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Elementary Science Teachers' Perceptions of Educational Reform in Relation to Science Teaching in Jordan

Ahmad Qablan*, Suhair Jaradat and Ibrahim Al-Momani****

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***Abstract**: This study aims at evaluating elementary science teachers' perceptions of the educational reform movement in Jordan with regard to their teaching practices. Data were collected from 87 elementary science teachers by means of an open-ended questionnaire and later interviews with 4 teachers. Analysis of the responses indicated that teachers see reform as a necessity, but they lack a common understanding of the purpose of the reform in relation to their science teaching practices. (**Keywords:** Educational Reform, Elementary Science Teachers, Jordan, Teachers' Perceptions).*

ادراكات معلمي العلوم في المرحلة الابتدائية للتجديد التربوي بالنسبة لتدريس العلوم في الاردن

أحمد قبلان، كلية العلوم التربوية، الجامعة الهاشمية، الزرقاء الأردن.

سهير جرادات، ابراهيم المومني، كلية العلوم التربوية، الجامعة الأردنية، عمان، الأردن

ملخص: تهدف هذه الدراسة الى تقييم ادراكات معلمي العلوم في المرحلة الابتدائية لحركة التجديد التربوي في الاردن وتأثيرها في ممارساتهم التدريسية. تم جمع البيانات من 87 معلم ومعلمة باستخدام اسئلة مفتوحة النهاية ومقابلات شخصية مع اربعة منهم. اشارت استجاباتهم بعد تحليلها الى ان المعلمين يرون ان التطوير التربوي ضرورة ماسة لكن الفهم المشترك لاهدافه هو ما ينقصهم. وأشار المعلمون إلى أن التجديد التربوي لم يؤثر على ممارساتهم الصفية. وأرجع المعلمون أسباب ذلك إلى بعض العوامل مثل: مركزية النظام؛ وعدم وجود طريقة منظمة لنشر ما يتعلق بالتجديد التربوي ليصل إليهم؛ وضعف التدريب أثناء الخدمة وقبلها؛ وعدم توفر طريقة تواصل مباشرة بين المعنيين في التجديد التربوي؛ وعدم وجود اتجاه واضح لكيفية تأثير التجديد التربوي على مستوى الغرفة الصفية؛ والمقاومة الطبيعية للتغيير لدى المعنيين وخصوصاً المعلمين. وقد اشتقت في ضوء النتائج مجموعة من التوصيات تتمثل في إشراك جميع المعنيين في عملية التجديد التربوي، وإيجاد طرق تواصل فعال ومباشر بينهم، وإعطاء دورٍ نشطٍ أكثر للمعلم والاهتمام في توظيف المعرفة في حياة الطلبة اليومية وتقليل الكم في المحتوى وعدد الطلبة في الغرفة الصفية. (**الكلمات المفتاحية: التجديد التربوي، معلمي علوم المرحلة الأساسية، ادراكات المعلمين في الأردن**).

Educational Context of Jordan

As a developing country, Jordan has witnessed an extensive educational reform movement since the late 1980s. As a country, Jordan might be considered young in terms of being an independent political entity. It gained its independence in 1946 after having been colonized by the British in World War I in 1916. Earlier, Jordan (Trans-Jordan) was part of the Ottoman Empire for around 500 years.

As soon as independence became a fact, the political leadership – the late King Hussein – emphasized the principle of education for all. Since then, Jordan has been very successful in providing basic schooling for every child; thus, the number of students has increased sharply. As an example, the number of students who finished primary school in the academic year 1945/46 was just 144, while the number of students who finished the same level in 1958/59 after about 13 years was 9 384; and in 1960/61, the number increased to 12 930 (Jordan Ministry of Education [MOE], 1980).

This tremendous increase in the number of students was accompanied by an increase in other measures as well. As an example, in the academic year 1999/2000 compared to the academic year 1959/60, the percentage increase in the number of schools, students, and teachers was 696%, 1 141.5%, and 2 104%, respectively (Al-Momani, 2000). According to recent statistics, the number of students who were in the primary school in the year 2007/2008 was 1,311,100 (Department of Statistics [DOS], 2009), taking into account that these numbers are only in the east bank (Jordan) since 1988. While before that both the west (Palestine) and the east banks were included.

This trend was also paralleled by the funds Jordan allocated for education. For example, in 1946 the country allocated 2.5% of its gross national product (GNP) for this purpose while 7.7% of the GNP was allocated in 1990, which is 8.75% of the country's total budget (Batah, Fraihat, & Billah, 1992). This success in providing education for every child in the country was a real achievement for such a young country. However, this could be one of the issues that contributed to the inadequacy of the quality of education provided to students (Ahlawat & Al-Dajeh, 1997). Such inadequacy is evident from the international comparisons with

* Faculty of Educational Sciences, Hashemite University, Zarqa, Jordan.

** Faculty of Educational Sciences, University of Jordan, Amman, Jordan.

Jordanian students' achievement level with those of other countries in 1988, especially in science (Al-Momani, 1997; Appelbome, 1996; Hlebowitch & Tellez, 1996) and in 1999 (Ba'arah, 2002; Hasan, 2001).

