WP4| D4.3

Project No.: 244749
Project Acronym: ESTABLISH
Project Title: European Science and Technology in Action: Building Links with Industry, Schools and Home

Work Package 4 | Deliverable 3

D4.3 Interim Profile of in-service science teachers' attitudes and understanding of IBSE

Dissemination Level: CO
Thematic Priority: Science in Society
Funding Scheme: Coordination and Support Actions

Deliverable No.: D4.3
Due date of deliverable: April 2012
Actual submission date: 20/12/2012

Start date of project: 01/01/2010 Duration: 48 months

Name of Coordinator: Dr. Eilish McLoughlin
Name of lead partner for this report: DCU

Total Number of Pages: **52**

A. Background to this report

This report is a deliverable of Work Package 4 (WP4) of the European FP7-funded project "European Science and Technology in Action: Building Links with Industry, Schools and Home" (ESTABLISH; 244749, 2010-2013). The report presents an interim profile analysis generated from the collection of questionnaires completed by teachers participating in ESTABLISH teacher education workshops from across Europe. The list of beneficiaries of ESTABLISH are listed in the following table.

This document, published in December 2012, has been produced within the scope of the ESTABLISH Project. The utilisation and release of this document is subject to the conditions of the contract within the Seventh Framework Programme, project reference FP7-SIS-2009-1-244749.

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B. The ESTABLISH consortium

Beneficiary short name	Beneficiary name	Country	Abbreviation
DCU	DUBLIN CITY UNIVERSITY	Ireland	IE
AGES	AG EDUCATION SERVICES	Ireland	IE
UCY	UNIVERSITY OF CYPRUS	Cyprus	CY
UmU	UMEA UNIVERSITET	Sweden	SE
JU	UNIWERSYTET JAGIELLONSKI	Poland	PL
CUNI	UNIVERZITA KARLOVA V PRAZE	Czech Republic	CZ
AL	ACROSSLIMITS LIMITED	Malta	MT
UPJS	UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH	Slovakia	SK
COUO	CARL VON OSSIETZKY UNIVERSITAET OLDENBURG	Germany	DE
UTARTU	TARTU ULIKOOL	Estonia	EE
UNIPA	UNIVERSITA DEGLI STUDI DI PALERMO	Italy	IT
MaH	MALMÖ UNIVERSITY	Sweden	SE
IPN	LEIBNIZ-INSTITUT FUER DIE PAEDAGOGIK DER NATURWISSENSCHAFTEN UND MATHEMATIK AN DER UNIVERSITAT KIEL	Germany	DE
CMA	CENTRE FOR MICROCOMPUTER APPLICATIONS	Netherlands	NL
MLU	MARTIN LUTHER UNIVERSITAET HALLE-WITTENBERG	Germany	DE

Interim Profile of In-service Science Teachers Attitudes and Understanding of Inquiry Based Science Education

Contents

Introduction

The ESTABLISH FP7 funded project is involved with development and implementation of professional development workshops to support teachers in adopting more inquiry based approaches in their teaching. Identifying teacher views, goals, practices and the challenges they face, make teacher educators more aware of the needs of their participating teachers and in turn can allow them to provide the appropriate support in order to help teachers overcome obstacles and develop their own practice. This report outlines the initial results from a profiling instrument used to examine teachers' beliefs about IBSE, attitudes to teaching science and teaching by inquiry and some ideas about their current practices. The data presented in this report outlines the profile of the teachers when they came to the first of the teacher workshops in each of the partner countries. Therefore, it represents the profile of the in-service teachers before they had access to the workshops developed under the ESTABLISH project.

This report outlines a summary of the development of the evaluation tool (Section 1) and how the evaluation data was collected and analysed (Section 2). Section 3 gives the main data obtained from the in-service teachers and the data is analysed based on the level of experience the teachers have declared themselves to be in IBSE, and any gender differences are also highlighted. The report concludes with a summary of the key findings.

1. Evaluation Study

1.1 Teacher Attitudes to IBSE

Inquiry is the "intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" (Linn & Davis 2004). This is the understanding of inquiry–based science education (IBSE) that is used in the ESTABLISH FP7 funded programme (Establish 2010).

Inquiry based teaching requires teachers to become facilitators of learning rather than the source of all knowledge. The National Science Education Standards advocate that teachers "create an environment in which they and their students work together as active learners" and orchestrate learning, so that students are engaged, focussed and challenged throughout each class (National Research Council, 1996). Posing questions and problems that are relevant to students' lives is one way of achieving this. According to Driver et al (1994 cited in Crawford 2000) inquiry teachers assist the improvement of students' current knowledge by encouraging students' involvement in inquiry based activities relevant to real world phenomena and "engaging in higher level thinking and problem solving." In turn, there is a shift from teacher centred to more student centred classrooms.

The difficulty that teachers have as regards changing their methods of instruction to more inquiry practices can stem from their own personal beliefs and their own education. Eick and Reed (2002) showed that teacher role identities are influenced strongly by the individuals own lived experience of teachers as well as the strength of their teaching beliefs. An individual is shaped by the experiences (s)he encounters through life, and in that sense, previous experiences with education and positive or negative teacher role models can shape the individual as a teacher herself / himself. Having strong beliefs about teaching, based on reflection of these past experiences, can also lead to a stronger role as a teacher in the classroom.

