IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education

2013, volume 2, issue 2

DEVELOPMENT OF AN INSTRUMENT TO DETERMINE SCIENCE TEACHERS' IMPLEMENTATION OF INQUIRY BASED SCIENCE EDUCATION IN THEIR CLASSROOMS

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ABSTRACT

The main aim of this article is to develop and validate an instrument on the usage of Inquiry-based Science Education by science and technology teachers in their classrooms. The questionnaire was developed on the basis of a literature review and prior instruments developed on inquiry-based science education (IBSE). The first version of the questionnaire was in English to seek international validation from expert. The instrument was subsequently carefully translated into Turkish. The Turkish translated version of the questionnaire, consisting of 27 Likert-type items, rating IBSE teaching and learning according to the frequency with which teachers apply these in their classroom, was distributed to 788 Turkish science teachers working in public schools in Turkey. The instrument was found to be internally consistent with high reliability scores. The results, based on the factor analysis, showed three factors named as structured, guided and open inquiry. Outcomes from this study revealed that the instrument is useful for assessing the extent to which science teachers using scientific inquiry in their classroom. The results provide evidence that the instrument is valid for further implementation on a wider scale and in larger samples.

Keywords: Inquiry based science education (IBSE), science teacher, Instrument.

INTRODUCTION

The quality of science education, which affects the future of countries, has priority internationally (European Commission 2004; 2007). There is a clear consensus that rich science education environments provide education to individuals to become scientific literate people (Abd-El-Khalick et al. 2004; Minner et al. 2010). According to The National Research Council (NRC 2000), scientific inquiry and teaching practices are defined as a set of interrelated processes by which students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a meaningful understanding of concepts, principles, models and theories. Inquiry is a critical component of a science program at all grade levels and in every domain of science, so much so that designers of curricula and programs need to ensure that the approach to learning, as well as the teaching and assessment strategies, reflect the acquisition of scientific understanding through inquiry. Students can then appreciate science in a way that reflects how science actually works (NRC, 2000, p. 214).

Science educators have suggested that many benefits accrue from engaging students in inquiry-type science activities. Studies indicate that the use of innovative and authentic inquiry-based practical approaches support not only student's learning of high-level investigative skills, but also enhance and develop students' meaningful learning, conceptual understanding, understanding of the nature of science, critical-thinking and communication skills (Kask & Rannikmäe, 2009; Laius et al., 2008; Trumbull, et al, 2005). Teachers play important roles in planning and implementing the type and suitability of science practical activities. It is shown in many studies that such experiences can have a powerful influence on students' understanding of science and their interest in science teaching (Boardman et al., 1999; Dana et al., 2000; Smith & Anderson, 1999; Zembal-Saul & Oliver, 1998; Blumenfeld et al., 2006; Hofstein et al., 2005).

It is clear from many studies that European students' interest in science, mathematics and technology has been declining while their grade levels have increased. Another alarming issue for Europe is the recruitment of students for science and technology related careers. According to ROSE project results, few girls wish to become scientists and even for boys, the percentage is low. While, in Europe, around 50% boys gave a positive response to the question: "I would like to get a job in technology," very few girls indicated that they would like to pursue such a career option (Sjoberg & Schreiner, 2010). These kinds of results from project reports highlight the urgent need for more effective action in the teaching and learning of science in schools. According to a report published by the European Commission (2007), the science education community mostly agrees that pedagogical practices based on inquiry-based methods are more effective for the teaching and learning of science.

However, the reality of classroom practice is that in the majority of European countries, these methods are only being implemented by relatively few teachers (Abd-El-Khalick et al., 2004; Kask et al., 2008; European Commission, 2007). Reports from European Commission continue to explain the advantages of inquiry-based science education and the recommendations clearly promote the use of IBSE for the teaching and learning of science in Europe (Cavas, 2012). However, it is not clear to what extent teachers use inquiry teaching and learning in their classrooms, as there is no clear report or studies which show the usage of inquiry methods by teachers. A similar situation exists in the USA. For example, Crawford (2006) mentioned that they are far from attaining a national stated goal of a shift in emphasis towards more inquiry-centered K-12 classrooms. She indicates that not all in the K-12 science teaching community embrace these recommendations. It is also reported that many teachers have difficulty to create inquiry based classrooms that support students in developing informed views of scientific inquiry and the nature of science (Chiapetta & Adams, 2000; Lederman, 1992; Marx et al., 1994; Minstrell & van Zee, 2000; Windschitl, 2004; Windschitl et al., 2008).

