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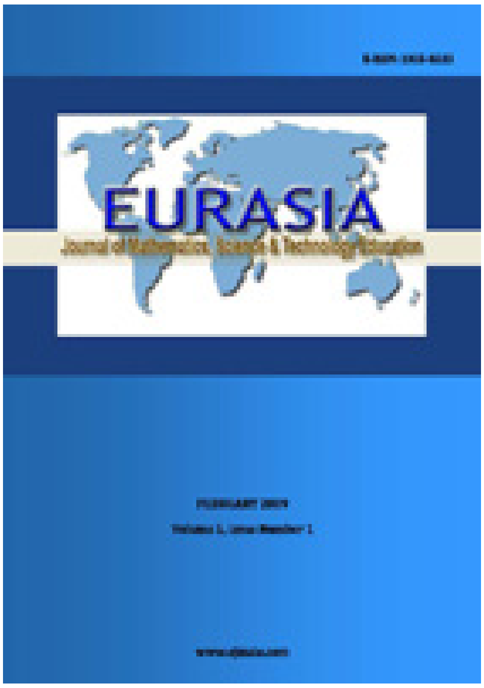

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The purpose of this study was to investigate relationships between teachers' attitudes toward science, knowledge and beliefs about inquiry, and science classroom teaching practices. Specifically, the study addressed three questions: What are teachers' beliefs and knowledge about inquiry? What are teachers' teaching related classroom practices? Do teachers' knowledge and beliefs about inquiry relate to their science classroom practices? The sample consisted of 34 teachers drawn randomly from schools in the city of Lebanon. To answer the first question, teachers responded to two questionnaires: *Views of Science Inquiry which* gauged teachers' views about science and how science is conducted and *Attitudes and Beliefs about the Nature of and the Teaching of Science* which measured teacher's attitudes and beliefs about the nature of and the teaching of science. To answer the second question, classroom observations documented actual teaching practices. Results from the questionnaires and the observation were used to construct individual teacher's profiles which were used to identify relationships between teachers' beliefs, knowledge, and teaching practices. Results showed that most teachers had restricted views of nature of science and unfavorable beliefs and attitudes about inquiry. Moreover, no consistent relationships between teachers' beliefs, views of nature of science, and classroom practices were found.

Keywords: Inquiry, beliefs, classroom practice, nature of science

INTRODUCTION

Preparing scientifically and technologically literate citizens has been a concern of educators around the world for more than three decades. UNESCO (1994) suggests that scientific and technological literacy are necessary for coping with the requirements of modern life. Consequently, an emphasis on expanding scientific literacy is apparent in many curricula all over the world. According to Chiappetta, Sethna, and Fillman (1993) and BouJaoude (2002) there are four aspects of scientific literacy: The knowledge of science, the investigative nature of science, science as a way of thinking, and interactions of science, technology, and society. Science as a way of thinking and the investigative nature of science are the aspects of scientific literacy that are related directly to inquiry-based science teaching and learning. Thus, it is argued that enhancing inquiry teaching and learning in science classrooms will help promote scientific literacy (Wallace & Kang, 2004).

However, implementing inquiry teaching is not a straightforward task due to several barriers. It has been argued that one of the major barriers for implementing inquiry practices in science classes is teachers' beliefs about teaching, learning, and classroom management (Pajares, 1992). A number of researchers such as Nespor (1987), Pajares, (1992), and Richardson (1994)

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State of the literature

- One of the major barriers for implementing inquiry practices in science classes is teachers' beliefs about teaching, learning, and classroom management
- Studies about teachers' knowledge and beliefs about inquiry and their classroom practices are still few and scattered.
- The study is conducted in a cultural context in which the language of instruction is not the native language but the second language.

Contribution of this paper to the literature

- This study provides one possible way to investigate the relationship between beliefs about inquiry and teachers' practices.
- Results show that there is a need of ample opportunities to understand the implementation of extended inquiry instruction because of apparent disconnect between what teachers say and what they actually do the science classroom.
- The results of this study demonstrate a need for further research to investigate the relationship between teacher's beliefs and attitudes about inquiry and their classroom practices.

have found that teachers' beliefs influence their practices. Moreover, teachers' practical knowledge drives the decisions they make in their classroom, while teachers' epistemological views about science influence their instructional beliefs and classroom practices (Lederman, 1992). Other research has shown that teachers' beliefs about students, learning, teaching, and the nature of science influence teaching practices and act as barriers to the implementation of reformed curricula (Brickhouse, 1990), Cronin-Jones, 1991, Gallagher, 1991, Tobin & McRobbie, 1997). Other barriers that impede the use of inquiry teaching in science classrooms include lack of equipment, laboratory safety issues, school policies such as preparing students for standardized tests and official exams, and finishing mandated curriculum content within a set time limit (Wallace & Kang, 2004). Finally, teachers' negative beliefs about inquiry and their lack of knowledge about inquiry and inquiry skills are major hurdles for implementing inquiry teaching and learning (Jarrett, 1997).

Overcoming the various barriers associated with using inquiry in science classrooms requires a concerted effort from policy makers, university educators, school administrators and other stakeholders interested in improving the quality of science education. However, there is a pressing need for understanding teachers' beliefs as they relate to their classroom practices (Verjovsky & Waldegg, 2005), an understanding that might help in finding ways to overcome these barriers and ultimately improve the quality of student learning (Richardson, 2003). Similarly, Keys and Bryan, (2001) believe that this research is needed in the following four domains: (a) teachers' beliefs about inquiry; (b) teachers' knowledge base for implementing inquiry; (c) teachers' inquiry-based practices; and (d) how the student learns in the science classroom from teacher-designed, inquiry-based instruction, including conceptual knowledge, reasoning, and nature of science understandings.

