TOPIC ARTICLE THE IMPACT OF EDUCATIONAL REFORM ON SCIENCE AND MATHEMATICS EDUCATION IN QATAR

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Abstract:
Despite the resources that have been invested in the educational reform in Qatar in the last few years, no systematic study has been conducted to investigate the factors behind the disengagement and disinterest in science and mathematics in Qatari schools. This paper explores why the Qatari education reforms launched in 2003 as "Education for a New Era" have not reversed the significant decline observed over the past 15 years in the number of students studying mathematics and science at both secondary and tertiary levels of education. It outlines the main features of current science and mathematics education at Qatari schools, examines the performance of Qatari students on both national and international tests, and looks at enrollment trends in science programs at Qatar University, the only national university in the state. It further seeks to identify the major factors influencing student attitudes towards mathematics and science, as well as the decline in interest and enrollment in these subjects. The paper will also discuss the long-term impact of this decreasing interest in sciences and mathematics and will review incentives that might reverse this trend.

Key Words: Science education, educational reform, independent schools, instructional strategies, students' attitude and interest

Introduction:

Science and technology were once fields that could attract young Qataris, but there are now concerns about the declining popularity of science and mathematics among young students in most countries (World Bank, 2008). Several developed and developing countries, such as those in East Asia, have taken certain measures to motivate their students to be engaged in science and technology (General Secretariat of Development Planning, 2012). Most countries of the world, however, still suffer from serious shortages in professional scientists, mathematics and science teachers, engineers and technologists because of low levels of engagement and reduced enrollment in science, technology, engineering, and mathematics disciplines, also referred to as the STEM disciplines.

In its 2008 report "The Road not Traveled - Education in the Middle East and North Africa," the World Bank indicated that only 20% of university students in most Arab countries are enrolled in science and engineering versus about 70% in social sciences and humanities; in Qatar, 19.1% are enrolled, primarily in engineering fields (World Bank, 2008). Qatar University's statistical summary substantiates the World Bank finding, indicating that over recent years less than 12% of students annually enrolled in science and engineering programs (Qatar University, 2008).

The World Bank report indicated that, as is the case in Qatar, this enrollment pattern is historically consistent with a policy of absorbing most university graduates into civil service jobs (2008). However, it points out that "it is ill suited to a development strategy which requires more contribution by scientists and engineers in economic growth than are social scientists and students of humanity. This is largely because of the increasing importance of technological innovation and adaptation in the development process" (World bank 2008, p. 22).

Since science and technology are often perceived as fundamental forces behind economic growth of developed countries, the Qatar National Vision 2030 (General Secretariat of Development Planning, 2010) stated that Qatar to become a developed nation and move towards a knowledge-based

economy, requires considering science, mathematics (and consequently technology) as important subjects to excel in. Further, the labor market strategy report prepared by the International Bank for the state of Qatar states that to achieve that goal the real solution rests on Qataris acquiring the right education, skills and motivation that would enable them to engage in high productivity jobs (World Bank, 2009).

Students' decisions about study and career paths are primarily based upon interest in a particular field, and particularly on their perception of job prospects in that field. Educational content and curricula play an important role in raising and maintaining young people's interest in science and technology, and positive contact with science and technology at an early age can have a long lasting impact. Negative experiences at school, due to uninteresting content or poor teaching and various other factors, often inform future choices. Furthermore, curriculum structures that motivate students such as practical investigation and problem solving can also play an important role in preventing students from pursuing their natural preferences (Hofstein & Lunetta, 2004, Millar & Abraham 2009, Russell & Weaver 2008).

Since 2003, a number of reports have focused on educational issues in Qatar: the United Nations Development Program (UNDP) human development reports published by Qatar's General Secretariat for Development Planning (GSDP); the World Bank report on labor market strategy submitted to GSDP; the RAND-Qatar policy institute reports; results of the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) international tests, Ministry of Education statistical reports; Supreme Education Council Evaluation Reports of the Qatar Comprehensive Educational Assessment (QCEA), and Qatar University statistical reports. These documents reveal trends in learning and highlight the attitude and perception of science and mathematics among schools and university students which will be discussed later in this article. These findings have served to direct the attention of educational authorities to the significance of the problems in science and mathematics education. They also provide insight as to the curricular change as content and pedagogy are revised and restructured.

In addition to looking at science and mathematics education and student trends in Qatar, this paper will also explore strategies that can improve the quality of education inputs and outputs in science and mathematics to achieve the goals and objectives of the Qatar National Vision. It will also outline the major impacts of the educational reform launched in 2003 under the initiative banner "Education for a New Era" (General Secretariat for Development Planning, 2010).

These issues will be addressed through posing the following questions:

1. What are the educational opportunities and incentives in science and mathematics that are available to Qatari youth?
2. What are the prevailing strategies of instructions in science education and how can they be improved to achieve the goals and objectives of the Qatar National Vision to become a knowledge-based economy?
3. What is the impact to date of the reform policy on science and mathematics education in Qatar?