In the light of the above discussion, it seems that there is a need to clarify teachers' preferences related to their use of inquiry-based science education in the classroom. For a science teacher to enact teaching science as inquiry, the teacher is required to develop approaches that situate learning in authentic problems, model actions of scientists in guiding and facilitating students to make sense of data, and support students in developing their personal understandings of science concepts (Crawford, 2007). The complexity of teaching science as inquiry in a K-12 school setting, and the demands on a teacher to take on a myriad of roles, may be important reasons why this kind of teaching is so rare (Crawford, 2007). The main aim of this study is to develop a valid and reliable instrument which determines science teachers' usage of inquiry-based science education in their classroom. The data collected from science teachers is expected to give further insights for designing and re-constructing better teaching strategies and learning environment orientations.

Theoretical Background

Inquiry has been a well-known teaching and learning science education method in many countries for the last decade. However, there is no clear definition about the inquiry. Actually, the term "inquiry," meaning, "search for truth," appears frequently in writings by philosophers but not so often in the work of social science researchers. The earliest known philosophical writings are thought to have been written around 1500 B.C. Then, as now, philosophers wrestled with questions about the nature of existence, knowledge, morality, reason and purpose or meaning (Michael, 2002). It is clear that there are many contributions from the longstanding dialogue about the nature of learning and teaching, in particular from the work of Jean Piaget, Lev Vygotsky, and David Ausubel. Contributions from these well-known theorists were blended into a philosophy of learning known as constructivism (Cakir,

2008) which was then used to shape instructional materials. These materials, based on constructivism, were named as inquiry-based and include hands-on activities to increase motivation of students and to engage them in concretizing science concepts. Scholars have promoted inquiry-based teaching methods for science classrooms since the time of Dewey (1997).

Inquiry

Wells (2001) argues that "Inquiry is not a 'method' of doing science, history, or any other subject, in which the obligatory first stage, in a fixed, linear sequence, is that of students formulating random questions to investigate. Rather, it is an approach to the chosen themes and topics in which the posing of real questions is positively encouraged, whenever they occur and by whoever they are asked. Equally important as the hallmark of an inquiry approach is that all tentative answers are taken seriously and are investigated as rigorously as the circumstances permit." Clearly the questions posed need to have importance and would be expected to provide a direction for a more positive image of science if students were determining the importance in this case.

In this study, we define inquiry mainly as "asking questions." noting that inquiry is actually much more. Inquiry includes science process skills to find answers for the question defined. It includes also socio-scientific problematic situations, because many questions can be based on the daily life.

The current study bases its view of inquiry on models of the inquiry cycle, described by the National Research Council (NRC) (1996) and developed by Dunkhase (2003) and Llevellyn (2002), through which the inquiry cycle is considered to involve 7 important stages:

- Identifying and posing appropriate scientifically oriented questions;
- making prediction / developing hypothesis;
- designing and conducting investigations;
- identifying variables;
- collecting data;
- analyzing data to develop patterns;
- communicating and connecting explanation.

Inquiry teaching

Inquiry teaching refers to the pedagogical approach that model aspects of scientific inquiry (Deboer, 2006). Inquiry teaching is an approach to teaching that involves students in a process of exploring the natural and material world that leads to asking questions and making discoveries in the search of new understanding.

Research has convincingly demonstrated the benefits of inquiry teaching, which contribute to:

- students' cognitive development (Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005; Wallace, Tsoi, Calkin & Darley, 2003),
- the development of flexible and adaptive thinkers, and the encouragement of students' creative thinking and handling risk-taking situations (Zion, 2007; Gürses, Açıkyıldız, Doğar & Sözbilir, 2007; Trumbull, Bonney & Grudens-Schuck, 2005).