Purpose and Research Questions

Studies about teachers' knowledge and beliefs about inquiry and their classroom practices are still few and scattered. Moreover, no such research has been conducted in Lebanon (BouJaoude & Abd-El-Khalick, 2004). One differentiating characteristic of conducting this study in Lebanon is the fact that it is conducted in a cultural context in which the language of instruction is not the native language but the second language. Consequently, this study investigated the following questions:

1. What are teachers' beliefs and knowledge about inquiry?
2. What are teachers' teaching related classroom practices?
3. Do teachers' knowledge and beliefs about inquiry relate to their science classroom practices?

METHODS

This correlational study employed a mixed methods design, which involved collecting quantitative and qualitative data. Accordingly, two questionnaires were utilized to colect each type of data. Data collected from the quantitative questionnaires were analyzed to gauge students' beliefs and knowledge about inquiry while the qualitative data were coded, categorized, and analyzed to produce patterns of behaviors. Teachers' classroom practices were observed and recorded using a special observation log.

Sampling

The study sample was randomly drawn from Beirut, Lebanon and used a two-stage probability sampling design with schools as the first level sampling units and teachers as the second level units. Schools were classified into private and public, then each group was classified into five groups: 1) schools having both elementary and intermediate grade classrooms (Elementary/Intermediate), 2) schools having intermediate and secondary grade classrooms

(Intermediate/Secondary), 3) schools having intermediate grade classrooms (Intermediate); 4) schools containing secondary grade classrooms (Secondary); and 5) schools containing elementary, intermediate and secondary grade classrooms (All Levels).

In the first stage of sampling, twenty-one private and public schools were selected for inclusion in the study. The list of schools in Beirut, Lebanon available from the Ministry of Education and Higher Education was used in this process. The sample of schools chosen constitutes approximately 9% of the total number of schools in Beirut, Lebanon (237) (Ministry of Education and Higher Education, 2002). The second stage of sampling involved selecting intermediate and secondary level science teachers from the sampled schools. For this purpose, a list of teachers at each level from each school was obtained and one or two teachers from each school were randomly selected to participate in the study. The total number of teachers included in the sample was thirty-four teachers. Table 1 provides the number of schools, teachers, and observations from the different types of schools.

Participants

Thirty-four teachers participated in this study. Eighty percent of them were females and their ages ranged from 23 to 59, with an average age of 41 years while the number of years of teaching experience ranged from one to 35 years, with an average of 18 years. Twenty six percent of the teachers held a bachelor of science, 21% held a license (a 4-year degree), 21% held a bachelor of science and a teaching diploma, and 32% held a masters degree. Fifty-six percent majored in biology, 26% in chemistry, 9% in physics, and 9% had a double major (Biology chemistry or chemistry physics). Moreover, 73% of teachers taught biology, 18% taught chemistry, and 9% taught physics. It is clear from the above that the percentages of teachers' teaching a subject matter do not correspond to the percentages of the teachers' field of study. Data about teacher's employment status show that 79% of the teachers were full time teachers and 21% were part time. Teachers were distributed on intermediate and secondary grade levels as follows: 3% taught grade 6, 26% grade 7, 21% grade 8, 18% grade 9, 18% grade 10, 11% grade 11, and 3% grade 12. Finally, English was the language of instruction of science in 62% of the schools while French was the language of instruction in 38% of the schools. Seventy-three percent of the teachers used Arabic less than 25% of the time in teaching science, 12% used Arabic 26-50% of the time, and 15% used Arabic 51-75% of the time. All the classes were taught in regular classrooms with no science facilities or materials.

Instruments

To answer the first question, (What are teachers' beliefs and knowledge about inquiry), teachers responded to two questionnaires: A Likert-type questionnaire entitled "Attitudes and beliefs about the nature of and the teaching of science" and an open-ended questionnaire entitled "Views of Science Inquiry" (VOSI-4) that gauged their beliefs and knowledge about inquiry. To answer the second question, (What are teachers' teaching related classroom practices?), a classroom observation log entitled "How's your IQ (Inquiry quotient)?" was used to document actual teaching strategies related to inquiry.

Table 1. Number of Schools and Teachers who Participated in the Study

		School Type					
	School Type	Elementary/ Intermediate	Intermediate /Secondary	Intermediate	Secondary	All levels	Total
Number of schools	Public	1	4	6	0	0	11
	Private	1	1	0	0	8	10
	Total	2	5	6	0	8	21
Teachers responding to questionnaire	Public	2	4	11	0	0	27
	Private	2	2	0	0	13	17
	Total	4	6	11	0	13	34
Teachers observed	Public	2	4	11	0	0	17
	Private	2	2	0	0	13	17
	Total	4	6	11	0	13	34
Number of observations	Public	4	8	22	0	0	34
	Private	4	4	0	0	26	34
	Total	8	12	22	0	26	68

Table 2. Categories and Items of the Attitudes and Beliefs about the Nature of and the Teaching of Science Questionnaire

Category	Item
Beliefs about the nature of science	• Science is a constantly expending field • Theories in science are rarely replaced by other theories • Science consists of unrelated topics like biology, chemistry, geology, and physics • Using technologies (e.g. calculators, computers, etc.) in science lessons will improve students' understanding of science • Getting correct answers to a problem in the science classroom is more important than investigating the problem in a scientific manner • In grade K-9, truly understanding science in the science classroom requires special abilities that only some people possess • To understand science, students must solve many problems following examples provided • The use of technologies in science (e.g. calculators, computers, etc.) is an aid primarily for slow learners
Attitudes toward science	• I like science • I enjoy learning how to use technologies (e.g. calculators, computers, etc.) in science. • I am looking forward to taking more science courses
Attitudes towards teaching science	• Students should be given regular opportunities to think about what they have learned in the science classroom • Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce science vocabulary • Calculators should always be available to students in science classes • Small group activity should always be a regular part of the classroom.

