Gender and Science in the Arab States: Current Status and Future Prospects

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There is currently a pressing need to reform science education systems in the Arab states because of the perceived relationship between science and technology and competitiveness, wealth creation, and quality of life. This is happening at a time when the performance of a number of these states on international comparison studies in science and math such as TIMSS and PISA is weak. A myriad of reports by UNESCO (2008a), United Nations Development Program, Regional Bureau for Arab States (UNDP/RBAS) (2003), and the World Bank (2008, 2011) indicate that education in general and science education more specifically in Arab states are in a state of crisis. These reports suggest that two major problems have characterized Arab science education: access to and quality of science education. However, a closer analysis of the status of science education in Arab states shows that these two problems are multifaceted and that gender is a central factor to consider because of the apparent inequality between men and women, a situation that leads to women not having equal opportunities for success in science- and technology-related careers. Problems of quality are of the same nature and magnitude for males and females. In addition, it is doubtful whether access is truly equivalent for males and females in terms of equality in the learning process, educational outcomes, and external results and equal opportunities in employment and salaries. To address these issues, this chapter analyzes gender and science education in Arab states from a sociocultural perspective. Factors associated with this perspective have been shown to influence student achievement in general and girls' achievement more specifically, negatively or positively depending on the classroom and cultural contexts in which these girls live. This chapter starts by presenting the essential elements of the social-cultural

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perspective which is used to frame the questions and discussions. This is followed by an overview of the status of science education in the Arab state with a focus on the status of women and the sociocultural factors that constrain their ability to go beyond a certain stage in development and role in society. Finally, the chapter explicates the complex relationships between gender and science education by analyzing existing literature on the topic with the aim of identifying specific questions worthy of future investigation in Arab states.

Sociocultural Perspectives and Science Education

Teaching students about redox reactions, controlled experimentation, and acid–base reactions outside their context is a relatively inefficient and inappropriate way of learning (Lemke 2001). Teaching these and other concepts outside their social, economic, and even political contexts is not in congruence with modern views of scientific literacy and the natures of science. Lemke considers science as a human activity that is not to be viewed in separation from politics, society, and culture. To account for context of teaching and learning, the sociocultural perspectives in science education emerged as important research areas which should be taken into account while designing curricula and teaching concepts and developing views about students' understandings. According to Lemke (2001), a sociocultural perspective entails viewing "science, science education and research in science education as human social activities conducted within institutional and cultural frameworks" (p. 296) suggesting the need to consider context in which science is being taught and developed. Lemke carries this argument further by asserting that student learning should also be viewed in light of the context in which it is happening, accounting for student attitudes, motivations, interests and the like. Such a notion is also asserted by Robbins (2005) when he suggests that student thinking is rooted within a sociocultural context and is, in particular, influenced by other individuals with whom students interact.

Lemke further suggests that, from a sociocultural perspective, ignoring the various identities and attitudes of students is not healthy for their academic as well as social development. He claims that "we could succeed better at science literacy for all if we supported the much wider range of uses for science learning that fit with the lives and identities of a much larger fraction of the population" (p. 308). Similarly, Carter (2007) claims that teaching science in a fragmented and highly abstract manner is clearly irrelevant to students' contemporary lives. She emphasizes "the need for science education to develop culturally sensitive and sociocultural perspectives beyond the normative canonical knowledge and skills that have traditionally dominated its agenda" (p. 172). For Carter, it is essential to recognize all types of people in all contexts and with all their knowledge generating endeavors in this multicultural dynamic world in which we all live.

Examining the sociocultural factors that enhance or impede student learning in science revealed that various factors coalesce to determine students' overall

achievement. Consequently, it is neither the cognitive abilities nor gender by themselves that enhance or impede success in science. Classroom culture and students' stereotypes greatly influence participation as well as achievement in science classes. Brand et al. (2006) affirmed that students in their study thought that only "smart" people can be high achievers in science and math. One student even expressed his belief that only white people can succeed in these subject areas. Such negative stereotypes, generated within the cultural context to which the student belongs, impede achievement in science. Another study by Cowie (2005) that investigated students' positions regarding classroom assessment revealed that these students related their performance in science to the relations between the teacher, students, and the subject of study. Students reported a more in-depth understanding and appreciation of science and attributed their success to teachers' encouragement and feedback in particular when the feedback came from teachers they respected. These findings suggest that students view learning as a social rather than an individual activity. Thus, and as claimed by Robbins (2005), adopting a sociocultural approach to research about students' understanding is of practical academic importance. This approach may shed light on student thinking which is "complex and fluid, and is constituted by many interpersonal and contextual factors" (p. 168).