Jordan's MOE realised the inadequacy of schools and attributed it to unsuitable textbooks, school facilities, and the low performance level of elementary teachers, which, according to the MOE, was due to the lack of suitable pre- and in-service professional preparation for workers in the educational field (Educational Training Centre [ETC], 1994). To overcome the problem of low-level performance of workers in the educational field, the MOE put into effect a series of new policies and plans for teachers' preparation and certification programmes that include a bachelor's degree certification as the minimum requirement for new teachers. In fact, a bachelor's degree is the minimum requirement for K-9 teachers, secondary teachers must have a higher diploma, and supervisors need a master's degree (Al-Wahish, 1993). In addition, other policies have been implemented, such as providing teachers with ongoing in-service training and improving the efficiency of nonteaching professionals in the educational system, for example, technicians and administrators in various levels of administration and supervision.

Science Education Reform in Brief

Science teaching has been a major part of the educational reform in Jordan, but the following question might be raised: Did science get a different focus – being fundamentally different from other subjects – or was it treated the same? Over the past few decades, considerable efforts to develop and support the implementation of more intellectually challenging science education programs have been taking place around the world. The main purpose of these efforts was to produce citizens who are scientifically literate. Schools were given the principal role in achieving that goal, and teachers have been ultimately held responsible for any dissatisfaction.

Despite such efforts, teachers around the world have been, to some extent, excluded from participation in the decision-making process and have been given the role of implementing what others want them to do (Garet, Porter, Desimone, Birman, & SukYoon, 2001; Patterson, 2002; Spillane & Callahan, 2000; Carter, 2005; Penuel, Fishman, Gallagher, Korbak, Lopez-Prado, 2009). This, however, has made the teaching/learning of science a painful process for both teachers and students, since they both have to passively receive what decision-makers - in the top hierarchy - decide for them to do, while students passively receive scientific knowledge provided in the textbooks through mainly verbal instruction from their teachers.

As a result, science has been singled out in many parts of the world as a subject area in serious need of reform with a deeper, second-order change in the structure of schools (Al-Momani, 1997; Fullan, 1992). Significant voices from around the world have been calling to move practitioners from traditional classroom practices toward student-centred approaches (Al-Momani, 2000; Cuban, 1990; Hasan, 2001; Stake & Easley, 1978; Suydam, 1977; Westbury, 1973) in order to reduce textbook-driven teaching (Al-Momani, 1997; Hasan,2001), since what teachers do inside the classroom directly impacts on what students learn (Al-Nahar, 1995). Science educators (Bell, Lederman, & Abd-El-Khalick, 2000; DeBoer, 2000; Gallagher, 2000; Yager, 1992) and science education reform publications (American Association for the Advancement of Science [AAAS], 1993; United States National Research Council [NRC], 1996; United Nations Educational, Scientific, and Cultural Organization [UNESCO], 1999, 2000, 2001) advocate the preparation of scientifically literate students, considering that science for all is a key goal of the contemporary reform in science education.

It is well known that such reform would not succeed without involving teachers directly in the reform efforts (Woodbury & Gess-Newsome, 2002). Teachers are viewed as a cornerstone of the success of any reform effort (Battista, 1994; Bullough & Baughman, 1997; Clark & Peterson, 1986; Czerniak, Lumpe, & Haney, 1999; Pajares, 1997). They are at the centre of reform since they must carry out the demands of the reform standards in the classroom (Al-Momani, 2000; Al-Nahar, 1995; Cuban, 1990; Garet, Porter, Desimone, Birman, & Suk Yoon, 2001). The AAAS (1990) as well as other researchers (Smith & Southerland, 2007; Penuel, Fishman, Gallagher, Korbak, Lopez-Prado, 2009) states that reform cannot be imposed on teachers from the top down or the outside in: 'If teachers have not been prepared to introduce new content and ways of teaching, reform measures will face big problems' (p. 213). Also, according to AAAS-Project 2061 (1993), the single most important source of knowledge that supports students' learning comes from thoughtful teachers. They have first-hand experience in helping students acquire science, mathematics, and technological knowledge and skills. In addition, they can, to some extent, make the classroom very dynamic or very static, depending on the belief system they hold regarding the education process. Yager (1992) argues that teachers are central to any solutions and successes for the current reform efforts. He addes that to have powerful solutions, teachers would be required to:

> *internalize goals for science teaching other than to prepare students for further study of traditional science concepts;*
>
> *be willing to abandon standard textbooks;*
>
> *assist students in utilizing science concepts and processes in attacking problems that exist in their own lives and communities;*
>
> *assess their successes with teaching and learning strategies beyond testing students for the extent which they can repeat information or perform certain skills outside any real-world context; and*

be professionally involved and demand new approaches and materials. (pp. 907-908)

Given this background, it is understood that reform comes from many sources, but central to reform efforts is the teacher. Reforming teachers' education, therefore, is the *sine qua non* of school reform; without involving teachers directly in the reform efforts and without good teacher-preparation programmes, the reform effort is just a quick fix, which always fails in education (AAAS, 1990).

In Jordan, huge reform efforts have been expended to develop science education in schools. However, these efforts have resulted in little difference in classroom practices, a situation that Woodbury and Gess-Newsome (2002) describe as 'change without difference'. Indeed, what accounts for this situation is the scant attention that Jordanian reformers have given to science teachers.

The national effort of reforming science education curricula that has been exerted since 1990 seeks evaluative studies that help to overcome the pitfall of these reform movements. This study, however, comes to fill that gap by examining the perceptions that Jordanian science teachers have of the context of educational reform in relation to their science teaching practices. Specifically, the study intends to answer the following main question: How do elementary science teachers perceive the context of educational reform in Jordan? Three subquestions are to be answered in response to the main question:

1. To what extent are elementary science teachers aware of the educational reform objectives in relation to their teaching roles?
2. What are the changes (innovations) brought about by the educational reform in relation to textbooks and teaching practices as perceived by science teachers?
3. What are the constraints that hinder the change in science instruction?