Attitudes and beliefs about the nature of and the teaching of science. The "Attitudes and beliefs about the nature of and the teaching of science" is a Likert-type questionnaire initially entitled "Attitudes and beliefs about the nature of and the teaching of mathematics and science". This questionnaire was developed for the Maryland Collaborative for Teacher Preparation (MCTP) for specialist mathematics and science elementary/middle level teachers (McGinnis, Shama, & Watanabe, 1997). The items of the questionnaire are designed to measure elementary and middle level teacher's attitudes and beliefs about mathematics and science, interdisciplinary teaching and learning of mathematics and science, and the use of technology to teach and learn mathematics and science. The Questionnaire initially included twenty-nine items to which teachers responded by selecting one of five options: Strongly agree, sort of agree, not sure, sort of disagree, and strongly disagree. Fifteen items out of the twenty-nine items were selected to develop the questionnaire used in this study. The fifteen items included those related to science only and measured teacher's attitudes and beliefs about the nature of and beliefs about teaching of science. The scale was converted so that five represented the most desirable answer and one represented the least desirable answer. The items of the questionnaire were categorized into three categories: beliefs about the nature of science, attitudes towards science, and attitudes towards teaching science. Table 2 presents the categories along with the items associated with them.

Views of science inquiry "VOSI-4". The questionnaire entitled "Views of science inquiry" (VOSI-4) was used to collect data on teachers' views about science and how science is conducted. The questionnaire was developed by Lederman and O'Malley (1990) and modified by Schwartz (2004) and included seven open-ended questions, several of which included sub-questions. The VOSI-4 items were developed based on descriptions of general aspects of the nature of scientific inquiry and served to identify respondents' ideas about these aspects. Schwartz derived these descriptions from the National Science Education Standards [NSES] (NRC, 1996) and from the American Association for Advancement of Science [AAAS] Benchmarks for Scientific Literacy (AAAS, 1993). The general aspects of nature of scientific inquiry covered in the questionnaire included a) questions guide investigations, b) scientific experiments and the development of scientific knowledge, c) sources, roles of, and distinctions between data and evidence, d) purposes of scientific investigations, e) multiple methods of scientific investigations, f) justification of scientific knowledge and community practice, and g) interpretation of data.

Table 3. The Scientific Inquiry-Related Categories for the VOSI-4 and the Related Subcategories

Categories		Subcategories
1. Conducting investigations	a.	scientific questions guide investigation
	b.	performing "the scientific method"
	c.	inquiry activities
	d.	lab and field activities
2. Meaning of experiment:	a.	an experiment involves testing a hypothesis and manipulating a variable
	b.	an experiment is conducted to solve a problem
	c.	an experiment prove that your hypothesis is true or false
	d.	an experiment is a procedure similar to "the scientific method"
3. Multiple methods of scientific investigations	a.	there is no single scientific method; experimental approach and observation of natural phenomena
	b.	only one scientific method: "the scientific method" (i.e. experimental)
	c.	making relationships and drawing conclusions from observations is a scientific investigation
	d.	the experimental method only is a scientific investigation
4. Interpretation of data:	a.	views of subjectivity in science
	b.	creativity or subjective influence of the scientist
	c.	science is value laden
	d.	same experiment always leads to the same results unless there is a mistake in the procedure
	e.	consensus may be reached through discussion
5. Difference between data and evidence	a.	data are information gathered during an investigation an evidence is a product of data analysis and interpretation
	b.	data are the recorded fact or measurements from and experiment
	c.	data is true information that cannot be doubted
	d.	in science data means: materials and tools used
	e.	evidence is the product of data analysis and interpretation
	f.	evidence differs from data because it is the proof that shows whether a certain idea is correct or not.
	g.	data could serve as evidence
	h.	data is quantitative and evidence is qualitative
6. Justification of claims.	a.	Evidence
	b.	consistent logical arguments and negotiation
	c.	use scientific principles, models, and theories
	d.	results must be repeatable
	e.	validity and reliability of results
	f.	communication and peer review

Observation log: How's your IQ (inquiry quotient)? In addition to biographical information about the teacher being observed and the observer (the observer's name, the teacher's name, the school, and the date of observation), the observation log included information about the teacher and the classroom, such as the level of education of the teacher and his/her employment status, the number of students in the classroom and the kind of room and equipment used. Following this information, 25 items developed by Lawson, Devito, and Nordland (1976), were used as a guide during the observation phase of the study to gauge teacher's inquiry. Each item was scored from zero to four, where four indicated a superior performance and zero poor performance. The items were organized into four categories; the first category described how the lesson is conducted and the materials and activities used during the lesson. The second category described student-learning behavior. The third category described teachers' behavior such as self-confidence, handling classroom interruptions, and playing the role of an investigator. The fourth category described teachers' questioning techniques (divergent or convergent questions), teachers' acceptance of students' opinion, and the allocation of time for student response (Appendix I).

Pilot Testing

The two questionnaires administered to teachers (Attitudes and Beliefs about the Nature of and the Teaching of Science and Views of Science Inquiry "VOSI-4") were translated to French by one of the researchers and were checked by a French Language teacher because science is taught in either French or English in Lebanese schools. Then they were piloted with a number of teachers who were asked to assess the content and comprehension of the questions. In addition, two education faculty members were asked to judge the sufficiency and suitability of the questions used in the questionnaires. The pilot study showed that all questions were comprehensible and suitable for teachers. Additionally, one of the researchers and another high school science teacher who was trained to use the observation log piloted it with seven teachers who were not part of the study. The two observers went to the same classroom, filled out the observation log, then compared results and resolved discrepancies if any. This process continued until they reached a high level of concurrence.

Procedure

Teachers responded to the two questionnaires before the observations started. No time limits were set for responding to the questionnaires; a fact that was especially important in the case of VOSI-4 that is open-ended and the advice by its developer (personal communication through email) was to provide teachers with sufficient time to fill it out. Respondents to the VOSI-4 were encouraged to write as much as they could, provide illustrative examples when asked, and address all subsections. Respondents were reminded that there is no right or wrong answer to any item in both questionnaires and the intention was to understand their views about science teaching and scientific inquiry. Following the administration of the VOSI-4 questionnaire, seven respondents (15%) were interviewed. During those interviews, respondents were provided with their completed questionnaires and asked to explain and justify their responses. Finally, each teacher was observed in his/her classroom twice and teaching practices were recorded by using an observation log adopted for the purposes of the study.