The difficulty for many teachers in adopting inquiry methods is that they themselves have been educated under concept-based programmes (i.e. knowledge without context) and this background may inhibit or slow down their shift to a more context-based method of instruction (King, Bellocchi, & Ritchie, 2008). The level of inquiry used by a teacher is strongly influenced by his/her core conceptions (Lotter, Harwood, & Bonner, 2007), such as, personal beliefs about teaching. Addressing and understanding these conceptions within teacher education programmes can help them in implementing inquiry.

1.2 Development of the Evaluation tool

Many obstacles that teachers have identified when implementing inquiry focus on their personal beliefs and attitudes towards teaching science as well as their own science knowledge. These have been reviewed already by the ESTABLISH project and a report is available as D4.1. Therefore, within the ESTABLISH project, the following aspects were determined for each of the participating teachers:

- Teachers'attitude to teaching by inquiry;
- Teachers'attitude to teaching science;
- Teachers'current classroom practice;
- Teachers'attitude to change;
- Teachers' self confidence in science knowledge;
- Teachers' self confidence in teaching science through inquiry.

A review of the literature found that no one particular available instrument was suitable to provide an insight on teachers views on the multifaceted area of IBSE. However, numerous tools and instruments used for profiling teachers were researched and evaluated as to their suitability for this project and helped inform the construction of the instrument presented here. These tools included TALIS (TALIS 2008 Technical Report, 2010), PSI-T (Campbell, Abd-Hamid, & Chapman, 2010), CLES-T (Taylor & Fraser, 1991), and the VNOS questionnaire (Abd-El-Khalick, Lederman, Bell, & Schwartz, 2001), and covered the areas of classroom practice, the nature of science and general attitudes toward inquiry teaching. It was also clear that teachers' views of the nature of science cannot be encapsulated using a paper and pencil instrument (Lederman, Wade, & Bell, 1998). A report on effective instruments and tools for evaluation of IBSE with in-service and pre-service teachers has been compiled by ESTABLISH and is available as D5.1.

A new instrument was therefore developed for this project, in the form of paper-and-pencil questionnaire. The questionnaire was developed in a number of stages in order to acquire a reliable and valid instrument. Initially, the theoretical framework and rationale behind the questionnaire was developed in order to determine the focus of the questions. Items were then selected and discussed by partners. Based on the relevant discussion, the question items were further filtered and refined. The final version of the questionnaire was then available to all partners to use in teacher workshops in each country and partners translated it, in cases this was considered necessary.

The final questionnaire comprises a number of sections - with the first section addressing participants background information including age and previous teaching experience. In this section, participants are also asked to rank themselves in terms of their experience in IBSE, from beginner to very experienced. Other sections determine teachers' views of inquiry, attitudes and views of science and teaching science, classroom practice/classroom environment, teaching science and challenges in inquiry teaching.

In total, two versions of evaluation instruments were developed – one version for in-service teachers (ITQ) and the other for pre-service teachers (PTQ). Within each version, there are two questionnaires, the A questionnaire for determining the profile at the start of the workshop intervention and then the B questionnaire that will be administered after completion of ESTABLISH workshops and following the teachers implementing inquiry within their classrooms.

This report discusses findings obtained from the in-service teachers across several European countries whom completed the ITQ-A questionnaire (see Appendix A). In this report, differences between teachers' level of experience and their attitudes and understanding of inquiry are reported. Where significant gender effects are evident, they are also noted.

2. Data Collection and Analysis

2.1 Data Collection

The In-service Teacher Questionnaire A (ITQ-A) is used to create an initial teacher profile at the beginning of the first development workshop. The term “inquiry” has been used in many different ways and therefore it was decided that the questionnaire should be completed during the first workshop, after participants have been informed of the ESTABLISH view of inquiry. This questionnaire takes between 15-20 minutes to complete. A follow-up interview can be undertaken by partners, if necessary to resolve any misconceptions or confusions the researcher may have about teacher responses. To date, no such interviews have been reported.

The individual teacher responses to ITQ-A are then recorded by each partner in a specially designed ITQ-A excel workbook which is then forwarded to the authors of this report for collation and analysis. All the background information responses from section 1 are coded in this excel file. Similarly, each likert-style question has a set of 5 responses, coded from 1 to 5, from “Strongly Disagree” to “Strongly agree, or ” “Almost Never” to “Almost Always”, depending on the question. Responses to open ended questions were reviewed by each national partner to firstly identify trends in answers and to secondly group responses under these trends after subsequent review. Section F of the questionnaire asked teachers to rank their main concerns about teaching through inquiry; responses to this question were coded based on each concern listed.

This report is based on the responses to the ITQ-A received to date, which is 161 responses across four countries, as shown in Table 2.1.

Table 2.1 Responses received to ITQ-A on which this report is based

Partner	*Code*	*No. of Teachers*
DCU	DC25042012	53
DCU	DC05062012	27
UmU	UU13032012	18
MaH	MH11052012	28
IPN	IP07022012	13
UNIPA	UN17112012	22

2.2 Data Analysis

The individual question items in the ITQ-A were sorted into six categories, as follows, in order to represent the results:

- Attitude to teaching by inquiry
- Attitude to teaching science
- Current Classroom Practice
- Attitude to change
- Self confidence in science knowledge
- Self confidence in teaching science through inquiry

Responses obtained in each of these categories are discussed in Section 3 below. All question items were considered individually under the appropriate categories.