Methodology

Participants

Respondents were elementary science teachers who had a minimum teaching experience of 12 years. We started with those teachers who were enrolled in four different classes at the Department of Curriculum and Instruction at the University of Jordan, where two of the researches are faculty members, since they were a convenient sample for them. All participants were trying to extend their education by pursuing a bachelor, master, or doctoral degree as part of their in-service teachers' preparation programmes at the University of Jordan supported by MOE. They were asked to take extra copies of the questionnaires and distribute them to their colleagues who were teaching at the same school and willing to participate. We selected the participants from among those having at least 12 years of teaching experience in order to ensure that they had witnessed the beginning of the educational reform movement that started in 1989. This study took place during the 2002/03 academic year. During the two semesters, 220 questionnaires were distributed and 145 were returned for a rate of return of 66%. Some questionnaires were excluded from the analysis due to reasons such as the respondent's not filling out the first part of the questionnaire, leaving more than three questions unanswered, or having less than 12 years of teaching experience. At the end, 87 questionnaires were used and analyzed.

Of the 87 questionnaires, 45 were from males and 42 were from females. Of the total, 13% of these participants had completed more than the bachelor degree (i.e. masters or doctorates), 56% of them had a bachelor degree, and the rest (31%) had less than a bachelor degree (i.e. community college degrees).

Four of these teachers were interviewed later to obtain a greater, in-depth understanding of their perceptions of the reform movement. All the interviewees had a degree in science education; one was a doctoral student, two received their master's degree in 2001, and one obtained a bachelor's degree in 2000.

Data Collection and Analysis

Instrument. A written open-ended questionnaire was given to participants. The first part of the questionnaire covered demographic and academic background variables that provided information on the sample member, years of experience, classes taught, qualifications, educational directorate (district), college/university attended, and year of graduation. The second part of the questionnaire consisted of 13 open-ended questions intended to get some in-depth understanding of how teachers perceived the impact of the educational reform movement on their teaching practices.

Each completed questionnaire was numbered, and a coding sheet was used to summarize each participant's responses and the number of responses in each category. All responses were translated into English, organized according to the issues addressed by the questions, and assigned to a primary set of three categories concerning the reform movement and science instruction: conceptions of the general reform movement, impact of the reform movement on science instruction, and constraints on successful innovation in science teaching. Assigning responses to these three categories revealed problems (e.g. duplication), so the categorization process was refined until all responses could be placed into mutually exclusive categories.

Follow-up interviews. Follow-up interviews were conducted with four participants who had different levels of qualifications and who volunteered to participate in the study. The interviews were conducted (a) to clarify issues that came out after analyzing the data collected by the questionnaire and (b) to get a more in-depth understanding of teachers' perceptions of the educational reform movement in Jordan. The interview questions were prepared after analyzing the questionnaires.

All the interviews were conducted individually; three teachers were interviewed in the first researcher's office, and one was interviewed in his house as it was his choice. Two interviews were audio taped, transcribed, and translated into English; the other two interviewees preferred not to be audio taped, so the researchers wrote down their comments carefully.

The translated transcriptions of the interviews were read several times and coded first by identifying themes as the subjects expressed them. Next the themes were reformulated in more theoretical words and turned into categories. Finally, the list of the categories was reduced by grouping topics that relate to each other.

Validity. The researchers tried to verify the validity of the results through the following procedures:

1. Listening vigilantly to the participants with the intention of giving them the opportunity to reveal their own perspective without imposing any opinions or interpretations.
2. Collecting data from a diverse range of teachers, with different levels of qualification and different geographic areas, and using two methods of data collection.
3. Including enough quotes to support the interpretations.
4. Membercheck since the participants approved the results of the study.

Reliability. The reliability of the research was verified by the following :

1. The use of multiple methods: open-ended questionnaire and follow-up interviews.
2. Multiple reading of the data, multiple listening to the audio tapes and multiple transcriptions of the tapes.
3. Double-coding by the researchers.

Results

Conceptions of the General Reform Movement in Jordan

The analysis of the responses to the open-ended questionnaire indicated that participants' conceptions of the reform movement were, in general, not clear. Teachers expressed the belief that it was essential to reform the educational system in general. When asked: *Do you think that there is a need for the educational reform that started in the early 80s in Jordan? Why or why not?* Eleven percent of the participant teachers (n = 10) responded that they did not know about the reform in the educational system, suggesting that they had not heard about Jordanian educational reform and despite some of them recognizing the importance of such reform.

Ninety-six percent of the participating teachers (n = 84) asserted that educational reform is a must. Notwithstanding this position, the words they used to express the necessity of the educational reform suggested that they did not have a clear vision of the purpose of the general reform initiatives. However, some (37%) explicitly expressed the view that educational reform is necessary because of the many weaknesses associated with the teaching/learning processes, as apparent from the low performance level of school leavers. These teachers suggested that producing new methods of teaching from the new educational innovations and curriculum development is necessary. (In this section, teachers' responses are presented in italics.) Some representative responses to this issue are:

There is always a necessity for the educational reform to help us learn innovative teaching methods and to understand what changes have happened.

There is a necessity for educational reform to accommodate new educational innovations and curriculum developments.

No doubt about that. In the new millennium there has to be a real reform of education that includes curriculum, teaching and teachers, who are responsible for preparing the manpower of the future.

Some teachers believed that educational reform is necessary to keep up with developments in different fields that have direct impact on the daily lives of human beings, especially in science and technology:

Yes, to go hand-in-hand with the huge development in the different fields of life.