Data Analysis

Data from the questionnaire entitled "Attitudes and Beliefs about the Nature of and the Teaching of Science" were used to compute mean and standard deviations for the variables used in the study. Analysis of the VOSI-4 questionnaire was qualitative and was guided by primary categories that were targeted in the VOSI-4 items. A number of inquiry-related categories obtained from questionnaire response guide (personal communication with R. Schwartz, September 15, 2006) which was developed by Schwartz based on research done by Schwartz, Lederman, & Crawford, (2004) and Schwartz, Lederman, & Thompson (2001), provided a primary guide of codes. Data analysis was conducted by the two researchers who used the following steps to establish the reliability of the analysis: a) The two researchers met to discuss and agree on the questionnaire response guide developed by Schwartz; b) each of them analyzed and coded a number of responses independently, c) the two researchers met to discuss the results of their analysis and resolved differences by discussing the codes with a science educator. This process was repeated until almost a consensus was reached; d) the second researcher conducted the rest of the analysis and coding by herself. During data analysis, the researcher looked for descriptions and examples in the written responses that served to generate a profile of inquiry conceptions for each participant. Moreover, during analysis subcategories emerged and were added under the primary ones. The subcategories, which were repeated occurrences of themes, clarified the views of the teachers. The scientific inquiry-related categories for the VOSI-4 and the related subcategories are shown in Table 3.

A table with the teachers' names in a vertical column and the individual questions in the header column was constructed to display responses of all teachers in order to facilitate data analysis and facilitate the development of themes and subcategories across teachers and questions. The teachers' responses to the VOSI-4 questionnaire were used to construct descriptive profiles of respondents' views of scientific inquiry. Teacher's views revealed in each question were grouped in three categories based on a continuum that included "Restricted views of inquiry" on one end and "Advanced views of inquiry" on the other, between these two lies the "Mixed views of inquiry". Questions that were coded as mixed included elements of both the advanced and restricted views.

Data collected from the "VOSI-4" questionnaire were used to answer the second part of the first research question (Teachers' knowledge about inquiry?). Responses to this questionnaire were coded and grouped in three categories, "Restricted views", "Mixed views", and "Acceptable views" of science inquiry, based on the questionnaire response guide provided by Schwartz (personal email communication, October 2007 – see Table 4).

To identify the overall views of scientific inquiry of each participant, a percentage related to the three categories of views (restricted, mixed, and acceptable) was calculated. To calculate the percentage of each category for each participant, the number of responses in each category was divided by the total number of responses and then multiplied by 100. Moreover, to clarify teachers' views, 15-20% of teachers were interviewed to discuss their responses.

To investigate classroom practices, the observation log developed by Lawson, Devito, and Nordland (1976) provided a method to calculate the teachers' level of inquiry in the specific lesson. Each item was scored

Table 4. Description of Restricted Views and Acceptable Views of Scientific Inquiry

Science Inquiry Aspect	Restricted Views	Acceptable Views
Investigations	Scientists conduct experiments to prove their ideas/hypotheses are right"	Scientists start by asking questions
Scientific experiment and the development of scientific knowledge	Any activity which comprises observations and conclusions is an experiment. Scientific knowledge develops only through experiments.	Experiment in science is that procedure that involves identification and manipulation of variables and use of controls. Experiments seek cause/effect relationships by changing only one variable in the system and measuring/observing the effect of that change. Scientific knowledge does not always need experiments to develop
Data and evidence	Data are numbers only. Evidence is something non-numerical or something that is only presented in a court of law.	• Data are observations. These observations could be qualitative or quantitative. • Different. Evidence is data that has been interpreted in light of a question. Evidence is that data or product of data analysis that supports a conclusion. Not all data are evidence.
Purposes of scientific investigations	To find the truth about science and collect more information.	Curiosity, social impact, economy, and practicality are just a few. The work of scientists may help solve a socially-based situation (such as disease), may be necessary to develop desired technology, may improve human condition, or may advance basic understanding of our world.
Multiple methods of scientific investigations	There is only one scientific method; it is an experimental approach with hypotheses, variables, and controls.	There is no single "scientific method" that all scientists follow to produce valid knowledge. "Scientists use different kinds of investigations depending on the questions they are trying to answer." Observations of natural phenomena, void of direct disturbance by the observer, can result in valid scientific understanding of the phenomena. Astronomy, geology, and anatomy are just a few of the many fields of science wherein investigations may not necessarily be experimental in the traditional sense.
Justification of scientific knowledge and community practice	Scientists have to have evidence to prove it works.	• Repeatable, statistical support, consistency, predictable, evidence. • Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The processes of negotiating meaning and gaining consensus involve building justification for claims.
Interpretation of data	If the same procedures were followed then they would get the same result unless someone did something wrong in the procedure. The data are collected and interpreted without creative or subjective influence of the scientist.	Scientists who ask similar questions and follow similar procedures may validly make different conclusions.

from zero to four where four indicates a superior performance and zero indicates poor performance, the scores are summed to obtain a total category score over hundred.

$$\text{Total criteria score} \times \frac{25}{\text{Number of questions answered}} = \text{Standard lesson score}$$

It is important to mention that not all items apply to all lessons. For this reason, this formula is used to obtain a total score on the questionnaire that serves as a consistent comparison measure.