Additionally, within some of these categories there are a number of question “groups”. For example, there are a number of question items, which relate to ‘making science relevant to industry and phenomena outside the classroom' i.e., items 33, 37, 38, 39, 40 and 41. The individual responses to each of these items were combined and then averaged to give one value for each teacher for this group of items. This value was then considered in the further analysis outlined below. The question "groups" are as follows (note that some question items are considered in two question groups):

- View of Good teaching – items 26, 27, 28, 29, 30, 33
- Making Science Relevant – items 33, 37, 38, 39, 40, 41
- Asking questions/framing research questions – items 47, 48, 49, 50
- Designing investigations – items 51, 52, 53, 54
- Conducting investigations – items 55, 56, 57, 58
- Collecting data – items 59, 60, 61, 62
- Drawing conclusions – items 63, 64, 65, 66

Descriptive statistics (e.g., derivation of mean responses, percent of responses etc) were conducted on each dataset obtained from each partner. The data from all countries was then combined into one data set. A one-way analysis of variance (ANOVA) was conducted on the combined data set. ANOVA analyses the means of three or more independent variables in order to highlight any significant differences between them. If the ANOVA gives a significant result ($p<0.05$), it indicates that at least two of the three independent variables are significantly different from one another. In order to determine which two variables these are, a post hoc test must also be conducted. A post hoc analysis shows multiple comparisons between the independent variables and highlights exactly which ones were significantly different from one another. For this analysis, Games-Howell post hoc test was used as it takes into account unequal group sizes, which is relevant in this case. This analysis process of ANOVA followed by post hoc tests was conducted repeatedly using different independent variables.

Selecting the independent variable of 'experience in inquiry', the data set was analysed using ANOVA and post hoc tests to determine how responses to the questions (dependent variables) varied depending on how the teacher categorised themselves in terms of experience level. Also, further analysis determined if there were any gender issues involved.

The terms 'beginner' (B), 'some experience' (SE) and 'experienced' (VE) will now be used in the remainder of this report to indicate that the teacher has categorised himself/herself as 'beginner in IBSE', 'some experience of IBSE' and 'very experienced in IBSE', respectively. Comparisons between countries are not included in this report as the number of teachers involved within some categories of experience was very low and therefore comparisons could lead to false conclusions.

In this report, the following notation is used to indicate statistically significant differences. When statistically significant differences are noted between the means of two distributions, this is highlighted in the text by giving each of the means and noting the p value of significance, e.g., B/SE= 3.00/2.18, $p=0.000$ indicates that the mean of the beginner group (3.00) was significantly different from the mean (2.18) of the some experienced group Values of p at less than 0.05 are deemed significant at 95% confidence level. In comparisons based on gender, M is used for males and F for females.

3. In-service teacher profile results

3.1 Overview of sample

In total, responses were analysed from 161 teachers, from 5 different ESTABLISH partners. Table 3.1 shows the details of this group in terms of numbers of teachers from each partner, the age range, gender and type of school they are teaching in. Table 3.2 shows the numbers of teachers in each data set that consider themselves as beginners, some experience or very experienced in IBSE together with their years of teaching experience.

The average age of the teachers in this total data set is 41 years, the majority are female (76%) and they vary in teaching experience from 1 to 40 years. Most of the teachers (80%) are teaching in a mixed school with students aged between 12 and 18 years.

When asked to rank their own experience of inquiry, the majority of the teachers indicated that they had 'some experience' (58%), while 29% classified themselves as 'beginner' in IBSE and 13% were 'very experienced' (see Table 3.2). Tables 3.2 also shows the experience level within each data set.

Table 3.1 Overall responses to ITQ-A, including age range, gender and type of school (N/D data not included in response)

Partner	Number of Teachers	Age Range				Gender			Type of School		
		20-35	36-50	51-65	N/D	Male	Female	N/D	All Boys	All Girls	Mixed
DCU	**80**	44%	35%	7%	14%	16%	84%	0%	9%	21%	70%
IPN	**13**	46%	23%	23%	8%	69%	31%	0%	0%	0%	100%
MaH	**28**	14%	57%	25%	4%	18%	79%	3%	0%	0%	100%
UmU	**18**	11%	50%	39%	0%	33%	67%	0%	0%	0%	100%
UNIPA	**22**	0%	64%	36%	0%	18%	82%	0%	5%	0%	95%
TOTAL	**161**	**29%**	**43%**	**19%**	**8%**	**23%**	**76%**	**1%**	**5%**	**11%**	**84%**

Table 3.2 Overall responses to ITQ-A, based on experience in IBSE and years of teaching experience. (N/D data not included in response)

Partner	Number of Teachers	Experience with IBSE			Years of Teaching Experience					
		B	SE	VE	1-5	6-10	11-20	21-30	31-40	N/D
DCU	**80**	39%	54%	7%	36%	16%	22%	18%	4%	4%
IPN	**13**	15%	85%	0%	46%	15%	39%	0%	0%	0%
MaH	**28**	0%	64%	36%	4%	28%	36%	25%	7%	0%
UmU	**18**	6%	72%	22%	0%	39%	39%	22%	0%	0%
UNIPA	**22**	59%	41%	0%	0%	0%	45%	46%	9%	0%
TOTAL	**161**	**29%**	**58%**	**13%**	**22%**	**19%**	**31%**	**22%**	**4%**	**2%**

Comparisons will not be made between different country cohorts. However, the overall cohort will be discussed in terms of the experience level of the teachers in IBSE. It is important to emphasise that the teachers' level of experience in IBSE was not related to the age of the teachers, or number of years of teaching, with several young and older teachers expressing themselves as beginners in IBSE. The age range and the number of years teaching is shown in Figure 3.1 for the overall group of teachers from the combined data set that categorise themselves as beginners in IBSE, with some experience and very experienced in IBSE, respectively. The ratio of male to female teachers within each experience level was approximately the same (Figure 3.2).

