# Palestinian science teachers' epistemological beliefs: A preliminary survey

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# Palestinian Science Teachers' Epistemological Beliefs: A Preliminary Survey

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Abstract

The purpose of the study was to determine what percentage of Palestinian science teachers held beliefs about knowledge and learning that are congruent with the recent constructivist/conceptual change epistemological basis of science education, what factors influence these beliefs, and if the beliefs about knowledge and learning were related. Two questionnaires were developed to probe teachers' beliefs in these two areas, and a sample consisting of 91 teachers with varying educational background and teaching levels responded to these questionnaires. The study showed that only a small percentage of Palestinian teachers subscribed to the recent views of learning and scientific knowledge (25% and nine percent respectively). With regard to the views of learning, this was mainly due to very few teachers believing or realising that students hold alternative preconceptions, and that science learning entails conceptual change. Very few teachers also believed that science itself develops through conceptual change. Indeed, more than 80% believed that science develops through accretion and about 40% preferred the inductive model of science to the hypothetico-deductive one which only 11% preferred. It was found that these views were not related to the teachers' years of schooling, years of experience, level at which they taught, or teacher specialisation. The two views of learning and knowledge were moderately related. The results and implications for future studies are discussed.

The study investigated teacher beliefs in two areas: beliefs about learning and about scientific knowledge. It is important to identify these beliefs and trace their effects on teaching since it is expected that teacher beliefs influence teacher behaviour. Hashweh (1985) found that teachers holding a constructivist view of knowledge and learning had a richer repertoire of teaching strategies than teachers not holding such a view. In addition, these teachers used strategies that are potentially more effective in changing student preconceptions in science (alternative frameworks), that is, in inducing conceptual change. Replicating and testing the findings of that study (which was exploratory and qualitative) using large samples and statistical hypothesis-testing techniques, if successful, would lend strong converging evidence to its findings. The first step in that direction is to develop reliable instruments to assess teacher beliefs, and the present study partially aimed at achieving this goal.

The identification of teacher beliefs about learning and knowledge, however, is an important endeavour for its own sake. The last three decades have witnessed a paradigm shift in psychology and the philosophy of science, in education in general and in science education in particular. The shift is exemplified in psychology where it is now possible to study unobservable entities such as knowledge structures and beliefs rather than just behaviour. In the philosophy of science, the works of Kuhn (1962), Lakatos (1970) and Toulmin (1972), among others, have undermined the empiricist inductivist basis of scientific knowledge and replaced it by a hypothetico-deductive constructivist view of scientific knowledge (for a good explication of this view see Phillips, 1985). In education, the effects of these shifts are exemplified by the acceptance of the variety of new

qualitative or interpretive methodologies, and by the renewed study of neglected areas such as teacher thinking, knowledge and beliefs. (See Shulman, 1986, for a discussion of these in the study of teaching). In science education the shift is exemplified by the vigorous research program on student preconceptions in science (Hashweh, 1986, 1988). It is also apparent in the various articles that explicate constructivism and advocate it as a base for new teaching/learning methods (e.g., Saunders, 1992; Wheatley, 1991) or for curriculum development (Cheung & Taylor, 1991). In summary, the shifts in our views of learning and of knowledge have affected research activities and scholarly work in many fields including science education. The two shifts in the views of knowledge and of learning are also related in that there is considerable correspondence between the two views because both are based on the main assumptions of constructivism and conceptual change. In particular, both views emphasise understanding the world as the purpose of learning or scientific activity, the active role of the learner or the scientist in constructing knowledge, the role of prior knowledge (as opposed to the inductive model of learning and of scientific knowledge), and the important role of conceptual change and knowledge restructuring (as opposed to gradual knowledge accretion).

In this study the recent views of both knowledge and learning were defined by identifying six components along which each of the two recent views differ from the early views of knowledge and learning that were generally accepted in the fields of philosophy of science, psychology and education prior to the shift described above. These components are described in detail in the next section. However, it is important to point out here that the recent views, as identified in this study, are based on both the constructivist and the conceptual change views of knowledge and learning, while the early views are based on the empiricist and behaviourist views. This does not mean that the study equates constructivism with conceptual change or empiricism with behaviourism; it merely acknowledges that our recent views are largely affected by both constructivism and conceptual change, while the early views were largely affected by empiricism and behaviourism. Indeed, the paradigm shift might not represent a complete inconsistency between the recent and the early views; it has been pointed out that constructivism and empiricism share some common assumptions (Matthews, 1992).