To disentangle the complexity of classroom life, Von Secker and Lissitz (1999) conducted a study with tenth grade students in various schools during which they measured their higher-order thinking skills along with their understanding of various concepts using questions from biology, physics, chemistry, and earth science. Results of this study revealed that students' socioeconomic status (SES), class, and gender present a threat to achievement. Students from a low SES, females, and minorities were found to be at risk of failure. This is due to the high positive correlation established between being a female coming from a low socioeconomic background and low achievement in science. The investigators claimed that critical thinking exerts an indirect effect on achievement due to the interaction between student gender and minority status. This finding implies that, on average, females and minorities are at a higher risk of low achievement when teachers are encouraged to adopt instructional practices that emphasize critical thinking.

As indicated above, gender, class, race, language, and culture influence students' achievement negatively or positively depending on classroom context. Lemke (2001) affirmed that none of these elements has an objective definition and that "all represent misleading and harmful oversimplifications of the complexity of human similarities and differences" (p. 303). According to Lemke all these elements have their origins in politics rather than science and as a result using them in research necessitates investigating their histories beforehand. Lemke further claims that researchers are not aware of the origins of these elements while doing research due to the insufficient training they typically have in the areas from which sociocultural perspectives originate. The sociocultural areas of research that were most prominent in the past decade are those related to gender equity issues, classroom discourse, language, and minority. These will be detailed in the following sections.

Gender Equity

Spelke (2005) suggests that there is no innate ability among males toward science and math and that on the contrary, both males and females have equal cognitive abilities. Spelke also asserts that differences in achievement and cognitive profiles of males and females basically stem from "differing strategy choices" (p. 956). In this respect both should be provided with equal access to education. The United States Agency for International Development (USAID) asserts that "Gender equity entails an equal opportunity for both males and females to be granted their human rights and to participate in and benefit from economic, social, cultural and political development" (2008, p. 5). USAID carries these arguments further by affirming that despite the fact that educating boys and girls is of equal importance in developing their capabilities and increasing their opportunities, educating girls in specific is of a particular importance and leads to additional socioeconomic gains. According to this report, "the benefits include increased economic productivity, higher family incomes, delayed marriages, reduced fertility rates, and improved health and survival rates for infants and children" (p. 1).

Addressing issues of inequity requires the implementation of focused interventions that target specific identified needs. These interventions should be based on gender analysis and should encourage learning, result in systemic modifications, and transform the power dynamics between the sexes. More importantly, these interventions should be culturally sensitive and focused on a careful sociocultural analysis of the needs of boys and girls and not assume that science is a culture-free enterprise. In addition, USAID cautions against interventions in which the attention is mainly focused on insuring girls' access to education while disregarding the quality of that education because such practices put girls at a disadvantage. Furthermore, to have a lasting impact, interventions should insure equality in access to education, equality in the learning process, equality of educational outcomes, and equality of external results; these are detailed as follows:

Equality of access. Equal opportunities for boys and girls to gain admission to basic education in its various forms whether formal or informal.

Equality in the learning process. Equal opportunities to learn as well as equal attention and treatment in class. According to the USAID report this equality necessitates using the same curriculum and exposing both boys and girls to teaching methods and materials that are free of gender stereotypes and the like.

Equality of educational outcomes. Opportunities for achievement should be equal for both boys and girls. What is more important is that achievement should be based on a person's own abilities and skills and in no way be affected by gender.

Equality of external results. This implies equality in an individual's chance to gain access to various career opportunities as well as the right to have fair earnings based on qualifications.

Classroom Discourse, Language, and Minority Status

Concerning classroom discourse and language, Lemke (2001) investigated interactions in science classrooms in which he used the social and functional linguistics theory to analyze students' and teachers' utterances. This theory regards the use of language as a "socially and culturally contextualized meaning-making, in which language plays the part of a system of resources for meaningful verbal action" (p. 304). From his work emerged various recommendations including providing students with the necessary opportunities to talk and use scientific language to communicate with their teachers and with each other during classroom teaching. Lemke asserts that if differences are taken seriously, then curricula and teaching methods should be designed by considering students' class, gender, language and intellectual abilities. Thus, a sociocultural perspective recommends adopting science teaching approaches that are responsive to the different needs of students in a heterogeneous classroom. Moreover, Brand et al. (2006) asserted that negative stereotypes and students' lack of minority role models impeded achievement in science and math.