There is always a real need for educational reform to be synchronized with knowledge that is discovered every day, obvious changes in lifestyle and daily problems that face students.

Other teachers had similar perceptions regarding the nature of the reform:

There was a necessity due to many reasons, such as the scientific and technological revolution, the accelerated developments in the field of science and their applications to daily life, the large increase in population, and weak connections between curriculum and the societal needs.

A substantial number (41) of the teachers (47%) held the view that the purpose of the reform is to deliver more knowledge to students, so they believed that the reform is necessary to offer new ways to increase content knowledge. For example:

To achieve the maximum level of accumulated, adaptable, and renewable knowledge that is suitable to the current era we live in.

To reduce the time and effort required to transfer experiences directly to the student without using 'theoretical' instruction.

Developing and delivering content in an appropriate way to be able to cover the textbook during the year.

As seen from these quotes about the purpose of the reform movement, teachers had mixed views about this movement. The way they perceived the nature and purpose of the reform is not clear. They agreed about the necessity of educational reform, but they held different views regarding the reasons underpinning the

reform initiatives. Some think that reform is necessary to help teachers cover textbooks; others think that educational reform is necessary to keep pace with new developments, especially in the technological field; the rest consider it a necessity to find new methods of teaching and learning.

Reform Impact on Science Instruction

Despite all of what teachers say about their agreement regarding the necessity of the reform efforts, they did not have a clear vision of how reform is moving in science instruction. The paper turns now to a consideration of responses to question # 2: *What are the objectives behind educational reform initiatives in the field of science teaching and learning in Jordan? Tell me about how these initiatives have influenced your teaching?*

A majority (76%) of the respondents (n = 66) believed that the objectives of the reform were mainly superficial and did not change their usual science teaching practices, except in finding new ways of simplifying the knowledge to be learned so they could provide students with more information. They are still looking for ways of filling students with more information. Some of the teachers' reasons for the education reform are:

The educational reform objective is to improve science learning. Earlier, science learning was a complete failure beside many weaknesses in other school disciplines.

The educational reform is to provide the student with some 'advanced level' scientific information, especially in the elementary school.

To put science instruction within a practical frame instead of lecturing and to help students learn more quality science.

To simplify scientific concepts by using drawings and illustrations.

To make science content matter easy and practical, so it will be easier and faster for students to comprehend.

The educational reform needs to present the content in a very simplified way and add more illustrations (pictures) for inclusion in the lesson.

To gain basic information and develop scientific attitudes.

A majority of these teachers (14%) talked about developing students' thinking abilities and process skills through science. Below are some quotes that support such a view of the reform:

More concentration on various intellectual skills; emphasis moves from memorizing, comprehending, and recalling to analyzing, synthesizing, evaluating, and experimenting to develop students' abilities in the field of thinking … and … the acquisition of science processing skills.

Reform usually provides better curricula that take care of students' developmental and intellectual needs, and encourages them to think.

The educational reform in science teaching in Jordan aims at changing the students' attitudes toward science and encouraging science-processing skills.

The educational reform is a method to communicate information and concepts in ways that are sensitive to students' perceptions and desires. It is also a trial to improve the level of learning in better ways.

While other teachers, around 9%, mentioned some sophisticated goals in their views of the reform movement, they perceived the reform movement as a way of integrating science with other areas of knowledge or with the students' lives. Below are some selected quotes:

Connect science, technology, and society together.

Use science in all fields of life.

Connect scientific ideas with student's experiences.

Learn some skills: observation, prediction, explanation, and inference among students through brainstorming, probing questions, and other methods.

As is evident in these quotes about educational reform and science instruction, teachers have different views and lack a clear, unified way of looking at the reform in science instruction. Their views ranged from providing students with more scientific information with direct instruction to improving students' thinking skills by applying scientific ideas discussed in the class in their daily lives.

However, the majority of teachers talked about finding ways to help students gain more information through verbal communication as was their normal practice in science teaching and learning before the beginning of the reform movement. A minority of the teachers talked about improving thinking skills and using science as a way of dealing with issues relevant to daily life. This means that teachers have some common assumptions regarding the impact of educational reform movement in relation to their teaching practices, confirmation of usual practice or need for new practices, but no consensus among them on the quality of such impact – although they have experienced and lived this reform since its very beginning in the 1980s.

Teachers' responses to the second part of the question # 2 (*Tell me about how these initiatives have influenced your way of doing science in the classroom*) indicated that no serious changes had happened in their teaching practices. Two different views of the quality of change in science teaching were apparent. The first view, held by 70% of the teachers, was that the reform movement had no impact on their teaching practices. They attributed this lack of impact to reasons beyond their influence, such as a large number of students in the classroom, a lack of understanding of what is going on, and a general feeling of helplessness. Below are several quotes that summarize this category of perceptions of the nature of reform:

I did not change my teaching practices due to the high number of students in the class; there is no chance of making any change.

I did not change my teaching practices due to many reasons: the high number of students in the classroom, the low number of science classes, and the extra emphasis of the MOE on low-level tests and exams.

I do not know how to change things. The high number of science classes that a teacher has to teach (more than 24 sessions per week), the lack of laboratories in the school, and the high number of students in the groups are hard to change!

I have no idea about how I can change my teaching practices in science classes, taking into account the problems that I face in my job as a third grade classroom teacher. Amongst the most important of those problems are the high number of students in the classroom, no ready instructional materials to buy even if money is available, and finally no room for the laboratory; the laboratory is just some segregated equipment that is dispersed in many places around the school.