Methods and Data Collection

Answers to this study's research questions relied on three different sources of data:

1. Analysis of relevant data from documents and reports dealing with education in Qatar.
2. A School Science Teaching Inventory Questionnaire (SSTIQ) was administered during February and March of 2011 in 24 schools (eight elementary, eight preparatory and eight secondary with four schools representing each type and gender of students) and included interviews with 48 science teachers from these schools. Each school filled one questionnaire guided by the science coordinator. SSTIQ was intended to collect data on all major aspects related to science teaching. The questionnaire was divided to cover nine themes of data on: students, teachers, technical staff, teaching strategies, teaching hours assigned for science subjects, lab facilities and resources, assessment weighing, classroom settings, and science related extracurricular activities. The lab facilities theme included four questions on availability of space and lab size and suitability, the status of schools' science instruments and materials (in general) that may enforce and enhance the delivery of the curriculum content and objectives, the way practical sessions are conducted, and

the limitations of performing practical sessions. These schools are independent schools which are generally equipped with similar packages of lab instruments and materials for the same school stage provided by the Ministry of education but are differently utilized; in some schools some instruments may be locked up in a store without being used, or some teachers are not aware of their existence. For this part of the study only data related to resources and teaching strategies were used.

3. A science teacher questionnaire on factors influencing students' interest in and attitudes towards science (May 2011). The questionnaire asked teachers to rate, on a five-point Likert scale their perception on the reasons of the decline in interest in, and attitude towards science subjects; listing 16 major factors. The question was *"Indicate the extent that the following factors may contribute to the decline in interest of students in science subjects (5 represents very strong influence and 1 is very low influence)"* the list of factors and teachers' responses are given in table-2. The questionnaire targeted science teachers from the 24 independent schools who filled the SSTIQ.

The Significance of Mathematics and Science Education to Qatar

In an increasingly globalized world, "high-quality science and engineering research are no longer the domain of only a small group of developed countries. The ability of science and engineering to contribute to societal goals, [and] address global problems, relies, to a high degree, on global communication and cooperation" in science and engineering (National Science Board, 2001, 7). Qatar has taken these latter priorities to heart as is particularly evident in the establishment and launching of the Qatar Foundation for Education, Science and Community Development in 1995.

In 2003 the Qatar education system initiated a reform initiative when the government commissioned the RAND Corporation to examine the nation's K–12 education system and to consider radical and innovative solutions when recommending options for building a world-class system that would meet the country's changing needs. The result was a wide-ranging critique of the public system.

4. By the 2010-2011 academic session, all 188 government schools had been replaced by independent schools and new curriculum standards in Arabic, English, math and science had been implemented throughout.

5. **Trends in Science Enrollment in Secondary Schools**

6. In Qatar, secondary school students are registered in one of two academic streams: Science or Arts & Humanities. Figure 1 (adapted from Qatar Ministry of Education, 2009) describes the numbers of students registered in the 12th grade during the years 1991-2007 distributed between science and art streams. As shown in the figure, enrollment in science sections in secondary schools increased steadily for five years before starting to decline in 1995.

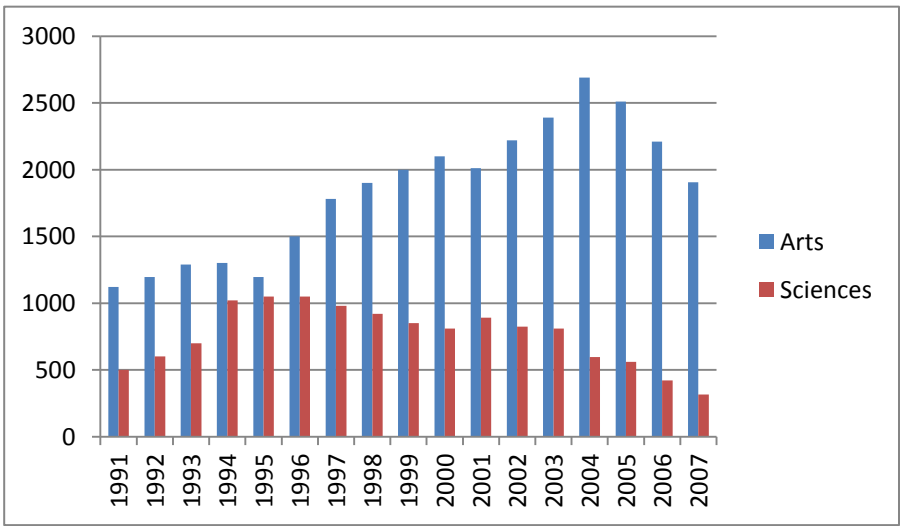

Figure 1: Grade 12 science and art enrolments in Qatar (1991-2007).

Independent secondary schools now require students to enroll in three advanced level subjects along with three others at foundation level. Although exact figures are not available, on the numbers enrolled in each subject, teachers at the different schools visited estimated that less than 20% are interested to opt into advanced mathematics or science subjects.

Trends in Enrollment in Mathematics and Science Programs at Qatar University

Figures 2 and 3 represent Qatar University's enrollment trends over more than a decade. (Qatar University, 2008, 2009, 2012). The figures reveal a decline in enrolment in all science and mathematics programs ranging from a decrease of 77% for biology to a decrease of 100% for physics, whereas the number of students enrolled in economics and finance at the university has increased 478% over the past decade. This has led to the suspension of enrollment in some science programs (Qatar University, 2008, 2009, 2012).