This shift, however, seems not to have affected science education programs or science teachers, at least in developing countries, (although as will be seen later, a review of studies of science teachers' beliefs in developed countries shows that the majority hold beliefs unaffected by the aforementioned shift). The discovery method, with its emphasis on induction, is still advocated as *the* method for science teaching in spite of the fact that this inductivist approach contradicts with the new constructivist view of learning and knowledge (Driver, 1983). Observations of classroom teaching show that lecturing and the neglect of students' ideas are the prominent methods of teaching, in spite of their contradiction with a constructivist basis of learning and teaching that focuses on students' prior ideas and the active construction of knowledge by the learner. The present study aimed at identifying teachers whose beliefs about learning and knowledge were congruent with the new epistemological basis of science education (Cleminson, 1990).

The study of science teachers' beliefs, and their epistemological beliefs in particular, is not a completely new endeavour. Billeh and Malik (1977) and Carey and Stauss (1968) studied science teachers' understanding of the nature of science and found it low. The majority of recent studies show that science teachers are not constructivist in their beliefs. Many studies concluded that teachers are predominantly scientific and positivistic in their views of scientific knowledge (Elkana, 1970; Hodson, 1985; Nadeau & Desautels, 1984). Recent studies, which employed qualitative or interpretive research methodologies, found that the great majority of science teachers hold beliefs that are incompatible with a constructivist view of knowledge (Benson, 1989;

Gallagher, 1991) or with a constructivist view of knowledge and learning (Prawat, 1992). The only recent exception to these findings has been a study by King (1991) which found that beginning teachers held beliefs closely related to constructivism. While all previous investigations have studied experienced science teachers, the last one studied beginning teachers, a difference that could account for the contradiction. Finally, it should be pointed out that, with the exception of Prawat's study (1992), these investigations examined teachers' beliefs about knowledge, and not beliefs about both knowledge and learning, which was the purpose of the present study.

In particular, this study aimed to answer the following questions:

1. What percentage of Palestinian science teachers hold beliefs that are compatible with the recent views about learning and scientific knowledge?

2. Do factors such as teacher education, specialisation, experience or the grade levels at which they teach affect these beliefs?

3. Are the beliefs about learning and about knowledge related?

## Method

### *Method and Sample*

Two questionnaires were developed as described below, and distributed and collected by the investigator. The population of the study consisted of about 300 science teachers in the central area of the West Bank, and about 40 science faculty members in one college in the area. The questionnaires were distributed to a random sample of about one third of this population. Ninety one teachers (about 90% of the sample) with an average of 12.5 years teaching experience answered the questionnaires. (The term teacher is used generically to include college faculty). Table 1 describes the characteristics of the sample.

Table 1
*Characteristics of the Sample*

| | Education | | | | |
|---|---|---|---|---|---|
| | PhD | MSc | BSc | Community College | Other |
| Percentage | 11.0 | 7.7 | 50.5 | 28.6 | 2.2 |
| Teaching grade level | 1-6 | 7-9 | 9-12 | 13-16 | |
| Percentage | 20.0 | 31.1 | 35.6 | 13.3 | |
| Specialisation | Physics | Chemistry | Biology | Other Science | Non Science |
| Percentage | 15.4 | 18.7 | 9.9 | 45.0 | 11.0 |

*Instruments*

Two questionnaires of teacher beliefs were developed over a period of six years. The first form of these questionnaires consisted of open-ended questions asked during intensive interviews with six science teachers in the United States (Hashweh, 1985). The second form consisted of 55 open-ended or closed-ended dichotomous items that were answered by 19 grade eight science teachers participating in an in-service course in the West Bank. The responses were used to develop a third form. This form was pilot tested on a sample of 30 teachers. Slight modifications in the wording of the items resulted from this trial.