In the pages that follow, we describe the status of science education in Arab states with a focus on the role that sociocultural factors play in enhancing or hindering the success of girls in science education in Arab states. The focus will be on gender-related issues in education because of the primacy of these issues in Arab states and scarcity of research on other factors such as class and language in the educational literature in these states. Therefore, we first describe the status of science education in Arab states with special emphasis on access and quality issues in educations especially as they influence girls in science. This discussion addresses quality as demonstrated in science curricula, student learning in science (as evidenced in international comparisons such as TIMSS and PISA), results of public examinations, and assessment practices in science education. This is followed by a description of the status of Arab women in science fields and careers and the role of women in knowledge production in science, technology, and science education. Finally, we discuss (a) attempts to improve access to quality education for girls, (b) the sociocultural factors that constrain the ability of women to go beyond a certain stage in development and role in society, and (c) future directions in research that aims to understand the current situation in depth and propose real and feasible solutions to the problems associated with gender and science education.

Status of Science Education in Arab States

Advancements in science and technology are important educational goals in various Arab states (Dagher and BouJaoude 2011). Attaining these goals requires establishing reform projects aiming to develop educational systems that include

Table 1 Adult and youth literacy in a number of Arab states

	Adult literacy rates (%)		Youth literacy rates (%)	
	1990	2000–2004	1990	2000–2004
Algeria	52.9	68.9	77.3	89.9
Bahrain	82.1	88.5	95.6	98.6
Egypt	47.1	55.6	61.3	73.2
Iraq	35.7	40.0	41.0	–
Jordan	81.5	90.9	96.7	99.4
Kuwait	76.7	82.9	87.5	93.1
Lebanon	80.3	87.0	92.1	–
Libya	68.1	81.7	91.0	97.0
Mauritania	34.8	41.2	45.8	49.6
Morocco	38.7	50.7	55.3	69.5
Oman	54.7	74.4	85.6	98.5
Qatar	77.0	84.2	90.3	94.8
Saudi Arabia	66.9	77.9	85.4	93.5
Sudan	45.8	59.9	65.0	79.1
Syria	64.8	82.9	79.9	95.2
Tunisia	59.1	73.2	84.1	94.3
United Arab Emirates	71.0	77.3	84.7	91.4
Yemen	32.7	49.0	50.0	67.9

This table is adapted from Hammoud (2005)

updated curricula and quality instructional materials. Such a development should be associated with teacher development programs that aim to prepare teachers for challenges inherent in new reforms. Below we describe the status of science education in Arab states with a focus on access, quality, and knowledge production in science education. Quality is discussed from many facets including curriculum, assessment, and student learning. Finally, we analyze science education in Arab states from a sociocultural perspective.

Access to Education

According to Dagher and BouJaoude (2011), Arab states are not quite different from other developing countries in terms of access to and the quality of science education and the production of science and technology. As shown in Table 1, adult illiteracy rates are relatively high in a number of states such as Algeria, Egypt, Iraq, Mauritania, Morocco, Sudan, and Yemen. Also, youth illiteracy rates are relatively high in Egypt, Mauritania, Morocco, and Yemen.

Efforts to improve access to education have resulted in an increase in student enrollment at all educational levels in the past decades and a decrease in illiteracy rates among the population in general and among females more specifically. However, the illiteracy rates are still relatively high and this poses serious implications

to the attainment of scientific and technological literacy for all (United Nations Development Program, Regional Bureau for Arab States [UNDP/RBAS] 2002, 2003; World Bank 2008).

According to the reports mentioned above, Arab states have achieved considerable strides in formal schooling for girls over the last 50 years, having accepted education as a basic human right and placed significant focus on enrollment. Compulsory public education laws enforced in most of the region's states have secured equal access to schooling and participation for girls. When compared to their counterparts in West Africa or South Asia, girls in Arab states are more likely to be enrolled in school. Yet recent evidence points out that the rapid growth in girls' school enrollment has slowed down or has even suffered a setback. Nearly one in four girls of primary school age in the Arab states is not in school. Finally, enrollment rates for girls in secondary and tertiary schooling continue to decline. Female illiteracy in the region is compounded by high dropout rates and number of girls who never enrolled in school, creating a staggering female illiteracy rate of 50 % on average for Arab women.

Quality of Science Education

Problems with science education quality are evident from the use of outdated curricula that do not focus on preparing future citizens who are capable of decision making in the twenty-first century (BouJaoude 2010). Moreover, this quality is caused by the adoption of instructional methods that emphasize theoretical science content and neglect inquiry teaching and learning and science as a way of knowing (Dagher and BouJaoude 2011), even though many science curricula and standards include explicit goals focused on inquiry and the nature of science (Dagher 2009).

