The teachers further mentioned that the Saudi secondary girls' attitude to science learning could be improved through the provision of more scientific laboratories (which are a common feature of the Course System learning approach), encouragement of science teachers' PD, and participation in scientific competitions, leading to scientific disciplines. SS and FA mentioned the following about the Course System in particular:

SS: Whether systematic or non-systematic, Course System experiments with safety rules applied make a difference for students' involvement in science classes.

FK: The Course System is helping for a lot of reasons. First of all, the percentage of admission of female students of the first secondary level is high because the Course System, which is a new system, teaches students self-autonomy. Also, the Course System provides scientific laboratories prepared in the school building and laboratory preparations … and encourages science teachers to develop and apply practical aspects of the students.

FK and LA further emphasized the importance of teachers' passion to teaching and thus influencing the students.

FK: A reality that is a love of physics...I enjoy completely teaching the materials that are relevant to students...it reflects on the psychology of students, they show receptiveness and enthusiasm for the materials despite their difficulties …. This applies to the majority of scientific subjects in my school.

LA: The level of cultural expectations of science is high and this makes students either interested or disinterested, but it all depends on the way the teacher influences her students and supports their learning.

SS and LA also suggested that female students should participate in scientific competitions in order to foster scientific understanding as well as to support their pursuit of a career in science or a science-related field. SS indicated that overseas scientific trips help to spark a desire in young students to place an early focus on science. LA further articulated the importance of the community's view of girls pursuing scientific knowledge.

SS: Participation of female students in scientific competitions such as the scientific research competition and the National Creativity Olympiad of the Mawhiba Foundation, Globe Environmental Program, SITEK Competition. All these competitions have helped their participation in the world of science and the opportunities for connecting to science understanding. Supporting the school administration and teachers to participate in scientific competitions and encouraging them to do so, in addition to scientific trips abroad... This helps students' self-efficacy and teachers' too.

LA: Community view of [female] students of scientific departments led to high tendencies of female students of the scientific section. This is a challenge for teaching science to those who are only interested because of family pressure.

Teachers' Profile of Their Science Class's Learning Environment

When asked to comment on their perceptions of their science class' learning environment, framed around the seven aspects of students' perceptions of an outcome-based learning environment (see Table 3), the teachers interviewed in this study presented the following general profile. Succinctly, they make conscious efforts to ensure student involvement, commenting on the challenges involved including instilling and maintaining their interest when investigating science issues. The science course content must be interesting and personally relevant to the students. Teachers encouraged cooperative learning, with one explicitly saying she disliked competition-based motivations to learn. The teachers all fostered equity and respected the need for differentiated learning. All three teachers respected the value of students being responsible for their own learning, indicating this is more possible when teachers can foster scientific curiosity and sustain students' stimulated interest in science learning. In effect, these three teachers endorsed the constructivist pedagogy.

Discussion

Since the Kingdom of Saudi Arabia established the first funded school for women in 1960 (Yizraeli, 2012), there has been an increase in emphasis on teaching science to female students, which recently intensified with the government's decision to prioritize science education innovation through science curriculum reform, science teacher education reform, and educational system reform. This study examined Saudi female secondary students' perceptions of the science learning environment and their metacognitive science learning orientation within the context of the KSA's science education reform, implemented in a country where unequal treatment for women regrettably remains embedded in the education system (Hamdan, 2005). The results and findings provide insights for science educators, teachers, and policymakers.

By way of cross-country comparison, the Saudi secondary girls' perceptions of science learning environments were higher than those found by Aldridge et al. (2006) in their study of grade eight South African secondary students' determined by using the same instruments. The Saudi secondary girls received higher scores in relation to all but one OBLEQ subscale: responsibility for one's own learning (Fig. 1). When reporting their study, Aldridge et al. (2006) did specify the respondents' gender. Our study of female science students, with an overall mean of 3.63, revealed that these girls tended to have a positive perception of their science learning environment.