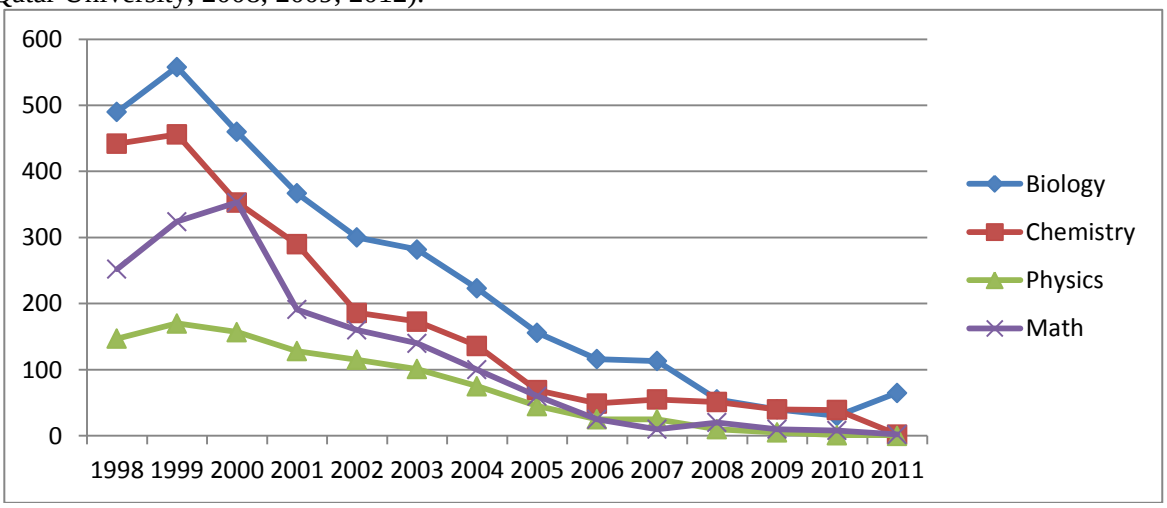

Figure 2: Enrolment in science and math programs at Qatar University (1998-2011).

Figure 3 compares the number of Qatari graduates from the faculty of science with the number of graduates from other faculties over the period 2002-2007. Over the six years, there were 505 science graduates, constituting 7.6% of the total graduates.

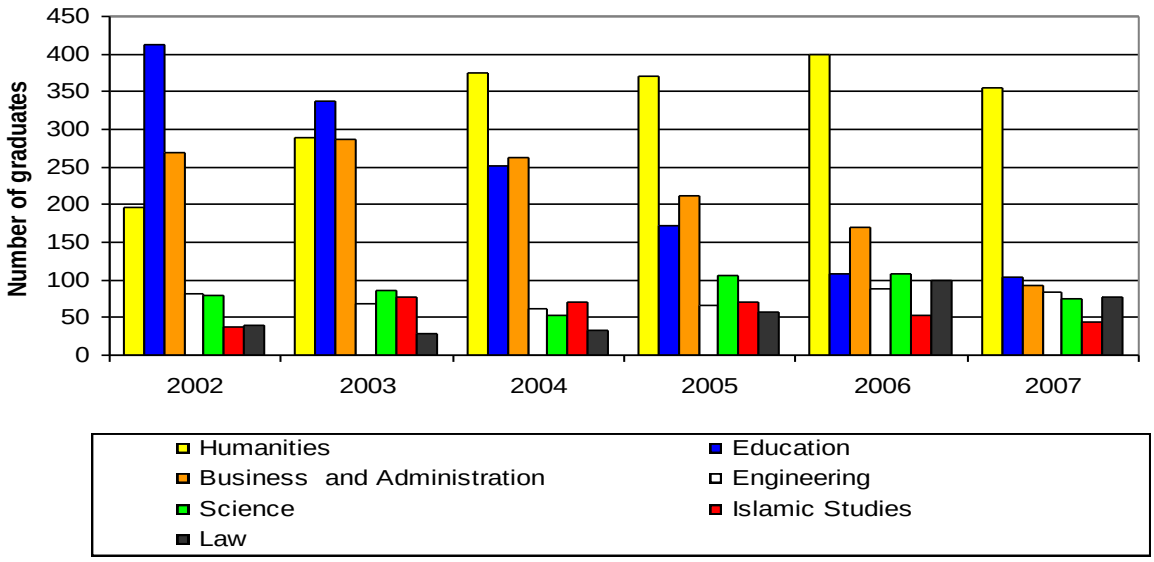

Figure 3: Qatari graduates from different faculties of Qatar University (2002-2007). Adapted from (Qatar Statistics Authority publications on education, 2009, Table 26).

Mathematics and Science Opportunities and Incentives Available to Qatari Youth

In the last fifteen years the state of Qatar has made substantial investments preparing its students to compete and succeed in the twenty-first century economy. Although this success depends largely on advanced knowledge in the STEM disciplines, there is still a growing gap between graduate readiness and the requirements and expectations of industry(General Secretariat of Development Planning, GSDP 2012, p.52). This may suggest that educational institutes are not producing enough potential workers who are educated in the STEM disciplines.