Science Curricula. Dagher and BouJaoude (2011) assert, based on a research review of studies conducted in different Arab states, that curricula and teaching methods neglect students' backgrounds, interests, and motivations, fail to stimulate their creativity and imagination, and do not develop their problem-solving skills. Similarly, these studies reported that many standards and curricula in the Arab states are adopted from foreign ones without regard to the culture in which they are implemented thus affecting their quality and the ability of teachers to integrate science in everyday life. In addition, such curricula fail to integrate the use of technology in the teaching of science. On the other hand, and despite the inclusion of the nature of science (NOS) among the goals of science curricula and standards, detailed objectives and instructional activities produced and used are devoid of any mention of NOS in these curricula (BouJaoude 2002; Dagher 2009).

Student Learning in Science. In the absence of comparative data on achievement of Arab students, results of international comparisons in science and math such as TIMSS and PISA can be useful to gauge the quality of learning of students in the countries that participated in such comparisons. The number of Arab states participating in TIMSS has increased from 2 in 1999 to 12 in 2007. Results

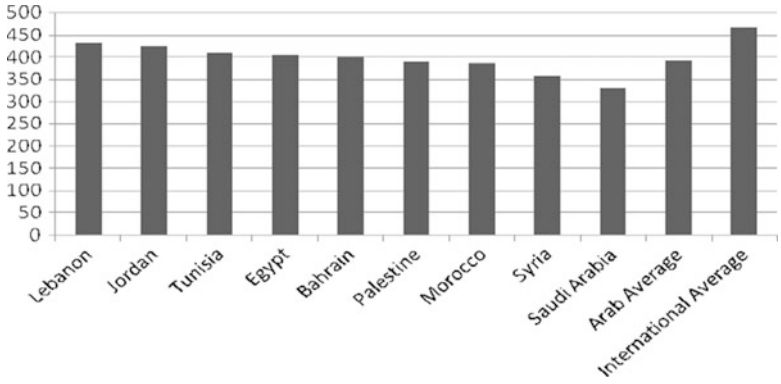

Fig. 1 Average math scores of Arab grade 8 students in TIMSS 2003

of TIMSS and PISA show that students in the Arab states scored lower than the international average on TIMSS in the years 2003 and 2007 with very few exceptions. Similarly, students who participated in PISA in 2006 and 2009[1] scored lower than the international average. These results suggest possible problems in the quality of science education at the precollege level. These problems require careful analysis of the results of international comparisons to identify factors contributing to the lower performance of students and propose possible solutions. Below is a detailed description of the results of TIMSS that includes a comparison of the performance of males and females.

TIMSS 1999. When analyzing results of TIMSS 1999 for items that exhibit gender-related differential item functioning (DIF) in math in Jordan, results revealed that all the DIF items on measurement favored male students, while most of the DIF items in algebraic and data analysis favored female students. Most of the DIF items that negatively impacted females were unfamiliar items that required some risk-taking such as estimation, expectation, or approximation. Most of the DIF items that favored females were familiar items which have one specific correct answer (Innabi and Dodeen 2006). Moreover, results of Jordanian fourth and eighth graders revealed that despite the lack of gender differences in mean achievement scores, there were significant gender differences favoring males when problem-solving skills were considered (Innabi and Dodeen 2006).

TIMSS 2003. TIMSS 2003 results (Fig. 1) indicated that Arab eighth graders scored 393 in math on average, placing them well below the international average of 467. Only a small percentage (less than 1 %) of Arab students reached the advanced international benchmark defined by TIMSS, while 45 % of the students did not reach the low international benchmark category (UNDP 2002). The gender differences in math between Arab eighth graders were negligible. At the country

[1]Qatar and Jordan participated in PISA in 2006 and 2009; Tunisia participated in 2003, 2006, and 2009, while Dubai participated in 2009.

level, girls outperformed boys in some countries, and boys scored higher grades in others (Lebanon, Tunisia, and Morocco), while similar achievements were attained in Egypt, Syria, Palestine, and Saudi Arabia. Among the entire pool of students participating in TIMSS, differences in achievement between boys and girls were negligible in about one third of the countries. In the remaining countries, girls had higher achievement than boys, especially in math (UNDP 2002).

Arab eighth graders' average score in science was 419, which was also below the international performance average of 474. Jordan is the only Arab country that scored above the international average by one point. As for gender differences in science, Arab girls outperformed boys. At the country level, girls had significantly higher average achievement than boys in Bahrain, Jordan, Palestine, and Saudi Arabia. Boys obtained higher average achievement in Morocco and Egypt, whereas no significant differences were found in Lebanon and Syria (UNDP 2002).