Some teachers made changes in their practices in the classroom. However, from my point of view, very few teachers made the change but most teachers, especially the old ones, do not accept any change.

Very little change has happened due to the pressure in the school schedule (high number of classes), lack of laboratory supervisors, and shortage in teachers and other school personnel, so there is more pressure on existing teachers as the result of adding some administrative work for them to do.

The second view, held by the remaining 26 teachers (30%), was that the reform did have an impact on their teaching practices; this group explicitly mentioned that belief. Below are several quotes that summarize these teachers' perceptions of the nature of reform in relation to science instruction:

Yes, I became a facilitator of learning, not a knowledge provider.

Yes of course, I changed my teaching practices. Some aspects of change are simplifying the curriculum to make it suitable to the students' environment and connecting students' experiences with the topic through the use of instructional media (laboratory, different tools, stories, field trips…).

Some teachers noticed the changing roles of teachers and students. They perceived that the reform helped them to require students to be more responsible for their learning of science.

There must be changes in science teaching practices. The instruction no longer depends on lecturing or on teachers but on students starting to take major roles. Students, for example, may conduct discussions among themselves, with laboratory attendants, or with a worker in a factory so that they get useful information according to each student's pace. The teacher's role has changed, so that he/she has become a guide or an organizer in the instructional process.

There should be changes in the instructional practices to accommodate new developments and movement in the curricula to achieve the best in presenting different pieces of knowledge for students. So, instead of focusing on memorization of verbal meaning, I use investigation and cooperative learning to let each individual student depend on himself/herself in looking for information and avoid making any of the students just a passive recipient.

Other teachers perceived change in moving toward doing more experiments and concrete science activities. Below are selected quotes:

I put more emphasis on laboratory experiences trying to let students improve their skills in doing experiments.

I made simple changes in moving toward more concrete activities. In the past we used to teach lessons in a verbal way, and now the process has become more concrete.

I depend mainly on scientific activities, prioritize the role of the laboratory in explaining science concepts, give students the main role in managing discussion, depend completely on cooperative groups and connect content knowledge with the student's real life.

Changes have happened in practices. Some new teachers abandoned old theories and try to apply new ones. The focus became more on the way in which students think than on filling them with information.

Implementation of lessons became more focused on the practical dimension even if it was just to let a student measure the temperature inside or outside the class using on available materials, regardless of whether it is a demonstration or a discovery or doing experiments formally.

As inferred from these quotes, for the majority of the participating teachers, the reform had no impact in changing their way of teaching science. However, teachers face some critical problems in teaching science, which can be categorized as either teacher-related or system-related. Most of the problems that teachers suffer from are system-related. Some of the most salient problems they face are the large number of students, lack of equipment, high number of classes to teach per week, and lack of suitable facilities.

When asked *Do you think that teachers must change their ways of doing science?* most teachers said they were willing to change their teaching practices. They know very well that they have to give the students a more responsible role in their learning of science. They know that, to some extent, the educational system in Jordan is still following the behaviourist ideology, using the direct instructional approach where teaching is lecturing and learning is memorizing facts. These

teachers showed awareness of the dangerous situation regarding segregated content that does not provide integration within the different topics in science curricula. They all agreed that the current science textbooks often lack integration and present scientific concepts in an isolated way.

When asked *Why did reform not change much in the way teachers do science?* the teachers said that the MOE had been mistaken in attempting to reform science education by dealing with parts of the problem and not taking the whole process into consideration. One teacher said:

The MOE took some general problems and assumed them to be the only problems that the elementary science programme suffers from, such as lack of textbooks, school facilities and teachers' level of qualification. The MOE did not conduct any kind of field studies to survey all the problems that the elementary science programme suffers from. As a result, the MOE put all its efforts into the improvement of school facilities, textbooks and teachers' qualification level, but forgot other real issues that still have negative impacts on the quality of graduates from Jordanian schools.

According to the interviewees, some issues that the MOE did not take into consideration and were not included in the reform efforts are:

1. The high number of students in a class (45-55) makes it difficult to conduct science experiments or to go to the laboratory.
2. The school administration does not support science teachers and considers science as no different from any other academic subject. One teacher said that the school administrator did not allow him to take his students on a field trip and did not allow him to conduct some experiments about pulleys and levers in the school yard.
3. Textbooks are overloaded with theoretical concepts despite the claim that changes were conducted during the reform era. The large number of concepts makes it very difficult for teachers to achieve mastery learning. Instead, they ask their students to verbally define these concepts, and that is all what is required since the textbook's coverage is compulsory. A teacher told a supportive story:

   A supervisor criticized me when I asked the students to answer a question as homework about the stomach and the fact that, as it is composed of proteins, why it doesn't digest itself. The supervisor called this kind of action not acceptable and considered it to be unacceptable, since it is not taken directly from the textbook, although the unit was about the digestive system!
4. Jordanian teachers usually teach 24 to 26 sessions per week with an average of 5 sessions a day, which makes it difficult for teachers to prepare for laboratory experiments or in-class demonstrations.
5. There is a lack of communication among teachers or between teachers and supervisors.
6. MOE does not coordinate efforts to circulate new academic and pedagogical knowledge nor provide teachers with new research papers or information or anything about new national or international developments in the field of science. One interviewee said:

Teachers need technical and administrative support to get good training about how to find solutions to the problems they face in the field. This could be achieved by teamwork among teachers in the same school or nearby schools. Administrators need to coordinate and give all possible support to conducting such meetings. In addition, the MOE needs to support some mini-conferences to help teachers get together and for new ideas to be circulated.