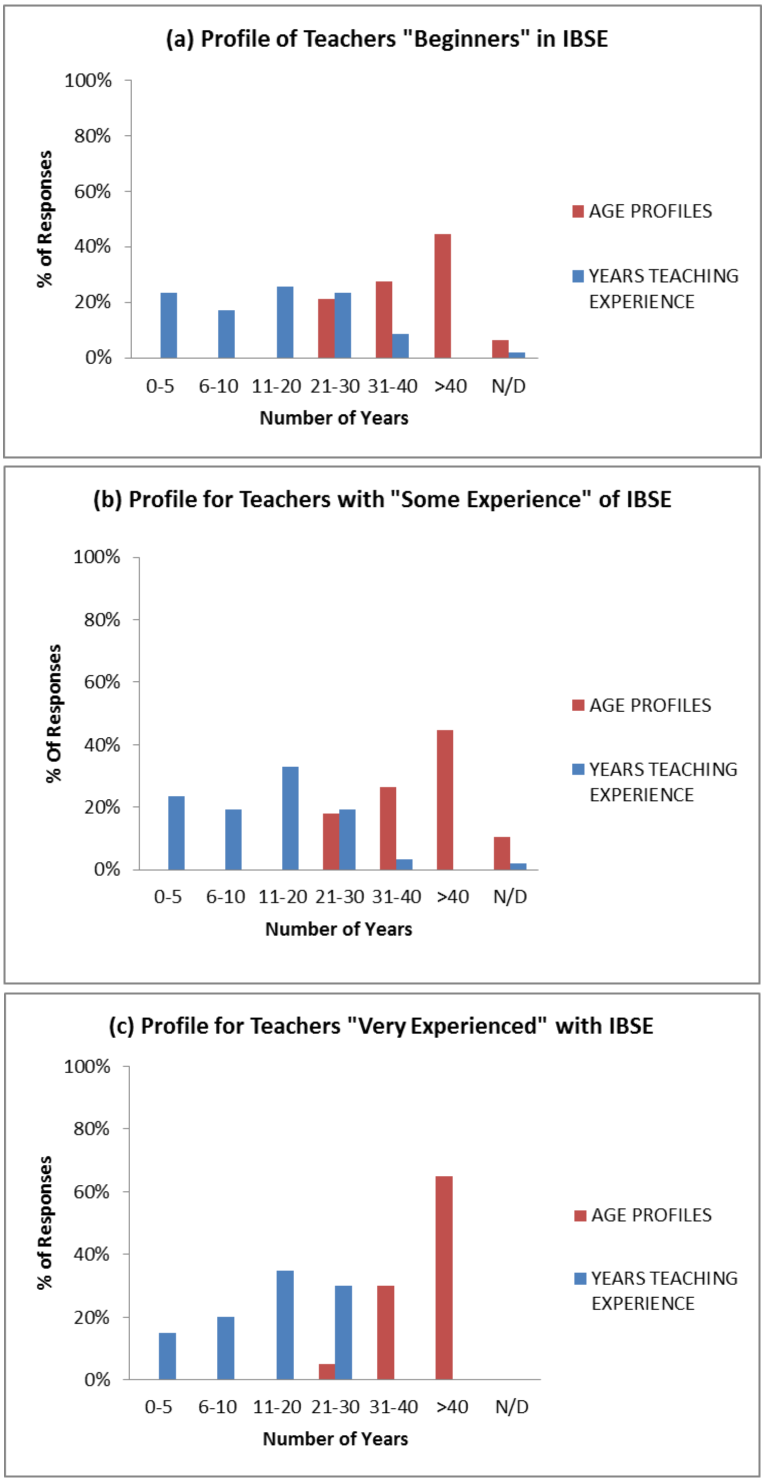

Figure 3.1 Age profile and range of teaching experiences in years for teachers self-classed as beginner (a), those with some experience (b) and those very experienced (c) in IBSE.