The final form consisted of two questionnaires each of which consisted of 30 dichotomous items. The Questionnaire of Teacher Beliefs About Learning (TBAL) aimed at distinguishing between teachers who held recent and early views about learning. Six components along which the two views of learning differed were identified, and items were constructed to probe these components. The recent view, which draws on the main ideas of constructivism and conceptual change, describes an active learner who is internally motivated to construct his or her own knowledge in order to understand. The view acknowledges that the learner, consequently, has developed many ideas on his or her own, many of which are incompatible with the accepted scientific ideas. As a result, learning in science often entails knowledge restructuring, and the learner can do that on a rational basis if he or she is aware of the limitations of these prior ideas. In contrast, the early view describes a relatively inactive and externally motivated person whose mind is almost empty or has some prerequisite knowledge. Learning, according to this view, is mainly a gradual process of knowledge accretion. Table 2 summarises the differences between the two views.

Table 2
*Components of Two Views of Learning*

| | Recent | Early |
|---|---|---|
| L1 | Learner changes behaviour if positively reinforced. | Active learner who has an urge to understand and constructs knowledge for this purpose. |
| L2 | Learner does not have many ideas about science before instruction. Prior knowledge important as prerequisite. | Learner developed many ideas on his or her own and uses them to understand new ideas. |
| L3 | Teacher not aware of presence of students alternative conceptions. | Many preconceptions (alternative conceptions) are inconsistent with orthodox science. |
| L4 | Learning in science largely a gradual process, involves knowledge accretion. | Learning in science often a conceptual change process, involves knowledge restructuring. |
| L5 | Emphasis on external reinforcement as basis of change. | Rational basis of conceptual change important. |
| L6 | Strategies involving neglecting alternative conceptions (if they exist) important. | Strategies involving confronting alternative conceptions important. |

Eighteen of the 30 items comprising the questionnaire asked the respondent to choose out of two statements the one that was closer to his or her point of view. The remaining twelve items required the respondent to agree or disagree with a statement. The two types of items were randomly ordered in the questionnaire. Representative items are found in Appendix 1. The questionnaire's reliability, using the Kuder-Richardson 20 method and the present sample was found to be .70.

The questionnaire of Teacher Beliefs About Knowledge (TBAK) aimed at distinguishing between teachers who held the early view about scientific knowledge and those who held the recent view that was more in agreement with the view presented by the new philosophy of science. Six components along which the two views differed were identified, and the items were developed to asses the differences along these components. The recent view maintains that the main aim of science is to develop theories to understand the world, absolute objectivity is impossible (observations are theory-laden), testing theories against experience is more important than their origins, scientific knowledge is tentative and invented, and emphasises the importance of scientific revolutions and conceptual change. In contrast, the early view maintains that the aim of science is to collect facts about the world, scientific knowledge is absolutely objective, permanent, and discovered (rather than invented), and emphasises the role of observations, the scientific method (as an inductive process) and the gradual and accumulative aspects of the growth of scientific knowledge (rather than the conceptual change aspect). Table 3 summarises the differences between the two views.

Representative items of the 30 items that comprised this questionnaire are found in Appendix 1. The questionnaire reliability (KR20) was .53. (This is satisfactory, however, since KR20 produces a lower bound for reliability and should be used with homogenous tests. The questionnaire was heterogeneous as will be shown later, and in this case KR reliability is usually inappropriately low (Allen & Yen, 1979, pp. 83-84)).

Table 3
*Components of Two Views of Scientific Knowledge*

| | Early | Recent |
|---|---|---|
| K1 | Scientific knowledge as gathering facts about the world. | Scientific knowledge as developing theories to understand the world. |
| K2 | Objectivity is central to scientific knowledge. Knowledge *is* objective. | Absolute objectivity is not possible (observations are theory-laden). |
| K3 | Scientific knowledge develops inductively from facts gathered objectively. Importance of observations and scientific method (defined as an inductive process). | Origins of theories unimportant: testing them against experience is. Importance of hypothetico-deductive approach and less emphasis on method. |
| K4 | Scientific knowledge is certain; it does not change. | Scientific knowledge tentative and not proved; it might change in the future. |
| K5 | Scientific knowledge exactly represents nature; it is discovered. | Scientific knowledge does not exactly represent nature; it is invented. |
| K6 | Scientific knowledge develops gradually with the new building on the old. Emphasis on knowledge accretion. | Scientific knowledge often develops through revolutions. Emphasis knowledge restructuring and conceptual change. |

*Data Analysis*

In order to answer the first study question, about the percentage of teachers holding recent beliefs about learning and knowledge, a teacher was considered to be holding recent beliefs about knowledge or learning if he or she chose a recent answer to at least two thirds of the items, while a respondent was considered to hold early beliefs if he or she chose an early answer to at least two thirds of the items. Answers to each of the components (previously described in Tables 2 and 3) were analysed in a similar manner.