Current opportunities and incentives during the K-12 education stages in Qatar include:

1. Free education in modern schools with good facilities (e.g. laboratories and advanced technology, including ICT and other learning tools), high modern standard curricula, low student / teacher ratio, etc.
2. Incentives for college and university graduates to enter STEM discipline workplaces, including attractive salaries and allowances, opportunities of professional development, work advancement, further education, interest-free loans for marriage and house building, life security, etc.

Qatar Foundation (QF) funds and supports innovative research and requires qualified researchers to carry out its mandate and manage projects. In 2010 the research division of QF initiated the Qatar Science Leadership Program, a research, administrative and scientific initiative that aims to build the human capacity needed to make Qatar a leader in innovative research, designed for Qatari "willing to discover and develop their potential in diverse scientific and research environments" (Qatar Foundation Research Division, 2010). Table 1 demonstrates the anticipated required human resources needed to carry out scientific research in Qatar over the next two decades.

Table 1

Expected Human Resources Required by Research Establishments at Qatar Foundation for 2010-2025. Number required by field.

Position	N atural Sciences	Mat hematics/ Computing	Engi neering	Bio medical
Researc h Assistants	30	150	50	150
Senior Researchers	50	200	200	300
Other*	50	250	-	700
Totals	130	750	250	1150

*Includes lab technicians and administrators

Source: Qatar Foundation Research Division (private communications)

Tracking Reasons for the Decline in Interest in Mathematics and Science

As part of a pilot study on Qatari students' interest and attitude toward science study, 62 science teachers responded to a question asking them to indicate the extent to which factors listed in table-2 below) contributed to the decline of students' interest in science. Most teachers selected the nature and length of the curriculum, while others selected the language factor, lack of incentives, and low level of practical activities as major factors. The responses of teachers are presented in Table 2 and full analysis will be presented in a subsequent publication after the study has been extended to include a larger sample.

Table 2

Results of Science Teachers Questionnaire (n=62) (5 is the strongest reason and 1 is the least)

Contributing factor	ean
Lack of incentives for learning	.44
The lack of practical activities	.23
The low participation in extracurricular activities	.07
The traditional learning based on rote memorization	.06
The nature of the curriculum	.90
The assessment and evaluation system	.84
The language of instruction	.81
Lack of parental and family intervention	.71
Shortage of resources	.66
Lack of self-efficacy	.52
The traditional methods of instruction	.48
The amount and nature of homework	.46
Lack of use (or misuse of) technology	.13
Lack of teachers' professional training	.13
Negative perception of related careers	.95
The classroom environment	.89

The first Human Development Report for the state of Qatar (General Secretariat of Development Planning, 2006) attributed the shortage in science graduates mainly to the nature of curriculum and instructional teaching methods of science subjects at schools. For example, most textbook questions are designed to measure students' basic knowledge; similarly, examinations also focus on basic knowledge. Therefore, neither textbooks nor exams measure students' skills and

capabilities nor do they distinguish amongst differing levels of learning. The content of the textbook is presented in a manner that does not contribute to developing skills of critical thinking, discussion and dialogue. The report further noted that there is an absence of question banks with assessment models that are aligned with scientific standards to guide them.

The above modality of teaching that relies on chalk and talk with the textbook as the major resource is still the dominant strategy. The difference now is the choice, by schools, of textbook from titles recommended by the Curriculum Standards Bureau of the Supreme Education Council. Results of the School Science Teaching Inventory Questionnaire (SSTIQ), which involved 24 independent schools, show that almost all schools and teachers consider the textbook as the source of nearly 90% of all knowledge and learning with some support coming from technology based-resources. The summary is shown in Table 3.

Table 3

Schools' Dependence on Major Strategies in Teaching Science (n=24) (5 is the most dominant strategy and 1 is the least)

Strategy of teaching	Mean
Textbooks	4.8
Presentations and use of ICT	3.8
Cooperative Learning	2.8
Problem-based Learning	2.6
Inquiry-based Learning	2.6

However, few schools have introduced more advanced strategies such as inquiry based learning and problem based learning although not as major strategies as shown from Table 3 above.

Most interviewed teachers complained that students do not take practical sessions seriously, because they (students) know there are no significant marks counted on practical. Asked why they don't assess practical if the curriculum standards recommend these assessments? Their answers were mainly because they are overloaded and schedules do not permit the conduct of long experiments.

One teacher from a preparatory school said:

" *I have nearly 100 students to teach from grades 7 to 9, how can I conduct experiments, weekly or even bi-weekly, without a teaching assistant to help in marking, and without a trained lab technician? We have one lab technician who is not sufficiently trained, in a school of 650 students, we have* also *a long curriculum to cover".*

One chemistry teacher in a girl secondary school said:

"we *demonstrate most experiments to students with no assessment or reports required because the curriculum is long, we find no interest from students to perform experiments, the comprehensive national exam do not test practical skills"*

A physics teacher in another secondary school that has been converted recently to independent school, added :

" *Although we deliver most physics lessons in the lab,* we *are not provided with a manual for experiments, teachers need more training on delivering lab experiments, schedule is very tight, curriculum is very long, students show little interest with majority depend on memorizing rather than inquiry; and therefore they face difficulty in understanding scientific concepts even when they run experiments. For these reasons we prefer to use the time to cover as much as we can from the curriculum, instead we give them more theoretical exercise, I only demonstrate for them four or five short experiments in the whole year, and mostly by simulation and showing them the equipment".*