When asked *How could science teachers teach for 14 years during the period of educational reform, and still lack a common understanding of the objectives of the reform movement?* the teachers gave some possible reasons for the multiplicity of teacher responses in relation to their perceptions. Some of those reasons are:

1. Teachers were excluded from all reform processes, so the movement did not really reflect teachers' needs or input. The only thing teachers received during this period of time was just more departmental courses at the university and training sessions about how to teach using the new textbooks.
2. Fear and resistance to change keep teachers doing the same things that they used to do, such as following the textbooks' procedures.
3. Teachers under a very centralized educational system used to and still accept and implement what the authorities want them to do.
4. Textbooks are the only resources available and allowed for teachers to use, and it is required that teachers have to cover everything in the textbook page by page. In addition, new textbooks became bigger in size and content than the former ones, especially for the 7^{th} and 8^{th} grades, as if the MOE tried to include everything of importance regarding new scientific developments in these textbooks. One teacher said:

Changes to textbooks were to some extent superficial, such as adding coloured pictures. But the real issue is the size of the textbook, which became bigger, and new concepts were added to those new textbooks.

Another teacher said:

One of my colleagues received a 'warning' because he was a little behind in covering the textbook, which made all of us (teachers) give this issue the first priority, without paying any attention to the real understanding or function of knowledge in the students' lives.

5. There is a lack of in-service training where teachers could get together and discuss issues of

importance and try to solve the difficulties they face. One teacher said:

There were no training sessions where we could get together as teachers, supervisors and curriculum planners to discuss new ideas and mechanisms, learn from each other or discuss how to tackle the difficulties we face. The sessions I participated in were few in number and focused on some superficial issues, such as how to write behavioural objectives, without taking into account any essential issues of importance for in-class teaching practices.

Constraints to Successful Innovation in Science Teaching

This aspect of the study focused on inherent constraints in the educational system that prohibit teachers from making significant changes. Unfortunately, teachers cannot change many of these constraints; therefore, they have to accept them, live with them, and feel bad about them. It is assumed that getting rid of these constraints will help teachers and make their professional lives easier, but we do not know for sure if that will enable them to change their teaching practices. Teachers were asked to list five constraints that prohibited them from doing science well in the question *What problems do you face in teaching science?* Below is a list of these constraints mentioned by more than 50% of the respondents:

1. Large number of classes per week that the teacher has to teach.
2. Large number of students in the class.
3. Textbooks are very large and loaded with facts that are difficult for students to understand.
4. Conducting so many experiments inside the classroom.
5. Lack of parents' participation and follow-up with their children.
6. Lack of financial resources available directly to teachers to make it possible for them to pay for some daily science activities.
7. Very few science classes per week.
8. Focus on factual knowledge.
9. Administrators do not believe in change, so they do not allow it to happen.
10. Minimum chances for students to think when using the experiment guides since the results of the experiments are already known.
11. Safety precautions are not suitable in the laboratories, so the danger level is high and teachers cannot be responsible for harm that might happen to students.
12. Teachers are not involved in the decision-making process.
13. General weakness among students in reading, writing, and mathematics.

These problems are similar to those problems that teachers faced at the beginning of the reform movement. In fact, 74% of the participants believed this to be the case. These problems prevent teachers from adopting or implementing any innovative ideas inside the classroom and might be the obstacles for any change in teachers' perception as to the possibility of changing their current teaching practices.

Most of the teachers reported being willing to change their teaching practices because they perceived them as inappropriate. When asked *Do you think you need to change your teaching practices? What are the reasons?* the majority of the teachers (72%) said 'yes' and suggested the main reason was that their science teaching methods were inappropriate. Some of the quotes follow:

I always have the desire to change, and I would love to do so but many factors need to be taken into account.

I do have the desire to change. I think about using cooperative groups, but the size of the classroom is very small.

I have the desire to be creative and develop creative thinking among students. Difficult school circumstances do not permit us to make the change or to move toward more creative ways.

I have the desire to change my teaching practices. I learned how to form cooperative learning groups, but I am unable to do that in the class because the room is small although I would very much like to do so.

I need to change my teaching practices to become more applied and relevant to students' lives instead of being abstract and factual, but I cannot do that because I have to teach five classes every day, and no one would help me set up the equipment to make science more concrete.

I would love to change my practices, and I believe in new ideas. I sometimes do not find help in implementing these ideas in the classroom.

I think what determines the way I teach is the student himself/herself according to his/her level of achievement. So, if I deal with talented students, I have to make more effort – since this treatment will motivate me to improve my teaching practices, but I am not able to do so because of the large number of students in the classroom.

I have the desire to change so I can work in parallel with the requirements of this era with all its intellectual and teaching method innovations, and minimize the traditional approach, where students depend on the teacher whenever he/she needs to think in solving a problem, but things around me in the school are not going very well.

As may be inferred from these quotes, teachers have the inclination to change their teaching practices and feel that they might do better when they change their current practices. However, they do not know how to overcome the system-inherent constraints.

During the interviews, teachers identified three major problems. In fact, three of the four teachers agreed about these problems when they were asked to choose the top three from the list of problems identified

earlier, although they listed them in a different order. These problems are: (a) the large size of textbooks which are loaded with facts that are difficult for students to understand, (b) the large number of classes that teachers have to teach per week, and (c) the large number of students in each class.