Each respondent was given a grade of zero if his or her choice to an item indicated an early view and a grade of one if it indicated a recent view. Thus, the lowest possible grade on any of the two questionnaires was zero, indicating an extremely early view. The highest possible grade of 30 indicated an extremely recent view. To determine the relationships between number of years of schooling, number of years of teaching experience, and the grade level at which the teacher taught on the one hand and their beliefs on the other hand, the correlations between each of these variables and the total scores on each of the two questionnaires were calculated. A one-way analysis of variance was conducted for each of the two total questionnaire scores to determine the relationships between teacher specialisation and teacher beliefs about knowledge and learning. Finally, the correlation between the total scores on the two questionnaires was calculated to determine the relationship between teacher beliefs about knowledge and about learning.

## Results and Discussion

*Teacher Beliefs About Learning*

Table 4 shows the mean scores of the teachers on the Questionnaire of Teacher Beliefs About Learning and on each of its components. One hundred percent on the total grade or on any of the components indicates that a teacher chose recent answers to all items, while a zero indicates a choice of early answers to all items.

Table 4
*Mean Teacher Scores (percent) on the TBAL Questionnaire and its Components*

| | | Components (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | L1 | L2 | L3 | L4 | L5 | L6 |
| Mean | 54.23 | 57.89 | 39.38 | 43.13 | 51.10 | 85.16 | 63.55 |
| S.D. | 14.38 | 18.45 | 26.58 | 30.58 | 22.85 | 25.13 | 30.95 |

Note. A score of 100 on the total or on any of the components indicates that the respondent had chosen recent answers to all relevant items.

Table 5 shows the percentage of teachers who held recent and early beliefs about learning, as defined previously.

Table 5
*Percentage of Teachers Holding Recent and Early Views about Learning*

| | Components (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | L1 | L2 | L3 | L4 | L5 | L6 |
| Recent | 25.3 | 24.2 | 26.4 | 14.3 | 36.3 | 72.5 | 68.1 |
| Early | 8.8 | 17.6 | 52.7 | 27.5 | 34.1 | 2.2 | 31.9 |

Note. A score of 100 on the total or on any of the components indicates that the respondent had chosen recent answers to all relevant items.

Examination of Tables 4 and 5 shows that, while the majority of the teachers held views that were neither recent nor early, about a quarter of the teachers held recent views about learning while about nine percent held early views about learning. Few teachers believed that students hold preconceptions about science phenomena (L2) (about a quarter of the sample compared to about a half who believed that students do not hold preconceptions and that their minds are more or less blank slates with regard to science).

It is interesting to note that a smaller percentage (14.3%) believed that these preconceptions were sometimes in conflict with orthodox science conceptions (L3). The majority were not aware of the presence of students' alternative conceptions. Examination of the scores and percentages on other components reveals that a high percentage believed in the rational basis of conceptual change and only about two percent were clearly against this basis of change (L5). Thus, in addition to the two relatively small groups of teachers who held either recent or early views about learning, there was a majority that held a view that incorporated components from the two views defined in this study. Specifically, the majority accepted the rational basis of conceptual change (a component of the recent view) and at the same time were not aware of the presence of students' alternative conceptions (a component of the early view). The two components, (L3) and (L5), did not discriminate well between the different groups of teachers. Table 6 substantiates this assertion and shows little relationships between each of L3 and L5 on the one hand and the other components and the total score (L) on the other hand.