To answer research question three (Do teachers' knowledge and beliefs about inquiry relate to their science classroom practices?) results obtained from each

Table 5. Teachers' Scores Sorted by Attitudes and Beliefs

Teacher	Attitudes and Beliefs Score (on a scale of 5)	Teacher	Attitudes and Beliefs Score (on a scale of 5)
1	4.18	18	2.76
2	3.64	19	2.76
3	3.64	20	2.76
4	3.64	21	2.76
5	3.47	22	2.76
6	3.47	23	2.76
7	3.38	24	2.76
8	3.38	25	2.76
9	3.29	26	2.76
10	3.29	27	2.67
11	3.11	28	2.58
12	3.02	29	2.58
13	2.93	30	2.58
14	2.93	31	2.49
15	2.84	32	2.49
16	2.84	33	2.31
17	2.84	34	2.22

of the instruments were used to identify instances where there was alignment between teachers' beliefs about inquiry and their classroom practices or where the beliefs and knowledge did not align with the practices.

Data from the interviews were used to validate the results from the questionnaires and were not analyzed as a separate data sources. Teachers in these interviews seemed to re-iterate their positions without any significant changes in their positions.

RESULTS

Results are presented in five sections: Teacher's beliefs about inquiry, teachers' knowledge about inquiry, classroom teaching practices, relationship between teachers' knowledge and beliefs about inquiry and their classroom practices, and teachers' profiles.

Teacher's Beliefs about Inquiry

To answer the first part of the first research question (What are teachers' beliefs about inquiry?) data collected from the questionnaire entitled "Attitudes and Beliefs about the Nature of and the Teaching of Science" were considered. Analysis of teachers' score on this questionnaire revealed that only 12 teachers out of 34 (35 %) had a score above 3 on a scale of 1 to 5, as shown in Table 5. Since the scale is from 1 to 5, 3 represents the category of "not sure" and everything below it was considered as negative attitudes and beliefs about the nature of science and science inquiry while scores above 3 represented positive attitudes and beliefs about the nature of science and science inquiry. Based on the latter categorization, it can thus be concluded that approximately one third of the teachers had positive attitudes and favorable beliefs toward scientific inquiry.

Teachers' Knowledge about Inquiry

Table 6 presents examples of verbatim quotes selected from the responses of teachers to the "Views of Science Inquiry" (VOSI-4) items and interview questions. The examples illustrate teachers' views of several important aspects of science inquiry. The presented views of science inquiry are necessarily interrelated, and one quote used to illustrate restricted or acceptable views of one aspect of inquiry could as well be used to illustrate restricted or acceptable views of another aspect.

Results (Table 7) indicate that most teachers had restricted views of science inquiry. Twenty-nine teachers out of 34 (85% of teachers) had 50% and above of their responses corresponding to the restricted views of science inquiry and only 5 (15% of teachers) had less than 50% of their answers corresponding to the restricted views of science inquiry. Only one participant out of 34 (3% of the teachers) had 50% of responses corresponding to the mixed views of science inquiry. Moreover, only one participant out of 34 (3% of the teachers) had above 50% of his responses corresponding to the acceptable views of science inquiry and all the rest had less than 50% of their views corresponding to acceptable views of science inquiry.

Classroom Teaching Practices

Correlation between the two scores on the observation log collected during the two observations was found to be 0.93, indicating a high degree of consistency. Analysis of the data drawn from the observation log indicated that 12 out of 34 teachers (35%) scored 50% and above on the first and the second observation as shown in Table 8. Out of these 12 teachers, 10 (29%) scored more than 50% on the second observation. Consequently, approximately one third of the teachers practiced inquiry teaching in classroom 50% of the time, while the remaining two thirds of the teachers practiced inquiry teaching less than 50% of the time.

Relationship between Teachers' Knowledge and Beliefs about Inquiry and their Classroom Practices

Analysis of the data indicated that the correlations of teachers' attitudes and beliefs with the first observation and the second observation were low (0.45) as shown in Table 9. Teacher's knowledge, drawn from the VOSI-4, was correlated with the attitudes and beliefs and with

Table 6. Illustrative Examples of Teachers' Responses on the VOSI-4)

Science inquiry aspect	Restricted views	Mixed views	Acceptable views
Investigations	- Scientists do experiments that prove theories and observations. - The scientists note their observations, formulate the hypotheses. Then they move to experimentation to confirm or reject their hypothesis.	- Observing, reading, experimenting and drawing conclusions.	- Scientists do Inquiry activities, i.e. they investigate starting with a question and they use several ways to investigate.
Scientific experiment and the development of scientific knowledge	- All activities which are based on observations and conclusion are scientific experiments. A scientific experiment is conducted to solve scientific problems. Its steps are: recognizing the problem, forming a hypothesis, testing the hypothesis, drawing conclusions. An experiment is needed for the development of scientific knowledge because it assures that the information is right or wrong - An experiment proves that your observation and hypothesis about certain subject are correct or not. Experiments allow progress of science.	- Observe with curiosity to solve problems and use certain processes to manipulate variables to solve problems. An experiment is needed to develop scientific knowledge.	- Explore a problem with specific variables to be controlled one at a time. Example knowledge about space and interior of the earth cannot be explained by experiments but by other procedures such as study pictures given by space ships, telescopes…. - A controlled experiment studies the effect of one factor at a time. New ways of interpreting something/building models to understand a phenomenon- those account for the development of scientific knowledge as well
Data and evidence	- Data is the acquired knowledge; The given are the true information, which are not doubted and they are the starting point of research or experiment. - Data is something used as a basis for calculating or measuring, or factual material used as a basis. Evidence is non-numerical statements.	- Data are factual information. Data could serve as evidence.	- Data encompasses all observations and measurements both quantitative and qualitative. Data is different from evidence. One may use data to reach evidence - Data means any information collected during observations. Evidence comes from the analysis of data.
Purposes of scientific investigations	- Prove hypotheses	-	- Advancement of science
Multiple methods of scientific investigations	- There is only one scientific method which is based on experimentation. - Drawing a conclusion from observations that do not involve an experiment is not a scientific activity. -	- Investigations using statistical evidence and experimental scientific method are done for the advancement of science.	- Scientific activity depends not only on experiments; it depends on observations as well. - Drawing a conclusion and finding cause and effect relationship after doing many observations is a scientific activity.
Justification of scientific knowledge and community practice	- The scientific method mentioned before ends in a conclusion. If this conclusion is applied to a great variety of cases, then it is accepted by scientists. -	- Scientists discuss their work and get to a conclusion based on experiments and negotiations to reach a consensus.	- Experimental results must be repeatable and consistent.
Interpretation of data	- With the same procedure, doing the same work, people will reach the same conclusion because each scientific reality is unique. - Usually if the same experiment under the same conditions is done it should give similar results if not, which might be, they have to re-hypothesize and investigate why.	- Scientists discuss their procedures and their work and may reach the same conclusion.	- No, they will not come to the same conclusions because the thoughts of scientists differ from each other. - Scientists may look at the same event in different perspectives and so get to different answers (subjectivity).