With regards to the fourth grade, only three countries participated in TIMSS 2003, namely, Tunisia, Morocco, and Yemen. Results in math were even below those of the eighth graders: students' average achievement was 321 as compared to the international average achievement of 495. A staggering 76 % of Arab fourth graders did not reach the low benchmark defined by TIMSS (UNDP 2002). Gender differences between Arab fourth graders were insignificant. Among the entire pool of students participating, differences in achievement between boys and girls were negligible in approximately half of the countries in both math and science. In the remaining countries, girls had higher achievement than boys (UNDP 2002).

PISA Results

At the outset, PISA assessment focused on reading and math. Since PISA focuses on real-world applications and out-of-school learning that seem to be gendered in nature, slightly larger gender difference were found in PISA than TIMSS because such kind of knowledge is more gender specific and accessible to boys through activities such as playing football and videogames and exploring their neighborhoods (Else-Quest et al. 2010). By 2009, PISA evolved into an internationally standardized assessment of reading, math, and science literacy for 15-year-old students, which includes a combination of multiple choice and open-ended questions (National Center for Education Statistics 2009). Qatar was the first Arab country to participate in PISA in 2006. In 2009, three Arab countries participated, namely, Qatar, Jordan, and the UAE. In PISA 2009, female students scored higher on average than male students in the combined reading literacy scale in all 65 participating countries and other education systems (National Center for Education Statistics 2009).

Results of Internal Examinations (Public Exams). Boys outperform girls on public examinations in some countries. In Sudan, for example, in each year from 1980/1981 to 1989/1990, boys achieved higher grades than girls in the primary school leaving and intermediate examinations, despite the fact that there were more boys taking the examinations than girls (Greaney and Kellaghan 1995). Research

on reasons for girls' lower participation and achievement in examinations pointed to a number of factors, including cultural and religious beliefs regarding women's traditional roles, girls' obligation to carry out household chores, conflicting role expectations for girls and adolescents, and quality of schooling (Greaney and Kellaghan 1995). Recently, however, there has been increasing evidence that when girls are provided with access to education, they outperform boys in most academic subjects (Koushki et al. 1999; Queen's University 2007). According to UNICEF (2005) data for the Arab states shows that girls outperform boys in almost every academic area in the past decade. Moreover, when Arab girls are enrolled in primary school, they usually achieve higher than boys and have lower repetition rates than boys.

Assessment Practices in Science Education. Assessment practices in science education in many Arab states seem to be focused on recall and lower level cognitive questions. A study of end of secondary school public exams in Egypt, Jordan, Lebanon, Morocco, and Tunisia in addition to Iran revealed that most of these public exams focus on recall of traditional content (Valverde 2005). Only assessment goals in Lebanon and Morocco had performance expectations that included interpretation of data from investigations. Most other countries, except Lebanon, placed their performance expectations on understanding simple information. These practices still take place even though ministry of education documents in many states specify learning objectives associated with the development of knowledge, skills, and attitudes in science, the nature of science, and science technology and society (e.g., Jordanian Ministry of Education 2003).

Similarly, in the Sultanate of Oman, the evaluation guidelines categorize skills into five broad areas: initiating and planning, collecting and presenting evidence, analyzing and interpreting data, communicating and working in teams, and writing reports (Ambusaidi and Elzain 2008). These and other similar guidelines are not used appropriately and teachers in many Arab states tend to prepare students to succeed on exams following specific algorithmic criteria without any regard to the broader curriculum goals and objectives.

In summary, it is evident from results of international exams in math and science as well as public exams in specific countries that there is a trend of girls achieving as well as or better than boys in both subjects. This trend is evident also in higher education. What is unfortunate, however, is that despite these changes "Arab women remain poorly prepared to participate effectively and fruitfully in public life by acquiring knowledge through education" (UNDP 2006).

Arab Women in Science Fields and Careers

According to UNESCO (2010), school systems and curricula in Arab states generally reinforce gender bias against girls. Female students are mostly tracked into arts and humanities rather than science streams at the secondary school level. In vocational programs, females are more likely to be placed into fields like nursing, home economics, or simple bookkeeping, as opposed to the more technical fields.

The same phenomenon of relegating females to nontechnical positions persists in higher education as shown in Table 2 which presents percentages of females in the Arab states distributed according to field of study in tertiary education. The figures indicate that the field of study with the highest percentage is education, followed by humanities and social sciences. While a fair percentage of girls are studying science, this percentage is substantially lower in the fields of engineering, manufacturing, and construction, as well as, agriculture and services. The reasons for the above trends are complex. However, very little research has attempted to understand the complexity of students' views about science and investigate women's career choices within this context, an area of research that has been tackled in Western countries. For example, Haste (2004) found that students in the United Kingdom do not seem to see science as a unitary entity but rather as different "sciences" to which they relate differently. The results of her research show that individuals between the ages of 11 and 21 were found to belong to four distinct groups: "greens" interested in environmental issues but with a specific agenda, "techno-investors" enthusiastic about the potential of science, the "science oriented" keen on science as a way of thinking, and the "alienated from science" who were mostly young and female. These findings are echoed in the results of the ROSE project in Europe (Sjøberg and Schreiner 2005).