Furthermore, research has also pointed to the importance of the students' affective domain - motivation and positive attitudes towards undertaking science learning (Blumenfeld, Kempler, Krajcik, 2006; Chin & Kayalvizhi, 2005).

Levels of inquiry teaching

Based on the level or degree of students' involvement in the active learning process, three different *settings of inquiry teaching* can be differentiated. Differences, relating to the manner in which the experimental procedure or design is developed, can also be considered. Table 1 shows these settings.

Table 1. Different settings of inquiry teaching

Model of inquiry teaching	**Question investigated presented/posed by**	**Procedure prescribed/ designed by**	**Procedure for data analysis/ interpretation & making conclusion**
Structured inquiry	Presented by teacher	Prescribed by teacher	Procedure teacher directed and prescribed; student interpreted.
Guided inquiry	Usually presented by teacher	Usually designed or selected by students	Usually teachers guided, but student interpreted
Open-inquiry	Posed by students	Designed by students	Student led procedures and interpretation

Structured inquiry relates to a teaching approach, which involves an active teacher, but passive students: the student activities are directed and guided by the teacher. The students are given little freedom to do something by themselves. In structured inquiry, the students investigate a teacher-presented question through an exactly prescribed procedure, often coming from the textbook or a worksheet. Although the student is usually asked to interpret the outcomes, this tends to follow reasoning in a narrow subject matter context (Wee *et al*., 2004).

Guided inquiry involves the teacher, for the most part, in presenting the investigation question, but usually allows students to design or select procedures. Its strength over structured inquiry is that it includes student-created design/planning involvement as well as interpreting findings and drawing conclusions. This form of inquiry teaching does involve students in taking some responsibility for their activities and is a step on the way to the full involvement of students as is the case in open inquiry (Zion, 2007).

In open-inquiry, also called authentic inquiry, the teacher takes the responsibility to define the knowledge framework in which the inquiry is to be conducted, but leaves the students with the task of considering a wide variety of possible inquiry questions. In the course of open inquiry, the students investigate topic-related questions through student-designed procedures and take responsibility for the data collection, analysis reporting and the drawing of conclusions. The students experience decision-making throughout each stage of the inquiry process (Krajcik, Czerniak & Berger, 2003; Wee *et al*., 2004; Zion, 2007).

Problems related to Teaching and Learning Science as Inquiry

The implementation of inquiry lessons by science teachers is influenced by a multitude of factors. For example, Carlsen (1993) and Hashweh (1987) found that science teachers who implement inquiry-based instruction need to understand the prominent concepts in their discipline. This understanding encompasses not only the facts and principles of the discipline, but also the processes and nature of science (Duschl, 1987). Furthermore, although this knowledge is connected and accessible to the science teacher (Gess-Newsome & Lederman, 1993), a lack of competence often leads to knowledge that is fragmented or compartmentalized and does not help the teacher in crafting instruction that best represents science as inquiry (Rannikmäe, 2008).

Although inquiry is included in curricula of many countries and recommended by science educators and researchers worldwide, reports of problems in its implementation in the science classroom are commonplace.

- Inquiry teaching needs the science teacher to possess strong science knowledge, understanding and abilities in utilising experimental skills. Many teachers tend to use a simplified or deformed interpretation of inquiry (van der Valk & de Jong, 2009; Akerson, Hanson & Cullen, 2005; Shedletzky & Zion, 2005; Windschitl, 2004). Teachers with naïve or deformed understanding of scientific inquiry are not able to teach authentic inquiry (Chinn & Hmelo-Silver, 2002).
- Teachers are expected to design a suitable learning environment in which learners can seek, share, construct knowledge and develop skills through undertaking an inquiry process. Research has reported that teachers are not able to do that (Abd-El- Khalick et al., 2004; Justice et al., 2009; Sandoval, 2005; Hofstein, Shore & Kipnis, 2004, Laius et al, 2009).
- Students perceived poorly planned and executed structured inquiry by teachers as boring and this fact decreases the positive attitude towards learning in science within school (Millar, 2005). On the other hand – some students express a strong sense of frustration of not "knowing the right answer," instead of the expectation that students arrive at an outcome on their own using the inquiry process (Wenning, 2005).