Table 7. Percentages of Restricted, Mixed, and Acceptable Views of Teachers

Teacher Number	Percentage of restricted views	Percentage of mixed views	Percentage of acceptable views	Teacher Number	Percentage of restricted views	Percentage of mixed views	Percentage of acceptable views
10	100	0	0	23	75	17	8
24	100	0	0	16	71	21	7
25	100	0	0	4	67	33	0
1	92	8	0	6	67	25	8
11	92	8	0	12	67	25	8
17	92	8	0	19	64	29	7
33	92	8	0	18	64	22	14
31	86	14	0	28	60	17	10
3	85	15	0	21	57	21	7
15	85	15	0	8	55	33	18
34	84	8	8	9	50	25	0
32	83	17	0	26	50	25	29
30	79	14	7	7	50	29	33
22	79	7	14	5	46	22	23
20	77	23	0	14	36	17	28
13	75	17	8	29	31	21	38

Table 8. Teachers' Scores Sorted Based on the First Observation

Teacher	Attitudes and Beliefs Score (on a scale of 5)	Inquiry quotient 1	Inquiry quotient 2	Teacher	Attitudes and Beliefs Score (on a scale of 5)	Inquiry quotient 1	Inquiry quotient 2
1	4.18	83	89	4	3.64	43	41
27	2.67	80	74	6	3.47	42	40
9	3.29	66	79	30	2.58	41	42
10	3.29	66	57	7	3.38	39	46
18	2.76	65	65	23	2.76	39	40
19	2.76	61	60	24	2.76	38	38
15	2.84	60	55	33	2.31	37	35
2	3.64	59	57	14	2.93	36	28
13	2.93	58	52	25	2.76	33	39
3	3.64	56	49	31	2.49	33	29
11	3.11	54	55	26	2.76	31	28
20	2.76	50	37	12	3.02	29	29
28	2.58	47	43	8	3.38	27	30
21	2.76	46	50	32	2.49	25	26
22	2.76	45	41	16	2.84	24	28
5	3.47	44	61	17	2.84	15	16
29	2.58	44	45	34	2.22	14	24

Table 9. Relationship between Attitudes, Observations, and Science Inquiry Views

	Attitudes	Inquiry quotient 1 (over 100)	Inquiry quotient 2 (over 100)
Attitudes	1		
Observation 1	0.43	1	
Observation 2	0.48	0.93	1
Restricted views	-0.12	-0.15	-0.19
Mixed views	0.17	0.08	0.15
Acceptable views	0.37	0.16	0.16

the observations. In addition, results revealed that teachers' attitudes and beliefs were negatively correlated with the restricted views of science inquiry (-0.12) and had very low correlations with the mixed and acceptable science inquiry views of teachers. Both observations were negatively correlated (-0.15, -0.19 respectively) with the restricted views of science inquiry and had very low correlations with the mixed and acceptable views.

Teachers' Profiles

Teachers' attitudes and belief scores, the VOSI-4 scores, and the classroom observation scores were used to construct a profile for each teacher. Consequently, teachers with similar profiles were grouped to identify patterns in the data. The grouped data are presented in Table 10. The following findings can be gleamed from Tables 10 and the teachers' profiles..

1. There was only one teacher who had inquiry quotient scores above 50% whose views of inquiry were almost acceptable (46%) or mixed (23%) and whose attitude score was more than three.
2. There was only one teacher who had the inquiry quotient scores of above 60% and who had a total of more than 50% on the acceptable and mixed views of inquiry and whose attitude score was more than 3.
3. The rest of the cases did not show any clear pattern across the three variables. However the following were observed:
   a) *There were cases of teachers whose views of inquiry were clearly restricted, however they seemed to practice inquiry in the classroom (Teachers 1,2,3,5,9,11,13,16,21,23,24 & 25 for example).*
   b) *There were cases of teachers whose attitude and belief scores were less than three who seemed to practice inquiry teaching (Teachers 13,16, 21, 23,24 & 27 for example).*
   c) *There were cases of teachers whose views about inquiry were distributed over the restricted, mixed, and acceptable who practiced inquiry teaching to some extent (Teacher 30 for example).*
   d) *Table 10 shows that there were no consistent relationships between attitudes and beliefs scores, scientific inquiry views (knowledge) and classroom practices except for the teachers whose scores were negative on all variables.*

DISCUSSION

Results of the study indicated that more than half of the teachers (65%) had a score on attitudes and beliefs about inquiry below 3 and most of them (85%) had restricted views of scientific inquiry. Only one participant out of 34 had 50% of his/her responses corresponding to the acceptable views of science inquiry. Only one participant out of 34 had views of science inquiry mostly divided into mixed and acceptable. Sixty five percent of the teachers did not practice enough inquiry in their teaching. Moreover, teachers' attitudes and beliefs were negatively correlated with the restricted views of science inquiry and had low correlations with the mixed and advanced science inquiry views of teachers. Both classroom observation scores were negatively correlated with the restricted views of science inquiry and had no significant correlation with the mixed and advanced views. Moreover, investigating the relationships between teacher's attitudes and beliefs, knowledge, and classroom practices in each teacher's individual profile indicated that there is no consistent relationship between the three factors, attitudes and beliefs, knowledge about inquiry and practices.