As a consequence of the above, we use research findings from other context to conjecture about these reasons in Arab states. Research indicates that some women purposely choose not to pursue careers in science and technology because they believe they will feel "cultural discomfort." Moreover, many women perceive that entering what is commonly viewed as male terrain will have a personal and social cost (University of Wisconsin 2008). When venturing into the fields of science and engineering, women find themselves in the midst of systems and performance criteria strictly designed by men for men (Loughborough University 2000). Similarly, a recent UNESCO (2011) report examined factors behind girls' reluctance to take up science and technology subjects in school and their lack of interest in pursuing careers in these fields. These factors included societal pressures placed on girls to conform to stereotypical roles and status of women and a school environment and management which can affect girls' choices and their academic performance. This report recommends revamping career guidance programs to provide needed support to women in order for them to confront the phenomenon of female underrepresentation in science and technology careers.

Surprisingly, the same factors discussed above appeared in a study conducted in the United Kingdom which concluded that the main reasons that hinder young women's advancement in science, engineering, and technology include stereotypical attitudes of girls, boys, teachers, media, and the society at large. This study also revealed the unexpected result that even those women who choose to study science at the university often end up pursuing careers in fields totally unrelated to their field of study (Loughborough University 2000). The same study showed that fear of math remains to be a factor prohibiting young women from studying physics and chemistry, even though serious efforts had been exerted to make math more accessible to girls.

Table 2 Percentages of females in the Arab states distributed according to field of study in tertiary education

Country	Education (%)	Humanities and arts (%)	Social science, business, and law (%)	Science (%)	Engineering, manufacturing, and construction (%)	Agriculture (%)	Health and welfare (%)	Services (%)	Not known or unspecified (%)
Algeria	69	75	59	61a	31	47	60	29	45
Bahrain	51	83	70	75	21	–	85	69	72
Djibouti	–	48	47	22	21	–	–	49	–
Jordan	84	63	39	51	29	54	48	53	60
Lebanon	94	67	52	53	24	54	68	53	60
Mauritania	17	24	26	21	–	–	–	–	25
Morocco	38	52	50	41	29	38	67	48	–
Oman	63	69	43	56	23	74	66	–	48
Palestinian Authority	70	66	40	46	30	18	57	31	40
Qatar	85	85	65	68	25	–	76	–	40
Saudi Arabia	73	73	53	59	2	23	44	–	24
the United Arab Emirates	92	76	55	55	29	74	80	30	70

Source: UNESCO (2010)

Even though there are serious gender-related problems in the Arab states, there are still many Arab women who have excelled in the sciences. For example, the annual L'Oreal/UNESCO Awards for Women in Science grants 5 women $100,000 each. In the period from 1998 to 2010, 5 out of the 13 recipients of this award for the Africa and Arab states region came from Arab countries. They are Egyptian immunologist Rashika El Ridi (2010), Egyptian physicist Karimat El Sayed (2004), Tunisian physicist Zohra Ben Lakhdar (2005), Habiba Bouhamed (2007), and Lihadh Al-Ghazali (2008) from the UAE (UNESCO 2010a, b). Other achievements of Arab women in science are highlighted in the Arab Human Development Report (2001).

Knowledge Production in Science, Technology, and Science Education

According to BouJaoude (2006), science and technology input indicators in the Arab states are lagging behind those of the advanced and leading developing countries. In the period 1996–2000, Arab states devoted about 0.2 % of their gross domestic product to research and development compared to industrial advanced countries like Sweden, which devoted about 3.7 % of gross domestic product to research and development during the same period (Nour 2003). While a number of Arab states such as Egypt and Saudi Arabia spend more than other Arab states, they still fall short of the amounts spent by developed and a number of developing countries. It is worth noting, however, that the expenditure of many Arab states on education is almost the same as advanced countries. Additionally, the number of scientists and engineers in research and development is low in Arab states compared to both advanced and leading developing countries like Singapore and Korea. Moreover, the majority of science and technology researchers are employed by public and university sectors, while the percentage share of private sector is very marginal. Additionally, Arab states lag behind in the percentage of students enrolled in scientific fields.