Table 6
*Correlation Coefficients between the Components and the Total Score on TBAL*

| | L1 | L2 | L3 | L4 | L5 | L6 | L |
|---|---|---|---|---|---|---|---|
| L1 | 1.00 | | | | | | |
| L2 | .36 | 1.00 | | | | | |
| L3 | .07 | .11 | 1.00 | | | | |
| L4 | .48 | .20 | .18 | 1.00 | | | |
| L5 | .07 | .11 | .10 | .10 | 1.00 | | |
| L6 | .31 | .36 | .10 | .22 | .04 | 1.00 | |
| L | .83 | .65 | .16 | .70 | .05 | .55 | 1.00 |

*Teacher Beliefs About Scientific Knowledge*

Table 7 shows the mean scores on the Questionnaire of Teacher Beliefs About Knowledge and on each of its components.

Table 8 shows the percentages of teachers holding recent and early views about scientific knowledge.

Table 7
*Mean Teacher Scores (percent) on the TBAK Questionnaire and its Components*

| | | Components (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | K1 | K2 | K3 | K4 | K5 | K6 |
| Mean | 45.95 | 33.52 | 51.76 | 39.67 | 61.21 | 50.55 | 26.74 |
| S.D. | 11.54 | 26.91 | 21.46 | 17.29 | 22.91 | 25.55 | 25.66 |

Note. A score of 100 on the total or on any of the components indicates that the respondent had chosen recent answers to all relevant items.

Table 8
*Percentage of Teachers Holding Recent and Early Views about Scientific Knowledge*

| | | Components (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | K1 | K2 | K3 | K4 | K5 | K6 |
| Recent | 8.8 | 33.0 | 18.7 | 11.0 | 35.2 | 42.9 | 17.6 |
| Early | 27.5 | 65.9 | 17.6 | 39.6 | 9.9 | 30.8 | 82.4 |

Note that about two thirds of the teachers believed the main aim of science was to gather facts about nature (K1), about 40% believed science developed inductively from objective facts-gathering (K3), and that more than 80% believed it developed through accretion, with the old knowledge not changing, but forming a basis for the new knowledge (K6). Very few teachers (about nine percent) were recent in their views of scientific knowledge while about a quarter held early views, in contrast to the teacher beliefs about learning where about a quarter held recent views and only about nine percent held early views. It seems that Palestinian science teachers are more influenced by the early beliefs about the nature of scientific knowledge than by the early beliefs about learning and the nature of the learner. This is not really surprising. Science students are socialised through their studies at school and college to view science as objective, reliable, methodological, and built inductively on a solid bed of hard facts, hence it develops gradually through accretion. An examination of the school science textbooks used in the West Bank shows that on many occasions, and in particular when classroom or laboratory activities are presented, science is portrayed as mainly an inductivist-empiricist activity. In these activities, the student is usually asked to observe and collect information as the first step of the activity, and in most cases without explaining the purpose of the activity. The student is then asked, "What do you

conclude?" That is, the textbooks expect the student to collect information with no prior hypothesis about the problem, and then to reach a generalisation (conclusion) inductively.

Other factors probably contribute to reinforcing this early view of knowledge. Firstly, in Palestinian schools knowledge explained by the teacher and found in one official textbook is unquestionable and is to be remembered for future use only. Secondly, the school examination system focuses on the memorisation of information. Thirdly, there is high esteem in the Palestinian society for Western scientific knowledge. This might cause the Palestinian teachers to accept both the scientific knowledge and the empiricist beliefs about its nature which come with it in the same package. Finally, mostly male school teachers are usually unchallenged; although the Palestinian society is probably not as patriarchal as some other Eastern societies, knowledge is still legitimised by the status of the person who has that knowledge.

It is tempting to try to attribute the fact that only about nine percent held recent views about knowledge while about a quarter held early views to cultural factors. However, in light of the fact that the results of this study are in agreement with the results of formerly discussed investigations that examined teachers' beliefs about scientific knowledge in developed countries (e.g., Benson, 1989; Gallagher, 1991; Prawat, 1992), it seems that cultural factors are not the main contributing factors to these beliefs.

The empiricist and behaviourist beliefs about learning and the nature of the learner, in contrast, are part of a field (psychology) that is not regarded as highly as natural science especially by science students. In addition, many of the Palestinian teachers are teaching with no teaching credentials, that is without completing pre-service teacher education programs, and have not been exposed to these beliefs in educational psychology classes. Thus, science teachers are less likely to be influenced by early beliefs about learning than by early beliefs about knowledge.