The literature consists of many articles which supports inquiry learning in science courses. However, the researchers in these studies indicate that it is yet to be applied extensively in the average teacher's daily practice (Asay & Orgill, 2010; Goodrum et al., 2001).

Methodology

In order to develop a reliable and valid instrument which determine teacher's usage of IBSE in their classroom, a five stage development model is used (Campbell, 2010) These stages are: (a) category development and the formation of an item pool, (b) use of both national and international content experts to establish content validity, (c) refinement of the item pools based on reviewer comments, (d) pilot testing, and (e) statistical item analysis leading to additional refinement and finalization of the instruments.

Category and Item Pool Development

The survey instrument was developed by the researchers after an extensive review of the literature and used scales in different educational backgrounds guided by the theoretical base of the study.

In order to provide face and content validity, more than 6 meetings were held with Turkish and Estonian content experts who reviewed the items within each category. The content experts were selected according to criteria related to their experience in inquiry based science education, pre-service and in-service science teacher continuous professional development and related publications focused on inquiry as an instructional strategy in the science classroom. Before each meeting, expert content reviewers were asked to provide comments regarding the validity of the questionnaire for determining teachers' usage of IBSE in their science classrooms. The comments from experts provided the establishment of content validity.

The final instrument consists of four parts.
The first part, which consist 4 questions, focuses on the demographic information about science teachers including gender, grade level, teaching subject and length of science teaching experience.
The second part consists of 11 Likert-type items which measure science teachers' perception about their students' expectations from their science courses.
In the third part, three different inquiry settings are given to teachers and they are asked to indicate their preferences as a percentage.
The fourth part of the questionnaire includes 27 items. The subjects were asked to respond using a five-point scale (from *almost never* to *almost always*). The score 1 represented the option "*almost*

never" while score 5 on the scale represented the category "*almost always*". All of the items were positively written.

Table 2. The dimensions of the questionnaire (4th part).

First dimension "Stages of IBSE"	Second dimension "Levels of inquiry"	
1. Identifying and posing appropriate scientifically oriented questions	Structured	*I supply scientific questions to be answered by my students*
	Guided	*My students and I discuss and create scientific questions together which my students then attempt to answer*
	Open	*My students are given opportunities to create scientific questions as part of teaching*
2. Contextualizing research questions in current literature/resources	Structured	*I provide my students with the relevant literature and other resources to develop their plans for investigations*
	Guided	*I guide my students to think about the relevant literature and other resources they need to find to develop their investigations*
	Open	*My students find related literature and resources by themselves to develop their investigations*
3. Making prediction / Developing hypothesis	Structured	*I help my students to develop hypotheses about the solution to a scientific problem*
	Guided	*I provide my students with a hypothesis which the students test through investigations*
	Open	*My students are given opportunities to develop their own hypotheses aligned with scientific questions*
4. Designing and conducting investigations	Structured	*I give my students step-by-step instructions so that they can conduct investigations*
	Guided	*I guide my students to plan investigation procedures*
	Open	*My students design their own procedures for undertaking studies*
5. Identifying Variables	Structured	*I tell my students the variables they need to control in undertaking their investigations*
	Guided	*I guide my students on identifying the variables to be controlled in an investigation*
	Open	*My students identify the variables that they need to control in carrying out investigations*
6. Collecting data	Structured	*I give my students step-by-step instructions for obtaining data/making observations*
	Guided	*I guide my students on how to collect data to solve a scientific problem*
	Open	*My students determine which data to collect for their investigations*
7. Analysing data to develop patterns	Structured	*I undertake to interpret the data collected by my students and ask them to make a record*
	Guided	*I guide my students to develop conclusions to scientific evidence*
	Open	*My students use data to develop patterns and draw conclusions by themselves*
8. Communicating and connecting explanation (Drawing conclusions)	Structured	*I give my students step by step instructions to allow them to develop conclusions from their investigations*
	Guided	*I guide my students to use experimental data to explore patterns leading to conclusions*
	Open	*My students develop their own conclusions from their investigations*
9. Socio-scientific Issues	Structured	*I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues*
	Guided	*I guide my students to consider their scientific results when making decisions on socio-scientific issues*
	Open	*My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues*

IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education 2013, volume 2, issue 2

Seven IBSE stages (identifying and posing appropriate scientifically oriented questions; Making prediction / Developing hypothesis; Designing and conducting investigations; Identifying Variables; Collecting data; Analyzing data to develop patterns; Communicating and connecting explanation), whereby each was described on three levels of the inquiry teaching (structured, guided and open).