It is clear from the above that science and technology research in Arab states is not flourishing. This situation, combined with the fact that women are underrepresented in some areas such as engineering, manufacturing, and construction and agriculture (Table 2), points to the fact that women do not play a major role in knowledge production in science and technology.

When considering science education research, according to BouJaoude and Dagher (2009), there is a healthy level of science education research activity in some Arab states such as Jordan, Lebanon, Morocco, and the Sultanate of Oman. BouJaoude and Dagher have identified the following trends from a review of research studies in the four countries: (1) dominance of quantitative research methods, (2) limited access to published science education research studies published in Arabic journals and limited publication of science education research in international journals, (3) lack of attention to science learning in informal

contexts and the public's understanding of science, and (4) the formulaic nature of research studies possibly because most of them were completed to satisfy promotion decisions with colleges and universities.

Attempts to Improve Access to Education for Girls

In the following pages, we describe projects and programs to address issues related to access and quality science education for women in the Arab regions. These attempts are mainly implemented by governments or private institutions in collaboration with international organizations such as UNESCO and national and regional organizations for women in science and technology. However, these projects and programs do not seem to have been evaluated and thus it is not possible to report actual impact results. We present them because they offer a promise to improve the status of science education for females in Arab states.

UNESCO's Medium-Term Strategy (2002–2007) focused on eliminating gender disparities in primary and secondary education as a means of achieving gender equality and female empowerment. A Science Career Guidance and Counseling Training Module was developed by UNESCO's Section for Science and Technology Education in response to women's underrepresentation in the field of science and technology in most developing countries, particularly in Africa (UNESCO 2008b). The module targets policy makers, teacher trainers, education and career advisors, teachers, and inspectors. Its objective is to help reduce gender disparities in science and technology and provide women with a path toward having a career in science. Specific objectives of the module include (a) promoting a positive image of women in scientific and technological careers; (b) sensitizing parents, teachers, educators, school administrative staff, curriculum developers, and trainers to counter gender stereotypes with regard to science careers; (c) improving access of girls to scientific and technological education by providing clear ideas of career opportunities; and providing teachers with the necessary career guidance tools to meet the needs of female learners seeking careers in science and technology.

One of the early regional efforts to tackle the issue of women in science in the Arab countries was the Abu Dhabi Declaration, which was adopted by the World Conference on Science 1999 in the associated meeting entitled "The Interaction of Arab Women with Science and Technology." With regards to education, the Declaration underlined the need to make science and technology more attractive for Arab girls by establishing science clubs in schools and universities and encouraging girls to join them and assume leadership positions in these clubs. Moreover, the Declaration emphasized the necessity to increase the participation of Arab women specialized in science and technology (S&T) in research and development of new technologies and creating new job opportunities for women in these fields. The Declaration tackled legal issues of Arab women in S&T, such as the need for passing new laws or amending existing ones to include incentives for the private sector to employ women in S&T fields, guaranteeing equality between men and women in

S&T wages in terms of wages and career growth and providing women in S&T with fair reward systems and retirement plans (UNESCO 1999).

In line with the recommendations of the Abu Dhabi Declaration, the Saudi Science Club established a division for women to support preuniversity science students. Moreover, the Arab Science and Technology Foundation (ASTF) in the United Arab Emirates recently established a committee specifically for women members (Islam 2007). Similarly, the King Khaled Charitable Foundation in Saudi Arabia endowed one million Saudi riyals annually to support postgraduate research by Saudi women, while Al-Nahda Society offers young Saudi women scientist scholarship for graduate and postgraduate study abroad (Islam 2007). Additionally, the Joint Supervision Program (JSP) established by the King Abdul Aziz University (KAAU) in Saudi Arabia helped local women to enroll in UK universities while working and being supervised by the Saudi staff at KAAU. The program offers women an opportunity to have international academic experiences and obtaining a PhD from a UK university while remaining with their families in Saudi Arabia, thus taking into account the cultural context of Saudi Arabia while giving women the opportunity to pursue higher education. A total of 34 women obtained their PhDs through the JSP, 68 % in science (Islam 2007).

A number of national and regional organizations for women in science and technology were established to strengthen the participation of women in these fields. They include the Arab Network for Women in Science and Technology (ANWST), which was established in Bahrain to compile and disseminate achievements by Arab women in science and technology and promote the active participation of women in science and technology careers (UNESCO 2004). ANWST attempts to help in providing access to careers in science and technology for Arab women and addressing the gender imbalance in these fields. The network also collaborates with Arab and international organizations to offer scientific and technological training for women (UNESCO 2004).