It should be pointed out, however, that the low percentage of teachers holding recent beliefs about knowledge may also be a result of the relatively higher heterogeneity of the questionnaire about knowledge compared to the questionnaire about learning. Note that while very few teachers accepted that science was not completely objective, or not based on induction, yet more than a third accepted that scientific knowledge did change and develop with time. Table 9 shows the relative heterogeneity of the items of the questionnaire.

Table 9
*Correlation Coefficients Between the Components and the Total Score on TBAK*

| | K1 | K2 | K3 | K4 | K5 | K6 | K |
|---|---|---|---|---|---|---|---|
| K1 | 1.00 | | | | | | |
| K2 | .01 | 1.00 | | | | | |
| K3 | .20 | .12 | 1.00 | | | | |
| K4 | .07 | .03 | .05 | 1.00 | | | |
| K5 | .06 | .18 | .02 | .26 | 1.00 | | |
| K6 | .11 | .12 | .11 | .12 | .16 | 1.00 | |
| K | .25 | .49 | .56 | .47 | .62 | .44 | 1.00 |

*Factors Affecting Teacher Beliefs*

Number of years of schooling, number of years of teaching experience, and the grade levels at which the teacher taught were found unrelated to teacher beliefs about learning or knowledge (small and statistically insignificant correlations). The specialisation of the teacher was also found unrelated to the teacher belief (a one-way analysis of variance was conducted for the total score on each of the questionnaires with the teachers divided into five groups: science, physics, chemistry, biology, and non-science specialisations. The F values in both cases were statistically insignificant).

*Relationship between Beliefs About Learning and About Knowledge*

Finally, the study aimed at finding out if teacher beliefs about learning and about knowledge were related. The correlation coefficient between the scores on both questionnaires was .3 and was found to be statistically significant ($p < .01$). This result empirically supports the logically derived relationship between the two views. However, it should be pointed out that the relationship is weak although it is statistically significant. This is not inconsistent with the previous findings that more teachers held early beliefs about knowledge than about learning. We have argued that educational factors might explain this inconsistency between views about learning and about knowledge.

## Summary and Conclusion

The study showed that only a small minority of Palestinian teachers held recent views about learning and scientific knowledge (25% and nine percent respectively). With regard to the views of learning, this was mainly due to very few believing or realising that students hold alternative preconceptions, and that science learning entails conceptual change. Very few teachers also believed that science itself develops through conceptual change. Indeed, more than 80 percent believed that science develops through accretion, and about 40% preferred the inductive model of science to the hypothetico-deductive one, which only 11% preferred. It was found that these views were not related to the teachers' years of schooling, years of experience, level at which they taught, or teacher specialisation. The two views of learning and knowledge were moderately related.

The fact that the majority of the teachers did not hold recent or early views might be due to the fact that these teachers held a mixture of views, had not developed clear epistemological views, or held views that could not be captured by the methodology or the instruments used in the present study. It is appropriate that some limitations of this study be pointed out. Some science educators would argue that teachers do not hold generalised and stable beliefs but hold implicit and context-bound beliefs, and consequently, would argue against the use of the methodology of this study. In the opinion of this writer, whether teachers hold generalised stable beliefs or not is an empirical question that has still to be answered, and the present study shows that at least a minority of teachers hold stable and general beliefs. At the same time, one has to admit that the present methodology does not capture the context-bound implicit teacher beliefs in which one might be interested.

Another limitation of the present study and other similar studies that use questionnaires to identify beliefs is the problem of multiple interpretations of respondents (Aikenhead, Fleming, & Ryan, 1987). For example, different respondents might have different meanings for the term

*science is objective*. A third limitation, which has been mentioned earlier, is that although the questionnaires have been based on a dichotomy between recent and early views, constructivism and empiricism, which constitute the important elements of the two views, are not completely contradictory. A fourth limitation is related to the small reliability coefficient of the Teacher Beliefs About Knowledge Questionnaire. There is a need to develop an instrument with a higher reliability. However, in spite of these limitations, the instruments used in this study still offer the most effective means of conducting investigations using samples large enough to identify the minority of teachers who hold recent epistemological views, that minority whose beliefs seem to positively influence their practice. The teachers holding recent beliefs identified in this study were found to exhibit different and potentially more effective teaching practices compared to teachers holding early beliefs even when a period of one year separated the identification of these teachers and the investigation of their teaching practices (Hashweh, in press). This strongly validates the instruments and methodology of the present study in spite of the limitations.