1. Identifying and posing appropriate scientifically oriented questions — This category focuses on the extent to which teachers are responsible for identifying and posing appropriate scientifically oriented.
2. Contextualizing research questions in current literature/resources — This category focuses on the extent to which teachers are responsible for contextualizing research questions in current literature/resources.
3. Making prediction / Developing hypothesis — This category focuses on the extent to which teachers are responsible for making prediction / developing hypothesis
4. Designing and conducting investigations — This category focuses on the extent to which teachers are responsible for designing procedures for conducting investigations.
5. Identifying Variables — This category focuses on the extent to which teachers are responsible for identifying variables
6. Collecting data — This category focuses on the extent to which teachers are responsible for data collection during investigations.
7. Analysing data to develop patterns — This category focuses on the extent to which teachers are responsible for analysing data to develop patterns.
8. Communicating and connecting explanation (Drawing conclusions) — This category focuses on the extent to which teachers are responsible for Communicating and connecting explanation.
9. Socio-scientific Issues — This category focuses on the extent to which teachers use socio-scientific issues in their classroom.

Why the instrument is original?

Several instruments have been designed to determine teachers' usage of IBSE in the classroom. However, in general, these instruments are designed using logic and stages of scientific inquiry. The instrument developed in current study is based on 7 stages of scientific inquiry and described three levels of teaching for each stage. This allows measuring the steps used commonly in the science classroom by science teachers and the dominant level of inquiry teaching used. Data collected make possible evidence-based in-service courses to develop science teacher's professionalism to teach inquiry. The instrument developed in this study not only includes items from science process skills, but also includes items related to involvement of socio-scientific issues.

Administration

The questionnaire was administered to a convenience sample of 788 science teachers (434-primary science teachers; 354-physics, chemistry and biology teachers). Official permission was attained from the Izmir Education Directorate and the questionnaires were officially made available to the science teachers online. The sample size is considered to be good and consistent with sizes that have been used by other researchers developing instruments (Marek et al., 2003; 2008; Smith, 1993; Smolleck &Yoder, 2008).

As seen in Table 3, 35% of the teachers were male and 65% female. The grade levels at which the teachers were responsible for teaching were distributed approximately equally. Almost half of the science teachers were working at the primary level in state schools.

IOJPE
ISSN: 1300 – 915X
www.iojpe.org
International Online Journal of Primary Education
2013, volume 2, issue 2

Table 3. Characteristics of the participants

	%
Gender	
Male	35
Female	65
Grade level	
6	18
7	18
8	17
9	15
10	11
11	11
12	10
Teaching subject	
Primary science	55
Physics	15
Chemistry	14
Biology	16
Teaching experience	
1-5	16
6-10	12
11-15	23
16-20	25
20- +	24

Data Analysis

The data were analyzed by utilizing SPSS 13.0 for Windows. Descriptive statistics were used to describe and summarize the properties of the mass of data collected from the respondents.

Internal Consistency

Internal consistency is defined as the extent to which items in the instruments are ''at least moderately, positively (after recoding) inter-correlated. The most common statistical index of internal consistency reliability is Cronbach's coefficient alpha'' (Leong and Austin, 2006, p. 136). It is used in instrument development to measure whether items that are intended to measure the same construct (structured-guided and open inquiry) produce similar scores (Campbell, 2010).

In order to determine reliability of the whole scale and sub-scales, Cronbach alpha coefficients were calculated are as shown in Table 4.