A teacher from boys secondary school teaching grades 11 and 12 said "*It is good if it does not affect completing the long syllabus, I really want to focus on the theory part because this is the test that counts, I suggest that SEC should include testing practical skills or at least adding written questions on practical part"*

A secondary school biology teacher with several years experience in secondary school teaching in Qatar, and recently becomes a coordinator of science at a primary school attributed the little emphases on practical to several factors; she said " *the labs lack of several essential materials and instruments, lab technicians are untrained, time slot is not adequate, in Biology it is possible to run some experiments but most chemistry experiments need extended time which is not possible because of the crowded schedule, there is no emphasis on assessment of practical and no marks are counted in the final SEC comprehensive test, therefore teachers do not place emphasis on practical, and students become unaware of its significance".* However, she attributed the disengagement at the primary level to other reasons in addition to the mentioned above " *we have about 600 students, all take general science, we have one technician only for the whole school with no teaching assistants, these children need careful supervision especially during performance of lab activities for safety consideration , also several materials are not available, and schools forbid teachers from asking students to bring certain materials essential for activities such as food items or tools. In my opinion, students should be asked to bring from home certain materials, this will make students feel more responsible and encourage parents to follow up with them "*

Introducing new Strategies through Research

There is now a growing scientific research community in Qatar motivated by the successful launch of several scientific research initiatives during the last few years by Qatar National Research Fund (QNRF). These initiatives involve researchers from inside Qatar, as well as outside (Qatar Foundation, 2010). In addition, students from different levels are involved in different projects. Recently QNRF launched the Secondary School Research Experience Program (SSREP). According to recent data published by the Qatar National Research Fund (2011), the majority of projects submitted by schools are natural science projects.

This program is one among several, including the Undergraduate Research Experience Program (UREP), that contribute to improving education through research. SSREP aims to engage all students in secondary schools in Qatar (independent and private), under the mentorship of their teachers and/or subject coordinators, in undertaking projects that are directly derived from the curriculum standards that are accredited by the Supreme Education Council (SEC). SSREP will promote the tools of "Learning by Doing" and "Hands-On" research activities as effective methods in the secondary school education program. Students will gain their initial experience in implementing a modest research project to enhance their capabilities to carry out further university research projects.

The program is likely to enhance productive collaboration between teachers and students, and will help facilitate awareness of the research culture in Qatar. It will provide students with the opportunity to gain experience in problem-solving projects; develop scientific enquiry skills and work independently; understand research methods and introduce the idea of research as a career; network with school members beyond the classroom, and possibly worldwide; and interact with local industry and medical institutions.

Impacts of Reform to Date

Results of PISA 2006 and 2009

Nearly 10,500 fifteen-year-old students from 135 schools in Qatar participated in PISA 2009. Various types of schools were represented, including independent schools, Ministry of Education

schools, international schools, private schools, Arabic schools, and community schools. Qatar was one of 65 countries participating in PISA 2009 (Supreme Education Council, 2009). Comparison of the PISA 2006 and 2009 results will allow Qatar to externally validate the impact of its educational reform efforts. Results were published in December 2010 (OECD, 2010). Table 4 details the average results of Qatari students' performance compared with performances of students from selected countries (average score of OECD countries is 490-500).

Table 4
Comparative Performance of Students in PISA 2006 and 2009 (OECD2007 and 2010)

		2006			2009		
	Countr						
y		eading	cience	ath	eading	cience	ath
	Taiwa						
n		96	32	549	00	20	43
	China/						
Shanghai		--	--	--	39	*575	*600
	Finlan						
d		47	*563	48	35	54	41
	S.						
Korea		*556	22	47	*542	38	46
	Canad						
a		527	34	27	27	29	27
	Sloven						
ia		494	19	04	76	12	01
	UK						
		495	15	09	06	02	92
	UAE						
(Dubai)		--	--	--	60	66	53
	Turke						
y		47	24	24	61	54	45
	Chile						
		42	38	11	44	47	21
	Jordan						
		01	22	84	87	15	87
	Tunisi						
a		80	86	65	93	01	71
	Qatar						
		12	349	18	61	79	68
	Kyrgy						
zstan		**285	**322	**311	*293	*330	*331

* Represents the country with the highest average score
** Country with the lowest score
--- Country did not participate in 2006

Current results are also compared with results from PISA 2006. The table shows that while Qatari students are still at the bottom of the list, there is a significant improvement from the 2006 performance. For example, average scores for both reading and mathematics increased by 16% and science scores increased by 9%. In fact, the increases in percentages compared to 2006 results are the highest among most countries that demonstrated progress in their performance. However, despite of this progress and the clear improvement, the scores and rank are still not up to expectation.

Results of TIMMS 2007 and 2011

Recent published results of TIMMS 2011 (published December 2012), have shown better achievement than the above PISA results when compared with the results of the previous TIMMS cycle of 2007. Again Qatari students have achieved more significant progress. Table 5 below compares Qatari students' average scores, with others from selected countries for both grades 4 and 8 in mathematics and science at the two tests. The results are arranged in descending order according to 2007 results. Table – 6 summarizes the progress achieved by students from Qatari schools.