According to Nespor (1987) and Tobin and McRobbie (1997), teachers' beliefs influence their practices in different ways. Nespor conducted his study with eight teachers teaching math, history, or English in middle school classrooms. The teachers did not have much guidance from the school and it was left to them to choose the content and instructional methods that they thought appropriate to their classrooms. Nespor found that the teachers' beliefs about teaching were aligned with their teaching practices. Tobin and McRobbie (1997), on the other hand, conducted their qualitative study with one grade 11 public school chemistry teacher and head of the science department and found that teachers' and students' beliefs about the nature of science and inquiry were acceptable but the teacher's practices were at odds with those beliefs. However, the teacher's practices were aligned with his beliefs about power relations in the classroom and the nature of student learning. Thus, according to Tobin and McRobbie even though teachers may profess that they were inquiry oriented, they still use direct instruction in their classrooms.

The findings of the study conducted by Nespor (1987) are different from those found in this study. These differences could be due to the different environments in which the two studies were conducted. While the teachers in Nespor's study were free to implement their own curriculum using the teaching methods of their choice, teachers in Lebanese schools have to implement a required national curriculum even though they can choose their own instructional methods. In this study, most of them chose not to use inquiry for most of the time. Results of the study by Tobin and McRobbie (1997) however, are aligned with the results of this study when beliefs about inquiry and the nature of science are considered. That is, both this study and that of Tobin and McRobbie showed that teachers' beliefs and practices are not necessarily aligned

Table 10. Summary of Teachers' Profiles

Attitudes and beliefs score	Scientific inquiry views (knowledge)	Classroom practice	Number of teachers	Percentage of teachers	Profile
Above the mean	Positive	Positive	2	6	Attitudes and beliefs above the mean, most scientific inquiry views are between mixed and advanced, and inquiry teaching is practiced in the classroom more than half of the time.
Above the mean	Positive	Negative	0	0	----
Above the mean	Negative	Negative	6	18	Attitudes and beliefs above the mean, more than half of scientific inquiry views (knowledge) are restricted and some are mixed, and very little inquiry teaching
Above the mean	Negative	Positive	4	12	Attitudes and beliefs are above the mean, views of scientific inquiry (knowledge) are restricted, however, inquiry teaching is practiced in the classroom
Below the mean	Positive	Positive	1	2	Attitudes and beliefs below the mean, more than the half of scientific inquiry views (knowledge) are advanced, and very few are mixed, and the rest are restricted, and most of the time inquiry teaching is practiced in the classroom
Below the mean	Positive	Negative	2	6	Attitudes and beliefs below the mean, third of scientific inquiry views (knowledge) are restricted and the rest is divided between mixed and advanced, and very little inquiry teaching is practiced in the classroom
Below the mean	Negative	Negative	15	44	Attitudes and beliefs below the mean, all of scientific inquiry views (knowledge) are restricted, and little inquiry teaching is practiced in the classroom
Below the mean	Negative	Positive	4	12	Attitudes and beliefs below the mean, most of scientific inquiry views (knowledge) are restricted and very few are mixed, and more of half of the time inquiry teaching is practiced in the classroom

- *VOSI-4= Views of scientific inquiry, R= Restricted views of scientific inquiry, A= Acceptable views of scientific inquiry, M= mixed views of scientific inquiry, and IQ= Inquiry Quotient*
- *Positive science inquiry views (knowledge): 50% of the views are mixed and acceptable*
- *Positive classroom practice: 50% of the time inquiry is practiced in classroom*
- *Negative scientific inquiry views (knowledge): 50% of the views are restricted*
- *Negative classroom practice: less than 50% of the time inquiry is practiced in classroom*

and that they might depend on the context in which teaching takes place. Additionally, the results of this study (research question 1) are consistent with BouJaoude and Abd-El-Khalick (2004) who suggested that science instruction in Lebanon is still traditional in nature and that inquiry teaching is not prevalent in Lebanese science classrooms.

The scarcity of research on in-service teachers' beliefs about and knowledge of inquiry in Lebanon (BouJaoude & Abd-El-Khalick, 2004) makes it difficult to discuss the results of this study in the context of science education research in Lebanon. Nevertheless, several comments can be made about the results that have possible implications for teaching and research. First, even though most of the teachers had university degrees and almost 20% of them had teaching credentials in the form of a teaching diploma, they seemed to subscribe to a traditional positivistic views of science teaching. This could be due to the nature of university programs in science, which are still content oriented and science teacher preparation programs that prepare teachers who are technical experts rather than reflective practitioner (BouJaoude, 2006).

Second, most of the teachers in this study did not practice inquiry teaching in the classrooms and if they did, it was for short periods. This situation might be a reflection of the requirements of the Lebanese educational system in terms of national exams at the end of the intermediate and secondary levels. These exams are still paper and pencil tests that may require students to use science process skills but in the context of document analysis rather than authentic inquiry. Third, even though the Lebanese science curriculum includes goals and objectives focused on scientific thinking and inquiry skills (BouJaoude, 2002), most teachers have not been trained to implement these approaches in the classroom leading them to do "whatever works" in the classroom, which sometimes happens to be inquiry activities. Fourth, the lack of consistency between teachers' beliefs, knowledge, and practices may be the result of the absence of a Lebanese science education framework that provides a mechanism for establishing consistency between teacher preparation, teaching, and assessment. For example, even though there is a curriculum document that recommends the use of investigations in science, there are no directives for institutions that prepare science teachers to adapt to these suggestions and directives. Fifth, the fact that teaching credentials are not required for teaching in private schools (they are required for teaching in public schools) and many public and private school teachers do not receive continuous professional development may result in teachers who are proficient in the content matter but not in the methods of teaching, especially inquiry teaching approaches.