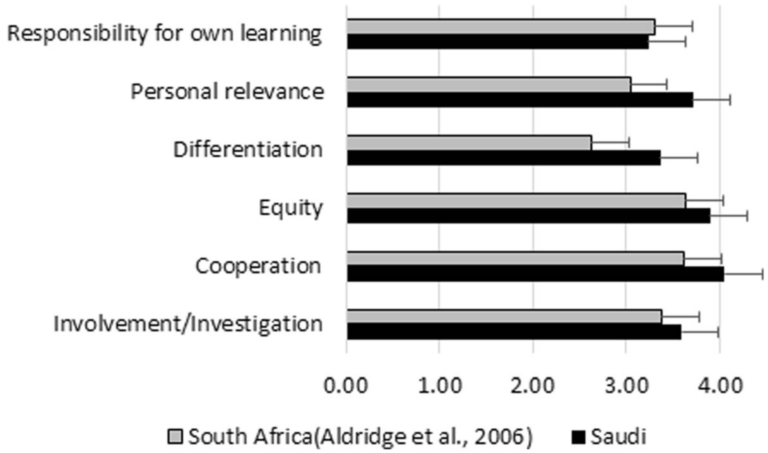

Fig. 1 Comparison of students' perceptions of outcome-based learning environments in Saudi Arabia and South Africa

Having students engaged in the learning and inquiry processes positively influences their metacognition of scientific concepts. The higher number of courses in the Course System, which is 7 for four terms and then 6 in the last two terms, leaves a greater room for student focus and involvement in the learning process and learning inquiry. The Saudi secondary girls' metacognitive science learning orientation in our study was higher than that of the Hong Kong secondary students in Thomas et al.'s (2008) study—in all five subcategories (see Fig. 2). Thomas et al. (2008) (who also used the same instrument) did not provide any information about the respondents' sex. The results of our study are meaningful in that while female Saudi students tend to lack an ideal environment for women's education (Alsuwaida, 2016), the Course System seemed to mitigate some of this influence.

Our results further suggest that science reform efforts help explain the Saudi students' higher scores relative to Aldridge et al.'s (2006) and Thomas et al.'s (2008) results. In a context similar to this study, Hamdan & Al-Salouli (2013) explored Saudi elementary

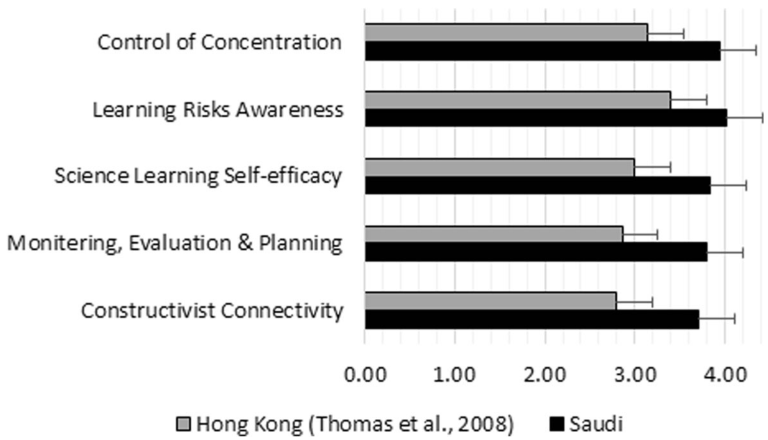

Fig. 2 Comparison of the students' perceptions of the metacognitive science learning orientation in the KSA and Hong Kong

school science teachers' beliefs and found that the teachers perceived differences between the old and new science curricula. Pasha-Zaidi and Afari (2016) similarly suggested that shifting to student-centered climate may affect students' perceptions of learning.

Our quantitative results further indicate that the students' scores in terms of metacognitive science learning orientation were statistically higher than those for the students enrolled in the regular system. It is noteworthy that the female students enrolled in the Course System represented the statistically higher scores in Science Learning Self-Efficacy and Monitoring, Evaluation & Planning. This result indicates that the students in the Course System tend to be more effective at regulating, organizing, and executing their own science learning than the female students enrolled in the regular system.

Compared to the regular system, where laboratory exposure is at the discretion of the teacher, influenced by their enthusiasm, the Course System regularly provides science laboratories. This strategy gives students opportunities to connect their learning to everyday experiences, which is the Constructivist Connectivity dimension of our measure of instrument. Albadi et al. (2017) reported students' preference of learning through experiments, which is now much more common within the recent reform in Saudi's secondary science education context. From another perspective, one of the teachers interviewed in our study observed that science experiments play a role in students' involvement especially when they have difficulty understanding scientific language. The language issue in the science classroom was noted in a recent study, which indicated that "difficulties with specialized language may seriously impede the development of physics understanding by Saudi students" (Albadi et al., 2017, p. 639).