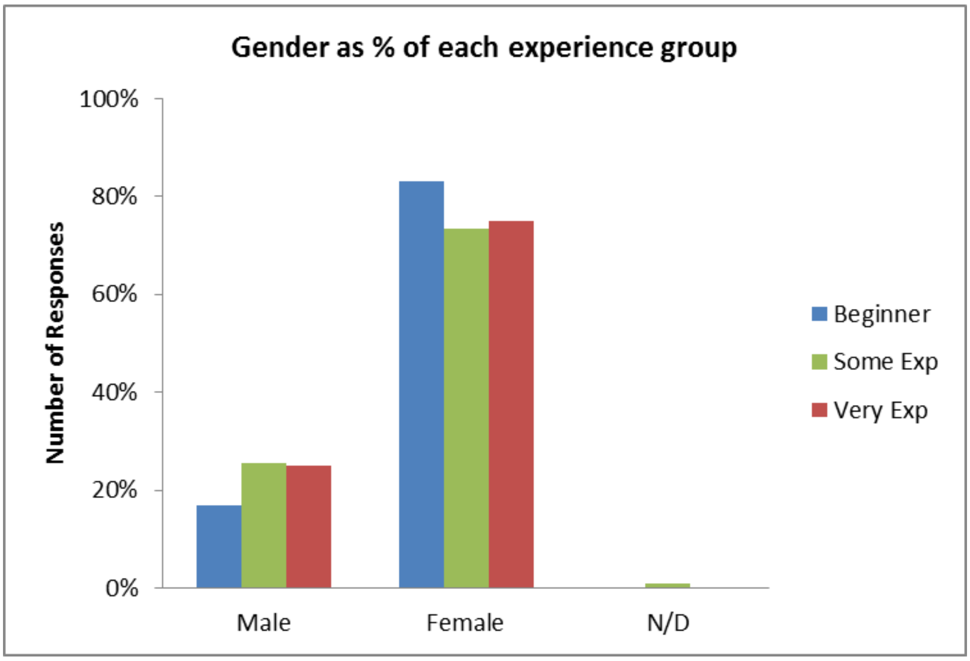

Figure 3.2 **Proportion of male and female teachers at each experience level. (N/D data not included in response)**

3.2 Attitudes to Teaching by Inquiry

3.2.1 Understanding of Inquiry:

(*Statement Items 11, 12 and 13 – Appendix A)*

Respondents were asked to indicate whether they understood inquiry based science education and the role of the teacher and the student in an inquiry classroom (items 11-13, ITQ-A.)

Responses from the overall group suggest that 70% of the teachers indicated that they understand inquiry fully and that they understand their role as a teacher as well as the role of the student within an inquiry classroom. There were no significant differences between responses from male and female teachers (*Table 3.3 and Figure 3.3).*

The responses to these questions varied greatly depending on the experience level of the teacher with IBSE. Beginners did not fully understand inquiry in contrast to both those with some experience and very experienced (B/SE = 3.02/2.03, p=0.000; B/VE = 3.02/1.21, p=0.000). Note that these three item statements (11, 12 and 13), were negatively phrased, so 1 indicates a full understanding of inquiry. Most of the teachers with some experience and very experienced (>80%) indicated that as well as fully understanding inquiry, they also understood their role as a teacher in the inquiry classroom and also the role of the students in the inquiry classroom. This contrasts markedly with the beginners, whose responses varied from 34% fully 'understanding inquiry based science education', to 49% 'understanding their role as a teacher within an inquiry classroom' to 62% 'understanding the role of the students in the inquiry classroom'. This could be interpreted as the beginner being familiar with the learning outcomes of the student in an inquiry classroom but are more unsure of how to implement this method of instruction.

Table 3.3 Teacher responses to understanding of inquiry (items 11, 12 and 13)

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
11. I don't fully understand inquiry based science education	B	34%	26%	38%	2%	3.02
	SE	83%	9%	8%	0%	2.03
	VE	95%	0%	0%	5%	1.21
	Total	70%	13%	16%	1%	2.22
12. I don't fully understand my role as a teacher in an inquiry classroom	B	49%	30%	21%	0%	2.69
	SE	80%	14%	5%	1%	1.99
	VE	95%	0%	0%	5%	1.21
	Total	73%	17%	9%	1%	2.11
13. I don't fully understand the role of the students in an inquiry classroom	B	62%	25%	13%	0%	2.51
	SE	80%	9%	8%	3%	2.00
	VE	95%	0%	0%	5%	1.16
	Total	76%	12%	9%	3%	2.05