At the international level, the Academy for Educational Development (AED) developed an innovative tool which can be used in the Arab region to garner the power of social media toward increasing girls' interest in science and technology. The program, entitled *Science: It's a Girl Thing*, offers user-friendly web-based resources for conducting science activities and experiments at home. What makes the tool interactive and dynamic is that updates, videos, and links are regularly posted on certain web sites and social media sites, thereby making science activities tailored specifically for girls available outside the school setting (AED 2009).

Sociocultural Factors that Constrain the Ability of Women to go Beyond a Certain Stage in Development and Role in Society

It is evident from the description of the status of science education in Arab states that access to education has improved significantly for both males and females at

all educational levels. It is also evident that when girls are given the opportunity to attend school their academic performance is superior to that of boys. However, the problem still exists in the lack of equity in the job market and in the type of specialization that girls "decide" to pursue in universities. This problem is persistent despite the fact that many regional and international organizations have developed programs focused on improving the quality of science education for girls and enhancing the opportunities of women to pursue careers in science.

It could be conjectured that cultural pressures in the Arab states are still significantly influencing the career choices of women even though more education and employment opportunities are becoming available. What is intriguing and consequently open for investigation is the fact that even though girls are achieving higher, their numbers are not increasing significantly in science- and technology-related fields. Reasons for this state of affairs are discussed below.

Several factors influence the fact that girls are participating less and show less motivation to take part in science careers. Many of these factors are associated with cultural and societal influences. The attitude of teachers, parents, classmates, and business people as well as the level of confidence of girls in their science skills might be determining the often observed gender gap in science education. Teachers sometimes, consciously or unconsciously, encourage girls to pursue nonscientific options in higher education because of the persisting belief that some careers are "feminine" and other are "masculine" (UNICEF 2003), typically associating masculinity with "hard" science- and technology-related careers. Parents typically have the same orientations and beliefs about stereotypical roles and careers of their female children: they succumb to cultural and societal norms that determine what is appropriate or inappropriate for girls to do. Using the same logic, business people promote the same type of thinking as parents and teachers. Unfortunately, girls' self-confidence in their abilities to pursue what society identifies as "masculine" careers becomes very low. It takes a very courageous women or parent to take a "road less travelled" by others. It thus is clear that to achieve gender parity in science and technology education (STE), it is important not only to motivate girls themselves but also to address the surrounding sociocultural and economic factors as well.

Another possible factor that might influence the participation of girls in science is that science educators in schools and universities have not accepted the social-cultural perspective, including the notion that science is a human activity that is not to be viewed in isolation from politics, society, and culture (Lemke 2001). Thus science might still be taught as a "culture-free" subject thus ignoring the possibility that there might be women's ways of knowing and other cultural, political, and cultural factors that influence career choices made by women.

Conclusion

It is evident from the above that science in Arab states is still male-dominated, especially in science- and technology-related careers, to a large extent even with the increasing access to education for females, the fact that females are achieving

higher than males in academic science, and the significant numbers of programs to encourage females to pursue science-related specializations and careers. One of the possible reasons for the current situation could be the lack of attention to sociocultural factors that influence the choices that females make. This situation requires concerted efforts to understand the situation in depth and propose real and feasible solutions to the problem. Results of questions like the following are essential to move forward in the future:

1. To what extent is a social-cultural perspective being considered when designing curricula and instructional materials?
2. Are there any attempts to establish a gender-responsive school management system and if so what are the characteristics of such a system?
3. Are there any attempts to establish gender-responsive social and physical environments in schools and universities and if so what are the characteristics of such environments?
4. Do teachers encourage girls to opt for science subjects? If yes, what specific approaches have been used to do so? If not, what are the reasons for not doing so?
5. What specific activities do teachers organize to promote science learning for girls and for boys? If such activities are organized, what are their characteristics and results? If no such activities are organized, why not?
6. What strategies and techniques do teachers use to ensure that girls and boys participate equally in science subjects including laboratory hands-on activities?
7. What strategies and techniques do teachers use to help students, especially girls, overcome their fears, inhibitions, and lack of confidence in science subjects and careers?
8. How does the performance of girls and boys in science subjects compare in national examinations and what are the trends over the years?

The above questions are not meant to provide an exhaustive list of research questions whose answers would provide a road map to address the issue of gender bias. They are provided to emphasize the fact that gender inequity in science education and science-related careers has not been taken as seriously as it should and has not been understood well in Arab states. This lack of understanding has resulted from using findings of research conducted in contexts that are not akin to local contexts to develop programs that are meant to solve a problem that is culturally and socially bound. What is needed is research that results in home-grown programs based on culturally and socially sensitive locally produced research findings.

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