On the other hand, there was no significant difference of students' perceptions of science learning environments between the Course System and the regular system. Regarding the subscale Responsibility for Own Learning, which is one of the subscales of science learning environment, the scores of the regular system students were significantly higher than the scores of the Course System students. Our study further analyzed the grade level differences of the scores of science learning environment among the students of the Course System and found that the grade 12 students' scores (M = 213.61; SD = 23.92) were significantly higher than the grade 10 students' scores (M = 188.28; SD = 21.89) ($t(61) = -4.332$; $p < 0.01$). Also, in regard to the subscale Responsibility for Own Learning, the grade 12 students' scores were significantly higher than the grade 10 students' scores ($t(61) = -6.713$; $p < 0.01$). These results may be explained by the grade 12 students' lengthier engagement in the Course System (2 years) compared to that of the grade 10 students (1 year). These results further imply that lengthening the Course System would increase students' perception of science learning environment in a positive way. The same premise holds for the subscales of metacognitive science learning orientation, such as Constructivist Connectivity, Learning Risk Awareness, and Control of Concentration, which did not show any significant difference between the Course System and the regular system.

Quality teaching is crucial for the successful implementation of innovative science education reforms (Alrushaid, 2010; Hamdan & Al-Salouli, 2013). Findings from the interviews confirm that the teacher participants in this study articulated the constructivist views in their science teaching (see the teacher profile). They advocated for "connecting science concepts to previous concepts and to personal lives," "providing inquiry learning environments through laboratories," and "supporting cooperative learning environment"—elements that are collectively equivalent to constructivist science teaching. The teacher participants also recognized the importance of female students' participation in scientific competitions, such as the scientific research competition and the National Creativity Olympiad, which are supported by school administrations and teachers. It certainly appears that these teachers were making efforts towards developing and strengthening student-centered science learning environments by promoting active participation in investigation and group learning rather than in competition and by further connecting everyday life to science learning. What is encouraging is that the teachers interviewed in this study perceived that (as articulated by teacher FK) the Course System provides "self-autonomy" when girls study science in "scientific laboratories." Women's education in Saudi Arabia is now steadily changing, including enabling girls to graduate earlier and study in constructivist ways. This fits in well with the recently articulated national strategy called Vision 2030, which aims to ensure that women become active participants in all aspects of Saudi life (King Abdullah University of Science and Technology, 2018).

Implications

UNESCO (2013) has confirmed that, over the last decade, Saudi Arabia has made the most noteworthy progress in women's education in the world. As a result, 81% of women are professionals, representing a massive improvement relative to 57% from one decade prior. The results and findings from our study suggest that science education reform efforts, such as the combination of science teacher PD, science curriculum innovation, and school system innovation, offer great potential to improve the KSA's science education environments and Saudi girls' science metacognitive learning orientation. Being aware of one's learning is the key to responsible learning and life success for female students. This learning self-awareness will, in turn, move Saudi society forward in terms of resolving inequity in education, including empowering women to pursue careers in science and science-related fields.

Study Limitations

First, this study used the convenient sampling method within two schools in one city at Saudi Arabia. Additional contexts would help to explore changes of Saudi girls' perceptions of science learning environments within the newly launched Course System couched within Vision 2030. Also, this study was limited to Saudi female students for cultural reasons as the coauthor is female (as in Hamdan & Al-Salouli, 2013). Further studies with male students would provide additional insights into Saudi Arabia's science educational reform efforts.

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Appendix. Teacher interview questions

1. What do you think of students' involvement in your science class?
2. What do you think of students' investigation in your science class?

3. What do you think of students' cooperation in your science class?
4. What do you think of equity in your science class?
5. What do you think of differentiation in your science class?
6. What do you think of personal relevance in your science class?
7. What do you think of students' responsibility for their learning?
8. Could you describe your science class? How do you usually teach (teaching methods)? In your class, what do you think about how students learn?
9. How do you evaluate the Course System?

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