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined*

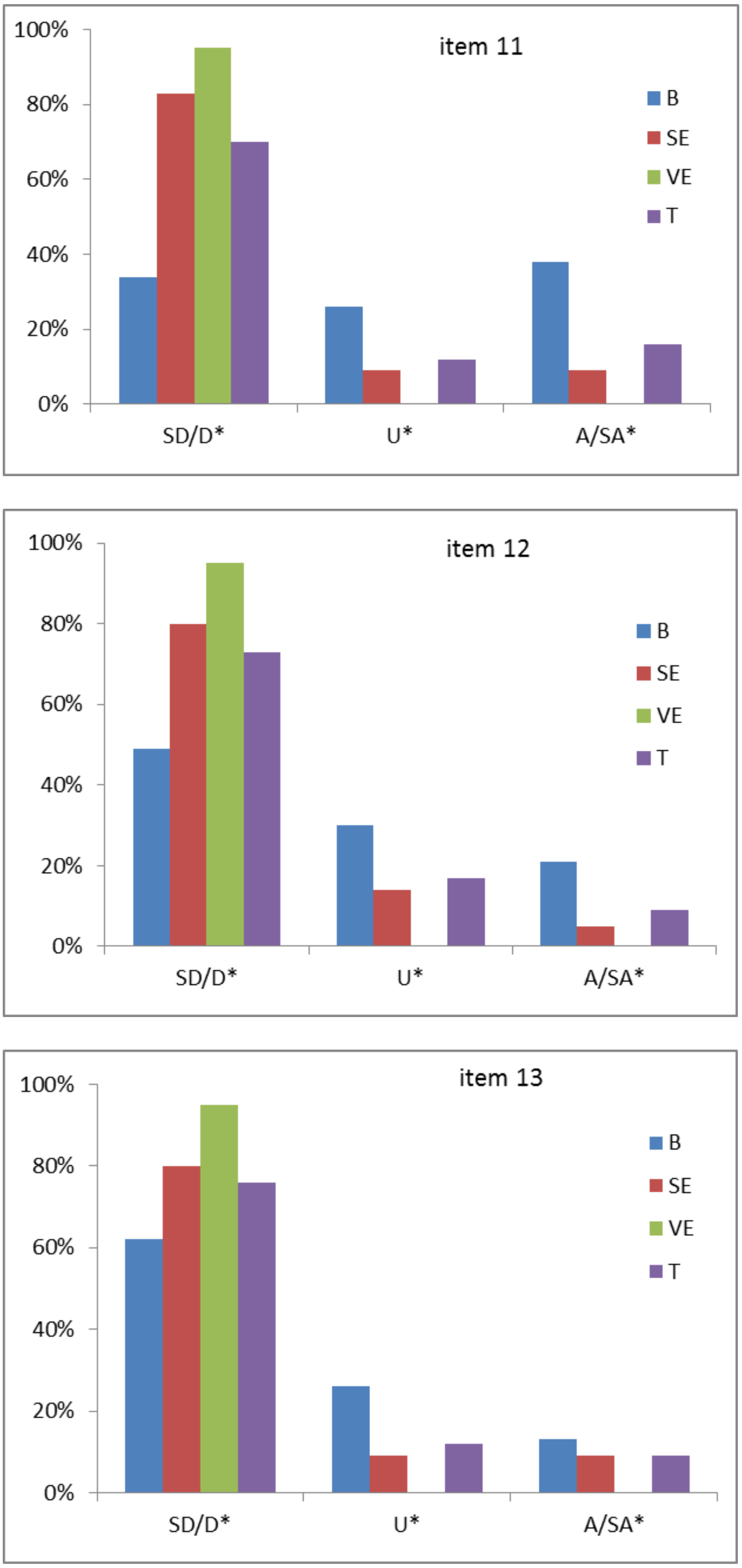

Figure 3.3 **Teacher responses to understanding of inquiry (items 11, 12 and 13)**

3.2.2 Views of Inquiry:

(*Statement items 14, 15, 16, 17, 25 and 31 – Appendix A)*

This sub set of items examines teachers' views of inquiry as a possible method of instruction and highlights their willingness to use it in their teaching.

Classroom Time: *(item 14)*

Nearly half of the teachers felt that inquiry does not take up too much classroom time, while 21% felt that it did and 28% were uncertain (*Table 3.4 and Figure 3.4)*. Based on their level of experience there was a significant difference between responses to this item from beginners, teachers with some experience and those who were very experienced at IBSE (B/SE = 2.98/2.53, p=0.016; B/VE = 2.98/1.72, p=0.000; SE/VE = 2.53/1.72, p=0.009; *Table 3.4).* Very experienced teachers clearly disagreed with the statement that 'inquiry takes up too much classroom time for me to implement,' while beginners were much more uncertain. Those with some experience (SE) tended towards the beginners view. This finding is significant in that one dominant reason from literature as to why teachers do not implement inquiry in the classroom is the perception of the lack of available time. Clearly, the more experienced teachers in inquiry did not see time as an obstacle in implementing inquiry methods.

Appropriate method to achieve curriculum aims: *(Items 15, 25)*

Over 70% of respondents felt that inquiry methods are appropriate to achieve the aims of their curriculum with 19% uncertain and there were no significant differences based on level of experience *(item 15, Table 3.4 and Figure 3.4)*. The females were more in agreement in their answers on this question than the males overall (M/F=3.57/3.89, p=0.038) and this was also true at each experience level, even though some of the numbers involved were small.

Even though the majority of all the teachers (72%) indicated inquiry methods as appropriate to achieve the aims of the curriculum *(item 15),* only a third of the overall group felt it was easy to do so with another 36% uncertain *(item 25, Table 3.4 and Figure 3.4)*. There was a significant difference between beginners and very experienced teachers responses to this item 25 (B/VE = 2.83/3.74, p=0.015), again supporting the view that the more experienced group of teachers consider it easier to implement inquiry within the curriculum (*Table 3.4 and Figure 3.4)*. There are however a significant number of teachers from the experienced group (21%) who do not find that it is easy to implement inquiry. Within the beginner group, the male group more strongly agreed that it was easy to teach the curriculum through inquiry than the female group (M/F=3.50/2.69, p=0.009) from the responses to item 25.

Teaching Method:

Nearly half of teachers stated that inquiry could be their main teaching method *(item 17),* 36% were uncertain about this and 13% felt that it would never be their main teaching method (*Table 3.4)*. Again the level of agreement with this statement that 'inquiry will never be my main teaching method' varies with experience in IBSE with the beginner group being more in agreement with the negative statement than the experienced or those with some experience (B/SE = 2.83/2.43, p=0.028; B/VE=2.83/1.78, p= 0.001; *Table 3.4)*. The experienced group are again indicating that inquiry could be their main teaching method (75%).