Table 5
Summary of TIMMS 2007 and 2011 results for Qatari students compared to some selected countries and Jurisdictions

Mathematics

	Grade 4			**Grade 8**	
Country	**Average Score***		**Country**	**Average Score***	
	2007	**2011**		**2007**	**2011**
Singapore	599	606	Singapore	593	617
Hungary	510	515	Hungary	517	505
Sweden	503	504	Sweden	491	484
Dubai, UAE	444	468	Dubai, UAE	461	478
UAE	---	434	UAE	---	456
			Lebanon	449	449
			Jordan	427	406
			Tunisia	420	425
Saudi Arabia	---	410	Bahrain	398	---
			Syria	395	380
			Egypt	391	---
Algeria	378	---	Oman	372	366
Kuwait	316	342	Kuwait	354	---
			Saudi Arabia	329	394
Tunisia	318	359	**Qatar**	**307**	**410**
Morroco	297	335	Algeria	387	---
			Morocco	381	371
Qatar	**296**	**413**	Ghana	---	331
Yemen	224	248			

Science

*TIMMS Scale average is 500 in 2007 and 475 in 2011

	Grade 4			**Grade 8**	
Country	**Average Score***		**Country**	**Average Score***	
	2007	2011		2007	2011
Singapore	587	583	Singapore	567	590
			Hungary	---	522
Hungary	536	534	Sweden	511	509

Dubai, UAE	460	461	Dubai, UAE	489	485
Bahrain	---	449			
Saudi Arabia	---	429			
UAE	---	428			
Algeria	354	---	Jordan	482	449
Kuwait	348	347	Bahrain	467	452
Tunisia	318	346	Saudi Arabia	403	436
Morroco	297	264	Tunisia	445	439
			Syria	452	426
Qatar	**294**	**394**	Oman	423	420
Yemen	197	209	Kuwait	418	---
			Qatar	**319**	**419**
			Lebanon	414	406
			Egypt	408	---
			Algeria	408	---
			Morocco	402	376
			Ghana	303	306

* TIMMS Average Score (475 in 2007 and 500 in 2011)

--- country did not participate

Sources of data: 2007 results from : Institute of Education Sciences (2008);

2011 results from : International Association for the Evaluation of Educational Achievement, IEA (2012) and National Centre for Education Statistics. (2012)
Although the 2011 results show that Qatar is still below the average bench mark scale, the achieved progress is very significant. Table 6 below shows the extent of this progress

Table 6
Progress Achieved by Qatari students in TIMMS 2011 compared with TIMMS 2007 results

Subject	Grade	Increase in average points	% increase over 2007 results
Mathematics	4	117	39.5
	8	103	25.1
Science	4	100	34.0
	8	100	31.3

These results indicate that efforts on reform have started to pay back; reform is a slow progress but the benefits are obvious.

Discussion

Most independent academic research on improving learning tends to focus on the impact of one factor, such as the influence of attitude or curriculum on the choice of students to pursue science at tertiary education. This undermines the importance of cumulative effects and interrelationships between separate, but, equally important factors. As Roberts (2002) wrote, "tackling any one aspect whilst neglecting others is unlikely to deliver a strong overall improvement" (p. 50). On the other hand, these strongly interrelated factors will complicate any possible improvement in one aspect by individual educators or schools.

These assertions are supported by this research. Of the 48 teachers who were interviewed during the conduct of the SSTIQ, 30 considered the nature and length of the curriculum as the main reason for the decline in students interest to study science, while 40 out of 62 teachers who responded to the questionnaire consider the difficulty of the curriculum as the primary reason, and 15 consider it as a secondary reason with a mean of 3.90 (see Table 2). The extensive and long curriculum forces teachers to put reduced emphasis on practical work, critical thinking, and inquiry based activities. Students have to write exams that cover all topics found in the curriculum, while assessment of the practical aspects are not required, despite a recommendation that inquiry based skills account for nearly 25-35% of weighted assessments (SEC Evaluation Institute, 2005). As a result of this assessment breakdown, teachers rarely use the laboratory, and if they do, they either demonstrate the experiments recommended by the curriculum or present simulated experiments. Despite the reasonably well equipped laboratories at schools, students are not given many opportunities for hands-on interaction with equipment and materials. It is clear that any change in how teachers approach testing and curriculum, requires a major shift in the overall pedagogical approach. Nonetheless, individual efforts can make positive, although limited, contributions to improvement.

An important factor that needs to be addressed is the quality and practices of the teachers in the classroom. Widely accepted research now indicates that these are perhaps the most important factors in increasing student learning. Research shows that a child who is being effectively taught mathematics and science by teachers who have the knowledge and skills needed to teach is more likely (the child) to be able to close achievement gaps and succeed in work and life (National Science Board, 2001). Many unsuccessful reform efforts in different countries have failed because these efforts did not fully consider teachers' existing knowledge, beliefs, and attitudes (van Driel, Beijaard & Verloop, 2001). Research also suggests that teachers are not only instructors but also motivators (den Brok, Brekelmans & Wubbles, 2004; Elton, 1996).

Most schools in Qatar are concerned with this issue because many face a serious shortage of qualified teachers, especially male teachers. This shortage is a natural consequence of the non-existence of a mathematics and science education system at the tertiary level in Qatar. Many Qatari teachers have limited English fluency and, therefore, have difficulty teaching in English. Science and math teachers are mainly Arab expatriates, although there are some Qatari teachers (mainly females) and a few non-Arab expatriates.