When asked about the reasons why Jordan scored low in the international achievement test, the teachers attributed that to system-related problems. Some of their quotes follow:

The curricula are intense and full of concepts and scientific information, and this forces the teachers to use the lecturing method in teaching the students, and make their first priority to finish the curriculum. The school administration pays great attention to the number of pages that the teacher completes and they check on that from time to time. ... One of the teachers took a medical leave for a month. When he came back, his students were behind in the curriculum, which forced the school administration to push him to speed up in covering the textbook. All of that is in reality counter–productive to the students' understanding of the scientific concepts.

Curricula are loaded with a huge number of concepts, and this makes it hard for both teachers and students, and the goal will be coverage and not mastery. Coverage is very important, and teachers are usually held responsible by the MOE.

The textbook is the only source of knowledge. All experiments presented in those textbooks are just procedures to be followed with given results, so the students don't even have to think about anything, thus they are not being able to be creative.

When asked about the solutions for these problems and how to improve science learning in Jordan, they suggested the following:

1. Mutual understanding among concerned people. This implies that teachers, students, parents, the community, and educational authorities should all work together and set up goals, achieve them, and decide what to teach and why to teach it.
2. Teachers' active role. This means that the MOE has to consider a more active role for teachers in the curriculum planning and development process.
3. Students' daily lives are the best start. It is very important to start teaching scientific concepts from the problems that students experience in their daily lives, to motivate them better for learning.
4. Less is more. Having fewer concepts in the curriculum and concentrating on the big concepts.
5. Number of students in the class. Fewer students in the classroom (around 25) would be more appropriate and help teachers to manage the classroom in an effective and safe way.
6. Teaching load. It is very important for teachers to have time to be able to go to the laboratory and prepare equipment and the necessary tools to conduct the experiments for the students because there are no laboratory attendants in some of the schools.
7. In-service training sessions. Teachers need in-service training to provide them with theoretical frameworks and help them implement some of these ideas inside the classroom.

Discussion and Implications

The purpose of this study was to examine teachers' perceptions of the reform movement and their attempts to implement reform proposals in their teaching practices. Results showed that teachers believe in the necessity of the reform movement. However, they do not have a clear vision of the purpose of the reform.

Participating teachers' perceptions of the nature of the educational reform vary, and there is little common ground in the manner in which they perceive the reform movement. Some participants perceived the reform as a reaction to the low achievement level of students, which was true because the reform's purpose was to improve the quality of graduates. Nevertheless, it is very strange that some teachers did not believe that the attainment levels of graduates of the Jordanian schools are not good enough despite the MOE declaration of this fact (ETC, 1994). Some teachers perceived the whole idea behind the reform effort as being to provide students with more information or to find ways to simplify the process of gaining more information which is completely rejected in science teaching (Marx, Blumenfeld, Krajcik. Fishman, Soloway, Geier, and Tali Ta, 2004). Science teaching/learning is more than knowledge acquisition in a verbal abstract way; it is about problem solving, processing skills, and improvement in students' thinking abilities. Other teachers had parallel perceptions regarding the purpose of the reform in the teaching/learning process, such as producing new methods of teaching or keeping current with new developments in different fields, especially in science and technology. However, there is a significant number of teachers who still perceive the whole reform movement as an opportunity to stuff students with more information.

This idea of providing students with more information might be a result of several factors. Firstly, the reform movement in highly centralized educational systems is usually based on a top-down model, which is not enough. What might be needed is a coordination of top-down and bottom-up strategies (Fullan, 1994a; 1994b; Smith & Southerland, 2007). The major problem of using the top-down model is that teachers become the dead-end of the road. In this state of affairs, teachers may not have a major role to play in the reform process, nor in the implementation process, and eventually have to accept whatever the authority demands. For example, top educational authorities decide on all initiatives in policy making, planning and development of curricula. All these efforts culminate in developing textbooks for different topics. The teachers' role becomes just to teach all the content in these textbooks. Science teachers have to cover, by law, the science textbooks page by page. In this way, teachers might be more concerned with the

coverage than students' construction of understanding. In addition, the suitability of the science textbooks needs to be questioned as they claim to be traditional, focus on the content, disregard thinking skills, individual differences, and applications to students' daily life (Elsheikh, 2001). Teachers declare that the first question usually asked by supervisors is 'What did you cover from the textbook?'or 'Where are you in the textbook?' School administrators criticize teachers if they are behind in covering the textbook. With this kind of attention from supervisors and school administrators, teachers may not care much if most of the students do not understand the material or have a lot of misconceptions in regard to scientific concepts! This forces teachers to rely on textbooks in their instruction as the only resource of knowledge, and they follow them page by page. They do not have any other resource to use.

Secondly, teachers appear to exhibit a natural tendency to resist change as found by other researchers. A few researchers (Davis, 2003; Fullan, 1992) indicated that 'resistance to change is the natural tendency of human beings'. So, the MOE should use some other means, such as in-class training, to convince teachers that the change to new and better strategies is fruitful. In this way, the natural tendency to resist change might be overcome (Schneider, Krajcik, Blumenfeld, Phyllis, and Joseph, 2005).

Thirdly, another reason for such teachers' perceptions might be the lack of appropriate in-service training. Studies (Garet et al., 2001) indicate that teaching, as any other profession, needs continuous training to be able to deal with the new requirements of the profession. Benchmarks for scientific literacy (AAAS, 1993) likens the teaching profession as similar to any other profession, such as medicine, that needs continuous in-service training, which is necessary to keep up with innovations in theory and practice.