Students:

The majority (78%) of the teachers stated that inquiry could be used with students of all capabilities *(item 16)* and that the students did not need to know a lot of facts prior to participating in inquiry activities (74%) (*item 31*; *Table 3.4)*. However, it is interesting to note that approximately 10% of each group of teachers (beginners, some experience and experienced) felt that inquiry was only for the more capable students and 17% of all teachers felt that students needed to know a lot of facts before participating in inquiry activities. There were no significant differences to the responses concerning these two items, based on level of experience or gender.

Table 3.4. Teacher responses to views of inquiry (items 14, 15, 16, 17, 25 and 31)

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
14. I think inquiry takes up too much classroom time for me to implement.	B	30%	40%	28%	2%	2.98
	SE	52%	28%	19%	1%	2.53
	VE	80%	0%	10%	10%	1.72
	Total	**49%**	**28%**	**21%**	**2%**	**2.57**
15. The use of inquiry is appropriate to achieving the aims of the curriculum.	B	2%	28%	70%	0%	3.77
	SE	10%	17%	72%	1%	3.78
	VE	15%	5%	75%	5%	4.00
	Total	**8%**	**19%**	**72%**	**1%**	**3.81**
16. Inquiry based teaching is only suitable for very capable students.	B	72%	19%	9%	0%	2.23
	SE	80%	8%	11%	1%	2.09
	VE	85%	0%	10%	5%	1.68
	Total	**78%**	**11%**	**10%**	**1%**	**2.08**
17. Inquiry will never be my main teaching method.	B	32%	53%	13%	2%	2.83
	SE	51%	34%	14%	1%	2.43
	VE	75%	5%	10%	10%	1.78
	Total	**48%**	**36%**	**13%**	**3%**	**2.48**
25. It is easy to teach the curriculum using inquiry based teaching.	B	34%	45%	19%	2%	2.83
	SE	25%	38%	35%	2%	3.08
	VE	21%	5%	74%	0%	3.74
	Total	**27%**	**36%**	**35%**	**2%**	**3.10**
31. Students need to know a lot of facts before they can participate in inquiry activities.	B	70%	17%	13%	0%	2.33
	SE	74%	4%	20%	2%	2.56
	VE	85%	5%	10%	0%	2.05
	Total	**74%**	**8%**	**17%**	**1%**	**2.30**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined*

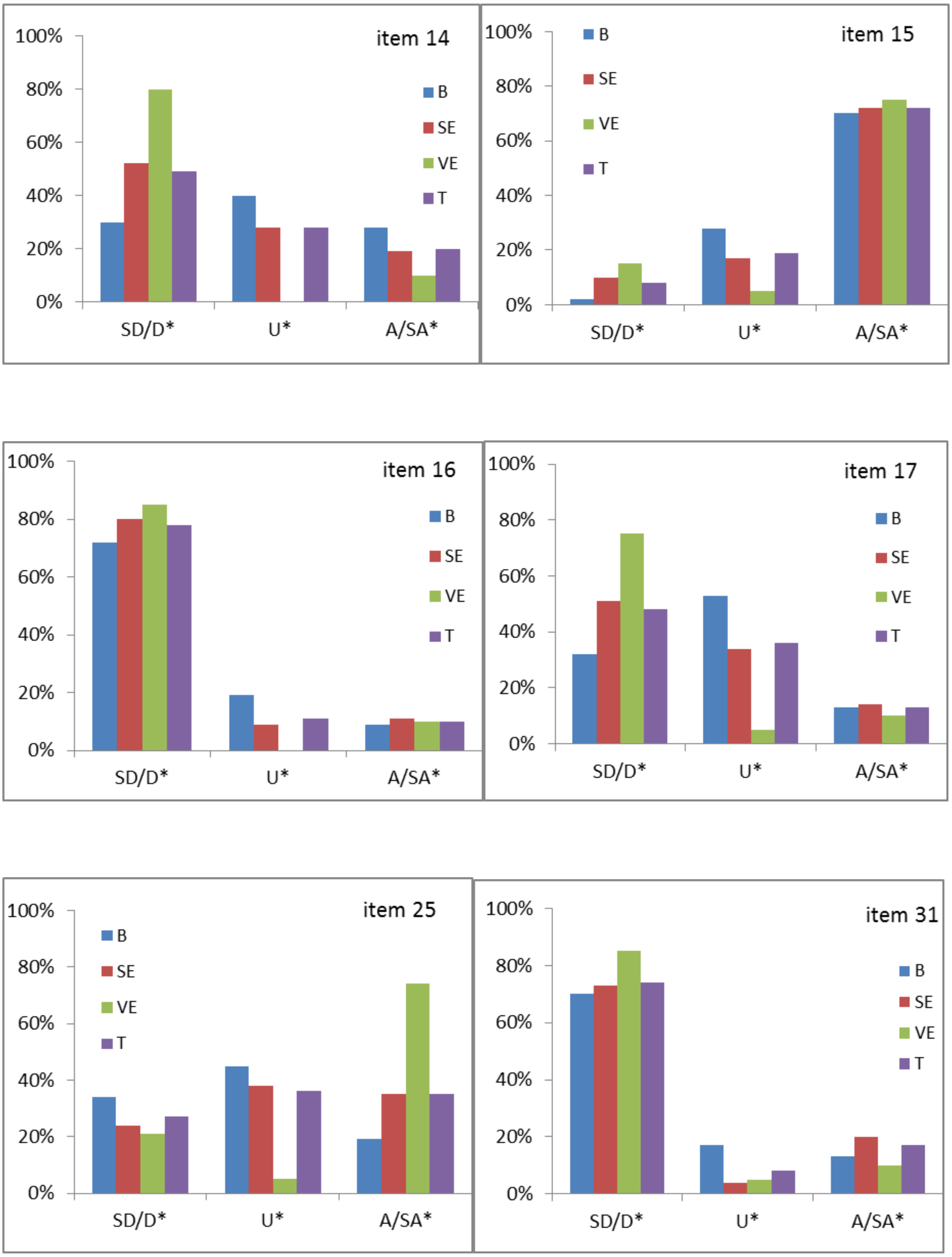

Figure 3.4 **Teacher responses to views of inquiry (items 14, 15, 16, 17, 25 and 31)**