The language factor has been identified by teachers as a key factor behind students' disengagement and declining interest (Table 2). Teachers explained that students' poor language restricts and affects delivery of the whole curriculum. It is true that teaching science and mathematics involves a range of communication methods – such as visual representation, diagrams, tables, charts, models, graphs, practical work, mathematical symbols, etc. – but these modes complement each other.

Qatari students with modest English language skills may find themselves at a disadvantage when curricula require all students to study science and mathematics in English at their preparatory and secondary level, even students who have received minimal instruction in English. This sudden shift has confused students and teachers alike. Grades 10 and 11 students of MOE secondary schools that were changed to independent schools are required to study science and mathematics in English if they want to stay in their schools. As more schools are transformed over the years, fewer options are left and most students have to integrate within the new system. The same policy is applied to preparatory and primary school, although the impact is less noticeable. Standardized tests, by nature, place great emphasis on language skills and therefore teachers have to spend ample time on the language component of the subject. Of the 62 teachers surveyed, 41 (mostly secondary and preparatory schools teachers) consider the language factor as a major factor in declining interest and achievement and six consider it as a secondary reason. Only 15 (mostly primary school teachers) think it is not important (see Table 3).

In practice, total immersion in English language may be considered a best fit for students with good language skills, but for learners with low language proficiencies, as is the case for Qatari students, the use of Arabic as a supporting language would be a mitigating factor for science literacy to occur. This notion of dual language would support bilingual models of instruction that favor two-way instruction or the transitional bilingual model. Cummins (1999) suggests that a lack of understanding of the processes of academic language acquisition would be a failing of the institution

as a whole, creating greater academic difficulties for the learner. Very recently, SEC has decided for the first time to allow students taking the QCEA test to choose their preferred language (Arabic or English) for science and math sections (Supreme Education Council, 2012).

Conclusion:

Despite the substantial progress witnessed in most aspects of education in Qatar, and the introduction of a radical reform that started in 2003 upon the launch of the initiative "education for new era", there has been a significant decline in the number of students studying mathematics and science at both secondary and tertiary levels over the past 15 years. This has led to a serious shortage of trained STEM graduates able to fill employment vacancies.

Declining interest in mathematics and science subjects at schools and colleges in Qatar is attributed to a combination of several interrelated factors, namely the lack of the availability of qualified teachers, the complexity associated with introducing English language as a medium of instruction without adequate preparation, the traditional methods of instruction and assessment, the lack of knowledge and understanding of the importance of mathematics and science to everyday life, and the negatively stereotyped image of scientists among the public. Other factors include the lack of media focus on scientific activities, the lack of a framework for practical activities aligned with curriculum standards, weak student counseling and career services, the absence of science centers and museums, and the lack of strong ties between schools and professional workplace and research centers. Each of these factors has contributed to reinforcing negative attitudes towards studying STEM subjects at schools and colleges.

However, plans to establish a world class education system are being gradually implemented. In order for Qatar to achieve the ambitious 2030 vision of building a knowledge-based economy, education authorities realize that the education system may be falling short in supplying enough qualified graduates in the STEM disciplines because of the weak mathematics and science education system. To face this challenge, the education authorities should set out a new policy aimed at tackling diminishing interest in science and mathematics by inspiring students and increasing their passion for these subjects.

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References:

Bevins, S., Brodie, M., & Brodie, E. (2007). UK Secondary School Pupils' Perceptions of Science & Engineering. A Report submitted to the Engineering & Physical Sciences Research Council and the Practical Physics & Astronomy Research Council – UK, Centre of Science Education, Sheffield Hallam University p.6, den Brok, P., Brekelmans, M, &

Cummins, J. (1999). The ethics of double-think: Language rights and the bilingual education debate. *TESOL Journal, 8*(3), 13-17.

Elton, L. (1996). Strategies to enhance student motivation: A conceptual analysis. *Studies in Higher Education, 21*(1), 57-67.

General Secretariat for Development Planning, GSDP, (2006). *First human development report of the state of Qatar.* Doha: Qatar.

General Secretariat for Development Planning, GSDP, (2008). *Qatar national vision 2030.* Doha: Qatar.

General Secretariat for Development Planning, GSDP, (2009). *Second human development report of the state of Qatar.* Doha: Qatar.

General Secretariat for Development Planning (2012). *Qatar's third national human development report: Expanding the capacities of Qatari youth.* Doha: Qatar.