The findings of the present study show that Palestinian teachers' epistemological beliefs are not different from science teachers' beliefs in the developed countries. Consequently, it becomes interesting to investigate how science teachers' beliefs, and the public epistemological beliefs in general, develop in different societies. The effects of schools and the public media, and television in particular, are some obvious starting points for these studies.

Other important questions that arise are how persistent these teacher epistemological beliefs are, and under what conditions and for what reasons would teachers change these views. Some researchers in science education are starting to address these questions (e.g., Etchberger & Shaw, 1992).

Previous studies (Hashweh, 1985) have shown that constructivist teachers have a rich repertoire of potentially effective strategies for inducing student conceptual change. Since these teachers constitute a small minority among science teachers, they should be observed and their pedagogical content knowledge (Hashweh, 1985) made explicit, described and shared. Additional studies that explicate the influence of science teachers' epistemological beliefs on teaching are needed. While it is intuitively obvious that teacher beliefs would influence teacher behaviour, it is necessary to go beyond this and carefully describe what specific beliefs influence what specific teacher behaviour. Some studies are starting to investigate this question (Hashweh, in press). However, this is a burgeoning area of research with no clear outcomes. In a review of the few studies that have investigated the influence of teachers' conceptions of the nature of science on classroom practice, Lederman (1992) found contradictory results and concluded that "complex issues surround the possible influence of teachers' understanding of the nature of science on classroom practice and have yet to be resolved" (p. 347).

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## Appendix 1

Representative items from the teacher beliefs about learning and about knowledge questionnaires.

Teacher Beliefs about Learning:

*L1 (Active Learner–Constructs knowledge):*

Item 27 If a student does not understand part of what I have taught, the reason probably is:
- a) The student does not pay attention; if students pay attention they should understand what a teacher explains well.
- b) The student considered what was explained unimportant, or connected it to previous ideas in a manner that led to misunderstanding.

*L2 (Learner developed ideas on his/her own):*

Item 8 The student has formed ideas about many topics in science before studying these topics in the classroom.
a) Agree b) Disagree

*L3 (Many of these conceptions are inconsistent with science):*

Item 21 Students hold ideas that are inconsistent with the modern scientific ideas in many topics in science.
a) Agree b) Disagree

*L4 (Science learning involves conceptual change):*

Item 9 The main role of the teacher is to:
- a) Present scientific knowledge in an organised manner
- b) Help students change their ideas about natural phenomena.

*L5 (Rational basis of conceptual change):*

Item 7 It is best to try to change students' ideas through
a) Drill and positive reinforcement
b) Rational discussion

*L6 (Strategies involving confrontation):*

Item 23 When I discover that students hold ideas that contradict with the scientific ideas that I teach, I:
a) Ignore these ideas and concentrate on teaching the acceptable scientific ideas in an organised manner.
b) Confront these ideas and show their limitations in comparison with the acceptable scientific ideas.

Teacher Beliefs about Knowledge

*K1 (Development of theory to understand nature);*

Item 1 The most important aim of science is to gather facts about scientific phenomena.
a) Agree b) Disagree

*K2 (Objectivity of science–observations are theory-laden):*

Item 8 Science is based on an objective description of nature.
a) Agree b) Disagree

*K3 (Induction and role of "scientific method"):*

Item 9 When scientists used the scientific method that is based on the careful observation of nature rapid scientific progress started.
a) Agree b) Disagree

*K4 (Tentativeness of scientific knowledge):*

Item 4 Scientific knowledge resulting from a specific research project might change in the future even though the research was properly conducted.
a) Agree b) Disagree

*K5 (Invention of scientific knowledge -- representation of nature):*

Item 18 Many of the scientific models are invented by scientists and do not claim to be duplicates of reality.
a) Agree b) Disagree

*K6 (Conceptual change model of scientific progress):*

Item 21 Scientific knowledge develops in a gradual, orderly and accumulative manner; it is not subject to conceptual revolutions like other branches of knowledge.
a) Agree b) Disagree