In addition to these three points, the quality of the teachers' certification programme or the preservice programme may be a contributing factor. In Jordan, a teaching position requires a bachelor's degree (ETC, 1994). To teach science with the MOE, teachers need a bachelor degree in science without any other conditions. Other factors that might be useful to teachers' effectiveness – such as classroom management, instructional beliefs, attitudes toward teaching, communication skills, and others – should be taken into account. Therefore, science teachers' recruitment needs to reconsider the teachers' educational practices and pedagogical knowledge as well as their science content knowledge represented in the science degree (Abell Foundation, 2001; Cochran-Smith, 2001; Cochran-Smith & Fries, 2002). Results from this study agree with other studies (Hasan, 2001) relating to teachers, especially those with higher degrees and improved teaching practices. But they were not affected by the orientations and philosophy of the educational reform movement towards other aspects, like students' thinking, taking individual differences into account, and connecting content knowledge with students' daily lives.

Fourthly, the hierarchal nature of the organizational system in Jordan does not appear to pay much respect to teachers' thoughts and ideas. Teachers are the 'working class' where the system requires them to teach what has already been agreed upon in the textbooks and without providing them with chances to make their own decisions. They appear to lose commitment since they are not involved, despite the fact that they decide the fate of the reform (Spillane & Callahan, 2000), because they are the gatekeepers of the scientific knowledge (Gallagher, 2000). Teachers have to be immersed in reforming the subject that they teach to be able to carry out the demands of the educational reform (Garet et al., 2001; Blanchard, Southerland, Osborne, Sampson, Annetta, Granger, in press).

Fifthly, the idea of systemic change might be more complex than anticipated and not easy to implement (Schneider, Krajcik, Blumenfeld, Phyllis, and Joseph, 2005; Davis, 2003). This was very clear from the outset of the reform movement in Jordan because the MOE focused on three elements: textbooks, school facilities, and teachers' qualification as measured by years of teaching experience. Systemic change requires taking into account the whole system, not just a few elements. Changing only some elements of the whole system in Jordan has not produced the desired results, which is similar to what happened in the United States (Gallagher, 2000; Davis, 2003; Marx, Blumenfeld, Krajcik. Fishman, Soloway, Geier, and Tali Ta, 2004). For example, many obstacles in science teaching that affected the performance level of Jordanian students are still in the system and still have an impact on the whole process of teaching and learning science. Those obstacles (Ba'arah, 2002) are:

1. Students are not interested or motivated and have negative attitudes toward science.
2. High student-teacher ratio in the science classroom.
3. Shortage of general science teachers; current teachers are not qualified.
4. Shortage of laboratory equipment and other audio-visual aids.
5. Shortage of heating, cooling, and lighting systems.
6. Science is found to be difficult and boring by students.
7. Shortage of resources needed for science teaching.
8. Instructional practices are teacher-centred.

Most of these problems are system-related, and teachers are not in a position to change them, especially those obstacles related to school facilities and resources. This means that more comprehensive, holistic, and systemic views are required to achieve better results regarding the desired outcomes, especially students' level of achievement.

The question *How could science teachers teach for 14 years during the period of educational reform, and*

still lack a common understanding of the objectives of the reform movement? elicited the following reasons from the interviews with the teachers:

1. No process of dissemination that moves from the top of the hierarchy down to the teachers' level.
2. No connectivity among stakeholders.
3. Lack of in-service training.
4. No clear direction as to how the reform movement should impact upon classroom practices.
5. No system of incentives to reward teachers who are creative and have good ideas in teaching.
6. Weak training programmes.

These reasons indicate that the way in which reform was planned and implemented was not appropriate. Students and teachers are still suffering from the same problems that were identified before the beginning of the reform movement. It is very necessary to redirect the reform efforts so teachers will have a more effective role.

These findings have many implications for elementary science teachers in Jordan if they are to be helped to be more responsive to change. Firstly, despite the fact that the change process is very difficult when teachers resist change, change is not impossible. Teachers have to be aware and eventually convinced of the reform efforts and ideas. They have to see the new ways of teaching and learning as more effective, fruitful and appropriate than the old ways of teaching and learning. Secondly, any reform effort in a developing country operating under a central ministry of education model with its clear top-down chain of command must involve individuals from those levels that make policy and those that carry it out. The change should not be forced from higher authority, but rather it has to begin from the classroom and move up. Thirdly, studying courses at the university during preparation programs is not enough for teachers to take a more positive role in the reform process as a change proceeds. More in-service training is required to let teachers feel and be aware of the direction of the reform. Finally, courses at the university are not enough to prepare science teachers for primary schools. Their initial training should involve clinical experience in real classrooms with all the variables that must be taken into consideration during teaching.

Recommendations and Future Research

Systemic reform like that described here involves several stakeholders and resources. Future research should interview supervisors to understand their perspectives and to clarify issues raised by the teachers, such as the burden of the textbook-driven way of teaching. One of the limitations of this study is that it did not hear the voices of the supervisors, which makes it hard to claim that they represent an obstacle for the reform movement to succeed; not all the interviewed teachers talked about this issue.

Another suggested future research direction is to interview students and hear from their attitudes and perceptions of science at the elementary level. It would be possible to do a few observations in the science classrooms in different areas of the country to get a better understanding of the situation and to check empirically some aspects of teachers' reports.

Creating a list of recommendations is a much simpler task than finding ways to implement them. Recommendations for individual teachers seem much more likely to occur than those recommendations whose target is the structure of the system. However, as the teacher education literature is careful to point out (Cuban, 1990; Woodbury & Gess-Newsome, 2002), change in teachers without accompanying structural changes is doomed to long-term failure. Implementation of the recommendations can help the Jordanian MOE better serve its wider community by calling attention to the need for considering the multiple factors that hinder the process of reforming science education in Jordan.

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