Hofstein, A. & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education. 8* (1), 28-54. Accessed from www.interscience.wiley.com

International Association for the Evaluation of Educational Achievement, IEA (2012):
TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College
http://timssandpirls.bc.edu/timss2011/downloads/T11_IR_S_Chapter, 2 and 3.pdf
Millar, R. & Abraham, I.(2009). *Practical work: making it more effective.* School Science Review (SSR), September 2009, 91(334) pp. 59-64.
National Science Board (2001). *Toward a more effective role for the U.S government in international science and engineering*. Arlington, VA: National Science Education, Science Foundation.
National Centre for Education Statistics. (2009). *Highlights from TIMSS 2007*. U.S. Department of Education. http://nces.ed.gov/pubs2009/2009001.pdf 7- 32.
National Centre for Education Statistics. (2012). *Highlights from TIMSS 2011*. U.S. Department of Education – Science .http://nces.ed.gov/pubs2013/2013009_2.pdf
OECD. (2007). Science Competencies for Tomorrow's World. Retrieved from http://www.oecd.org/dataoecd/30/20/39704105.xls
OECD (2010). PISA 2009 Results: *What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I).* Retrieved from http://dx.doi.org/10.1787/9789264091450-en
Ouda, A. H. (2009). *Students' perceptions regarding a variety of factors that influence science learning.* Doha, Qatar: Supreme Education Council. Retrieved from: www.sec.gov.qa
Qatar Foundation. (2009). *Science and research*. Accessed March 6, 2009 from http://www.qf.org.qa/output/Page18.asp
Qatar Foundation Research Division (2010). *Qatar science leadership program (QSLP*). Accessed March 28, 2010 from www.qf-researchdivision.org/qslp
Qatar Ministry of Education (2007). *Annual statistics report, 2005/2006.* Doha: Qatar.
Qatar Ministry of Education(2009). *Annual statistics report, 2007/2008*. Doha: Qatar.
Qatar National Research Fund.(2011). *QNRF newsletter February 2011*. Retrieved from http://qnrfnewsletter.org/issue5/news1.php
Qatar Statistics Authority. (2009). *Publications on education.* Retrieved March 6, 2010 fromwww.qsa.gov.qa/Eng/publication/annabs/2009/demographics_social_2009/education_2008.xls
Qatar University (2008). *Office of Institutional Planning & Development*: *Book of trends, 2005-2006 and 2007-08*. Retrieved from www.qu.edu.qa
Qatar University. (2008). *Qatar University Office of Institutional Planning & Development: Statistics fall 2008.* Retrieved from www.qu.edu.qa
Qatar University. (2009). *Qatar University Office of Institutional Planning & Development: Statistics fall 2009.* Retrieved from www.qu.edu.qa
Qatar University. (2012) *Qatar University Office of Institutional Planning & Development Factbook.* Retrieved from www.qu.edu.qa
RAND. (2007). *Design and implementation of K–12 education reform in Qatar: Education for a new era. A report prepared for the Supreme Education Council.* Accessed December 9, 2008 from http://www.rand.org/qatar.html
Roberts, G. (2002). SET for Success: the Supply of people with Science, Technology, Engineering and Mathematics Skills. ,
Retrieved from http://www.hm-treasury.gov.uk/d/robertsreview_introch1.pdf
Russell, C.B., & Weaver, G.C. (2008). Student Perceptions of the Purpose and Function of the Laboratory in Science: A Grounded Theory Study. International Journal for the Scholarship of Teaching and Learning, 2(2). Retrieved from http://academics.georgiasouthern.edu/ijsotl/v2n2.html
Supreme Education Council. (2009). Schools and schooling in Qatar. Accessed from http://www.education.gov.qa/EVI/SchoolingReport/English-08-09.pdf
Supreme Education Council. (2010). All state schools to be converted to independent status in 2010/2011. Accessed from http://www.english.education.gov.qa/content/resources/detail/10981
Supreme Education Council. (2011). New pilot tests of QCEA. Accessed 12 May 2011
From http://www.english.education.gov.qa/content/resources/detail/13775 Supreme Education Council. (2011). Schools and schooling in Qatar 2005-06, 2006-07, 2007-08. A statistical overview of aspects of schools and schooling in Qatar. http://www.education.gov.qa/EVI/SchoolingReport/English-10-11.pdf

Supreme Education Council. (2012). Results of questionnaire on family report on Qatar Comprehensive Educational Assessment (QCEA). Retrieved from http://www.sec.gov.qa/En/Media/News /Pages/NewsDetails.aspx?NewsID=3223

Supreme Education Council Evaluation Institute. (2005). Curriculum standards for the State of Qatar, science grades K to 12. Doha, Qatar: Supreme Education Council. Retrieved from http://www. english.education.gov.qa/section/sec/evaluation_institute

Supreme Education Council Evaluation Institute. (2008). Qatar comprehensive educational assessment (QCEA) 2007 results. Doha, Qatar: Supreme Education Council. Retrieved from http://www. english.education.gov.qa/section/sec/evaluation_institute/sao/_qcea

Supreme Education Council Evaluation Institute. (2009). Qatar comprehensive educational assessment (QCEA) 2008 results. Doha, Qatar: Supreme Education Council. Retrieved from http://www.english. education.gov.qa/section/sec/evaluation_institute/sao/_qcea

van Driel, J.H, Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Learning, 38* (2), 137-158.

World Bank. (2005). *Labour market strategy for the state of Qatar*. Doha, Qatar: General Secretariat for Development Planning.

World Bank. (2008). *The road not traveled: Education reform in the Middle East and North Africa.* Washington, D.C.

World Bank. (2009). *Labour market strategy for the state of Qatar – Phase II*. Doha, Qatar: General Secretariat for Development Planning.

Wubbels, T. (2004). Interpersonal teacher behavior and student outcomes. *School Effectiveness and School Improvement, 15* (3-4), 407–442