Informal interviews conducted with teachers who participated in this study may shed some light on the results regarding inquiry related practices of teachers. These interviews revealed that many teachers who participated in this study seemed to practice inquiry teaching but without actually calling their practices "inquiry". When asked about the nature of these activities, they classified them as "student-centered activities" rather than inquiry activities. Consequently, the inquiry practices of teachers could possibly be attributed to their belief about the necessity of using student-centered teaching approaches, which they did not seem to associate with inquiry, findings similar to those of Luft (2001). A number of teachers seemed to have an interest in implementing student-centered teaching because of its possible positive effects on student motivation. Thus, what the researchers identified as "inquiry" was labeled "student centered teaching", a situation that might have led the researchers to label 35% of the teachers as using inquiry for a significant amount of time in their classrooms in spite of the fact that these teachers had negative beliefs about inquiry.

Nevertheless, there are many factors that could have impeded the implementation of inquiry in the classrooms of the teachers participating in this study. These factors include school culture, the beliefs that the curriculum should be completed, and that students should be prepared for exams; factors that require emphasis on content coverage rather than inquiry (see Tobin & McRobbie, 1997). The culturally-based beliefs of the importance of preparation for exams, especially official exams, and the importance of efficiency in covering the curriculum probably had a powerful influence on impeding inquiry practices in the classroom. Teachers might have developed a set of "goals of learning" that are translated into such activities as obtaining good grades, passing exams, covering the official curriculum, attendance and acceptable behavior in class, among other issues. This vision is strongly promoted by the institutional context of Lebanese private and public schools that publicize success rates in official exams and consider these as indicators of institutional and individual accomplishment. These school cultural factors intercept to de-emphasize the importance of having positive attitudes toward inquiry and appropriate conceptions about and knowledge of inquiry because these do not seem to have a direct relationship to school activities valued by teachers, students, parents, and school administrators.

Moreover, new or young teachers usually show more positive attitudes and more acceptable views about inquiry. The fact that the average number of years of experience of teachers is 18 years might have affected the findings of this study, especially that according to Richardson (1996) experienced teachers seem to have more negative and rigid beliefs about inquiry than younger teachers. In addition, even though new teachers might have positive attitudes and more up-to-date conceptions of inquiry they might have more pressing concerns, such as managing classrooms and curricula and responding to the requirement of administrators, a situation that decreases their interest in inquiry and its implementation. Thus, teachers' experience and its relation to practicing inquiry in the classroom is an area that warrants more research.

It could also be that more biology teachers than chemistry or physics teachers held conceptions of teaching as a transfer of information (BouJaoude, 2000). Possible reasons for the differences among teachers of different disciplines include the educational history of the biology teachers and the way biology is taught and assessed in Lebanon. Tobin and Tippins (1996) suggest that teachers participate in different academic communities and have distinct experiences specific to certain subjects during their undergraduate studies, leading them to construct conceptions associated with their experiences in their respective disciplines. Moreover, teachers have experienced high school biology programs that over-emphasize doing well on biology national exams that are almost exclusively based on memorization rather than problem solving. Furthermore, Lebanese physics and chemistry teachers may have different experiences in their high school and undergraduate college experiences because of the emphasis on solving problems and laboratory work in both subjects. This also could be a factor for further investigation.

Implications for Research

The results of this study demonstrate a need for further research to investigate the relationship between teacher's beliefs and attitudes about inquiry and their classroom practices. An in-depth qualitative study of a number of teachers in this study would be a useful addition to this research. This study could focus on understanding the factors that impeded or facilitated the implementation of inquiry by teachers of different ages, years of experience, and content matter backgrounds. Moreover, different tools can be used to collect more accurate data such as videotaping the teachers in class, teachers' notes, teachers' reflections on their teaching, and more detailed discussions with teachers.

Moreover, there is a need to have a better understanding of the effect of each factor investigated in this study separately. For example, the effect of teacher's beliefs and attitudes on practices should be separated from the effect of their knowledge about inquiry. Furthermore, more research could be done to investigate the effect of other factors mentioned previously such as beliefs about student-centered teaching and beliefs related to school and community culture.

Implications for Teaching

If learning to teach inquiry is acknowledged as a complex process, then teachers need various opportunities to understand the implementation of extended inquiry instruction. Pre-service teachers should learn about inquiry and experience it and become more comfortable in doing it while in-service teachers need to receive continuous professional development and support to increase the possibility of implementing inquiry. In the absence of any regular reform of science teaching, particularly at the college level, it is most probable that candidate teachers will continue to join teacher education programs with naïve views of the scientific endeavor (Lederman & Latz 1995, Stofflet & Stoddart 1994). As such, science teacher education programs should continue their attempts to promote more adequate conceptions of scientific inquiry.

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Appendix: Examples of the Items of the Observation Log (How's Your IQ [Inquiry Quotient])?

Criterion	Scale					Criterion Score
The lesson 1. Materials and activities of interest	0 Students are bored	1	2 Students are mildly interested	3	4 Students very interested	
2. Materials and activities which provoke thinking, questioning, and discussion	0 No questioning or discussion	1	2 50% of students stimulated to think, question, discuss	3	4 All students are able to pursue investigation at own level and own direction	
Student Behavior 8. Students making observations and collecting data	0	1	2	3	4	
	0%	25%	50%	75%	100%	
	Percentage of lesson time					
9. Students formulating and testing hypotheses, models or predictions	0	1	2	3	4	
	0%	25%	50%	75%	100%	
	Percentage of lesson time					
Teacher Behavior 12. Is fellow investigator	0 No	1	2 50% of the time	3	4 Yes	
13. Acts as classroom secretary when data need to be organized	0 No	1	2 50% of the time	3	4 Yes	
14. Concept introduced after direct experiences	0 No	1	2 50% of the time	3	4 Yes	
Questioning techniques 18. Majority of teacher questions are divergent	0 No	1	2 Few divergent questions used	3	4 Yes	
19. Convergent questions used effectively	0 No	1	2 50% of the time	3	4 Yes	