Table 4. Cronbach's-alpha reliability for the scales

Subscale	Scale Label	N	Cronbach Alpha
1	Structured Inquiry	9	0.88
2	Guided Inquiry	9	0.93
3	Open Inquiry	9	0.90
	Total	27	0.94

Table 4 shows that the whole scale and each sub-scales are reliable with alpha values > 0.70.

Factor Analysis

In order to clarify the factors (structured, guided and open inquiry) on the items, data reduction using factor analysis was conducted on the dataset. [Pallant (2005) explains the differences and identities between Factor analysis (FA) and Principal Component Analysis (PCA):

It takes a large set of variables and looks for a way that the data may be 'reduced' *or summarised using a smaller set of factors or components. It does this by looking for 'clumps' or groups among the inter-correlations of a set of variables. This is an almost impossible task to do 'by eye' with anything more than a small number of variables. There are two main approaches to factor analysis that you will see described in the literature—exploratory and confirmatory. Exploratory factor analysis is often used in the early stages of research to gather information about (explore) the interrelationships among a set of variables. Confirmatory factor analysis, on the other hand, is a more complex and sophisticated set of techniques used later in the research process to test (confirm) specific hypotheses or theories concerning the structure underlying a set of variables. The term 'factor analysis' encompasses a variety of different, although related, techniques. One of the main distinctions is between what is termed principal components analysis (PCA) and factor analysis (FA). These two sets of techniques are similar in many ways and are often used interchangeably by researchers. Stevens (1996, pp. 362–363) admits a preference for principal components analysis and gives a number of reasons for this. He suggests that it is psychometrically sound and simpler mathematically, and it avoids some of the potential problems with 'factor indeterminancy' associated with factor analysis (Stevens, 1996, p. 363).] Any strong reason why this quote is necessary?*

The scale was analyzed using principal component analysis (PCA) method from SPSS. Prior to performing PCA, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of 0.3 and above. An inspection of the scree plot revealed a clear break after the third component. Using Catell's (1966) scree test, it was decided to retain three components for further investigation. To aid in the interpretation of these three components, Varimax with Kaiser rotation was performed. The three factor solution explained a total of 62.36 % of the variance, with the first factor extracted contributing 30.45 %, the second, 17.80 and the third, 14.11. Factor 1 was labeled as "Structured Inquiry", the second as "Guided Inquiry" and the last as "Open Inquiry". Each of these subscales includes 9 items.

The results of the factor analysis are given in appendix (Table 5)

Conclusions

In this study, an instrument has been developed to determine how science teachers use IBSE in their classroom. The results of this study show that the instrument can be used in comprehensive studies with wider samples. If the instrument is used as part of triangulation, then the validity of further research findings can be enhanced. The instrument will be made available for further research.

Acknowledgements: This research work was supported by the Estonian Science Foundation, grant number ESF Mobilitas MJD32. The authors thank to Estonian Science Foundation. The instrument can be asked from authors: bulentcavas@gmail.com

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Appendix

Table 5 . Descriptive Statistics, Factor Loadings and Item-Total Correlations of the Scale

Factors	Items	Mean	SD	Factor Loadings	Correlations
	1	4.04	.84	.747	.634
	2	3.77	.89	.591	.599
	4	4.00	.82	.765	.661
	7	4.01	.83	.776	.731
F1	8	3.89	.84	.717	.705
	9	4.04	.78	.786	.724
	14	3.99	.79	.776	.746
	22	3.98	.82	.785	.730
	23	3.98	.80	.767	.721
	3	3.76	.89	.665	.503
	6	3.71	.88	.675	.458
	15	3.49	.88	.649	.500
	16	3.25	.92	.785	.410
F2	18	3.63	.87	.473	.628
	19	3.22	.89	.825	.385
	21	3.09	1.06	.794	.310
	24	3.24	.93	.810	.382
	27	3.65	.87	.404	.660
	5	3.28	.88	.651	.579
	10	3.10	.94	.805	.526
	11	3.18	.90	.802	.551
	12	2.91	.95	.866	.464
F3	13	3.08	.97	.761	.502
	17	3.88	.80	.646	.587
	20	3.90	.82	.667	.369
	25	3.20	.95	.719	.400
	26	2.98	.90	.810	.444

IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education

2013, volume 2, issue 2

Table 6. Mean scores, Standard Deviation and Frequency Analysis for the questionnaire, part B

Items; Students	Mean	SD	Frequencies 1	2	3	4	5
1. are willing to develop hypotheses related to scientific questions they want to investigate	2.66	.97	11	32	38	15	3
*2. wish to attempt to carry out investigations without my guidance**	*2.36*	*.96*	*19*	*39*	*30*	*10*	*2*
3. expect that they learn how to plan investigation procedures	3.20	1.11	8	18	31	30	12
*4. wish to create their own scientific questions for investigation**	*2.47*	*.97*	*16*	*38*	*32*	*12*	*2*
5. are willing to find relevant literature and other resources by themselves to answer scientific questions	2.65	1.00	12	36	32	17	3
6. expect that they will learn how to identify variables to be controlled in carrying out investigations	2.95	1.08	10	25	34	24	8
7. are willing to collect experimental data in carrying out their own investigations	2.81	1.05	10	29	35	19	6
8. see the value of learning to use data to determine the general patterns leading to conclusions	2.83	.96	9	26	41	20	3
9. expect that they will learn how to present conclusions from their investigations**	**3.18**	**1.01**	**4**	**22**	**33**	**32**	**8**
10. demand full investigation instructions when carrying out experimental work	2.96	1.10	10	26	33	24	8
11. expect to ask scientific questions**	**3.06**	**1.08**	**6**	**25**	**34**	**23**	**10**

* lower mean scores; **higher mean scores

Table 7. Mean scores and Standard Deviation for items related to Structured Inquiry

Items – related to Structured Inquiry	Mean	SD
3. I give my students step by step instructions to allow them to develop conclusions from their investigations	3.76	.89
6. I give my students step-by-step instructions so that they can conduct investigations	3.71	.88
15. I tell my students the variables they need to control in undertaking their investigations	3.49	.89
16. I provide my students with the relevant literature and other resources to develop their plans for investigations	3.25	.93
18. I give my students step-by-step instructions for obtaining data/making observations	3.63	.87
19. I provide my students with a hypothesis which the students test through investigations	3.22	.89
21. I undertake to interpret the data collected by my students and ask them to make a record	3.09	1.07
24. I supply scientific questions to be answered by my students	3.24	.93
27. I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues	3.65	.87
Total	3.45	.88

Table 8. Mean scores and Standard Deviation for items related to Guided Inquiry

Items – related to Guided Inquiry	Mean	SD
1. I guide my students to use experimental data to explore patterns leading to conclusions	4.04	.84
2. My students and I discuss and create scientific questions together which my students then attempt to answer	3.77	.89
4. I guide my students to consider their scientific results when making decisions on socio-scientific issues	4.01	.82
7. I guide my students on identifying the variables to be controlled in an investigation	4.00	.83
8. I help my students to develop hypotheses about the solution to a scientific problem	3.90	.84
9. I guide my students to think about the relevant literature and other resources they need to find to develop their investigations	4.04	.78
14. I guide my students on how to collect data to solve a scientific problem	3.99	.80
22. I guide my students to plan investigation procedures	3.98	.82
23. I guide my students to develop conclusions to scientific evidence	3.98	.81
Total	3,97	.87

Table 9. Mean scores and Standard Deviation for items related to Open Inquiry

Items – related to Open Inquiry	Mean	SD
5. My students use data to develop patterns and draw conclusions by themselves	3.28	.88
10. My students design their own procedures for undertaking studies	3.10	.94
11. My students develop their own conclusions from their investigations	3.18	.90
12. My students determine which data to collect for their investigations	2.91	.95
13. My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues	3.09	.97
17. My students are given opportunities to develop their own hypotheses aligned with scientific questions	3.88	.80
20. My students are given opportunities to create scientific questions as part of teaching	3.90	.83
25. My students find related literature and resources by themselves to develop their investigations	3.20	.95
26. My students identify the variables that they need to control in carrying out investigations	2.99	.90
Total	3,28	.90