3.3 Attitudes to Teaching Science

3.3.1 View of Good Science Teaching:

(*Statement items 26, 27, 28, 29, 30 and 33 – Appendix A)*

The six items in this topic *(items 26-30, 33)* determine teachers' views of what 'good science teachers' should do in their teaching, i.e., in terms of asking higher order questions, focusing only on curriculum content, presenting facts and explaining them, using student questions to guide their teaching, allowing students to develop their own investigation/research question and encouraging students to discuss topics relevant to their everyday life. Rather than discussing each of these statements individually, it was decided to group them into one value depicting 'good teaching,' where the value of 5 was assigned to strongly agreeing with 'asking higher order questions', 'using student questions to guide their teaching', 'allowing students to develop their own investigation/research question' and 'encouraging students to discuss topics relevant to their everyday life'. The remaining two items were given 5 for strongly disagreeing with 'focusing only on curriculum content' and 'presenting facts and explaining them'. If the activities listed above are attributes of 'good teachers,' then the collective value can be used to represent the extent of agreement with practices that feature inquiry based teaching. Therefore, the collective value for each of these questions was determined for each teacher and then this value as divided by the number of questions indicating that the value of 5 more closely indicates a view of 'good teachers' aligning with 'inquiry teachers'.

The mean for the overall group was 3.88 suggesting that the group had views of 'good teaching' that were associated with inquiry teaching. There were no significant differences between responses based on gender. However, there were significant differences based on level of teaching experience with the more experienced teacher having a mean of 4.21, again pointing to more inquiry focus for more experienced in inquiry teachers (B/VE = 3.82/4.21, p=0.005; SE/VE=3.86/4.21, p=0.010; *Table 3.5*).

Table 3.5 Mean score for question grouping on view of good science teaching.

Question item group	Mean Performance			
	Overall group	**Beginner**	**Some Experience**	**Very Experienced**
View of Good Science Teaching	3.88	3.82	3.86	4.21

Mean is based on a 1-5 scale with 1 relating to non-inquiry oriented practices and 5 relating to very inquiry oriented practices with regards to the topic.

Examining in detail the responses for each individual statement items within this question in Table 3.6 and Figure 3.5, there is strong agreement by all teachers that 'good teachers allow students to develop their own investigation/research questions' *(item 30)* and that 'good teachers encourage student discussion on scientific topics relevant to everyday life' *(item 33).* There is a greater level of uncertainty in the beginner group to the statement that 'good teachers use student questions to guide their teaching' in comparison to the other teacher groups who agree more strongly with this statement. The use of higher order questions has strong agreement by the more experienced group but 30% of the beginners and 25% of the some experienced group disagree with this statement *(item 26).* This is another area that needs to be addressed within teacher education programmes as it is not clear from these results whether the beginner teacher is unsure of how to ask higher order questions and therefore, does not consider their use as an attribute of good teaching.

Table 3.6 Individual item responses to question grouping about teachers views of good teaching.

Statement item	Group	SD/D	U	A/SA	N/D	Mean
26. Good teachers ask higher order questions.	B	30%	17%	51%	2%	3.37
	SE	25%	9%	65%	1%	3.59
	VE	10%	5%	80%	5%	4.37
	Total	**25%**	**11%**	**63%**	**1%**	**3.62**
27. Good teachers focus on curriculum content only.	B	96%	4%	0%	0%	1.77
	SE	83%	4%	10%	3%	2.07
	VE	65%	20%	10%	5%	2.26
	Total	**86%**	**6%**	**7%**	**1%**	**2.00**
28. Good teachers use student questions to guide their teaching.	B	2%	17%	79%	2%	4.00
	SE	5%	7%	87%	1%	4.05
	VE	5%	0%	95%	0%	4.40
	Total	**4%**	**9%**	**86%**	**1%**	**4.08**
29. Good teachers present facts and then explain them.	B	34%	30%	34%	2%	3.00
	SE	38%	28%	34%	0%	2.94
	VE	60%	15%	15%	10%	2.39
	Total	**40%**	**27%**	**32%**	**1%**	**2.89**
30. Good teachers allow students to develop their own investigation/research questions.	B	4%	13%	83%	0%	3.89
	SE	1%	10%	89%	0%	4.07
	VE	0%	10%	90%	0%	4.30
	Total	**2%**	**11%**	**87%**	**0%**	**4.05**
33. Good teachers encourage student discussion on scientific topics relevant to everyday life.	B	0%	2%	98%	0%	4.40
	SE	0%	0%	98%	2%	4.42
	VE	0%	0%	100%	0%	4.70
	Total	**0%**	**1%**	**98%**	**1%**	**4.45**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined*

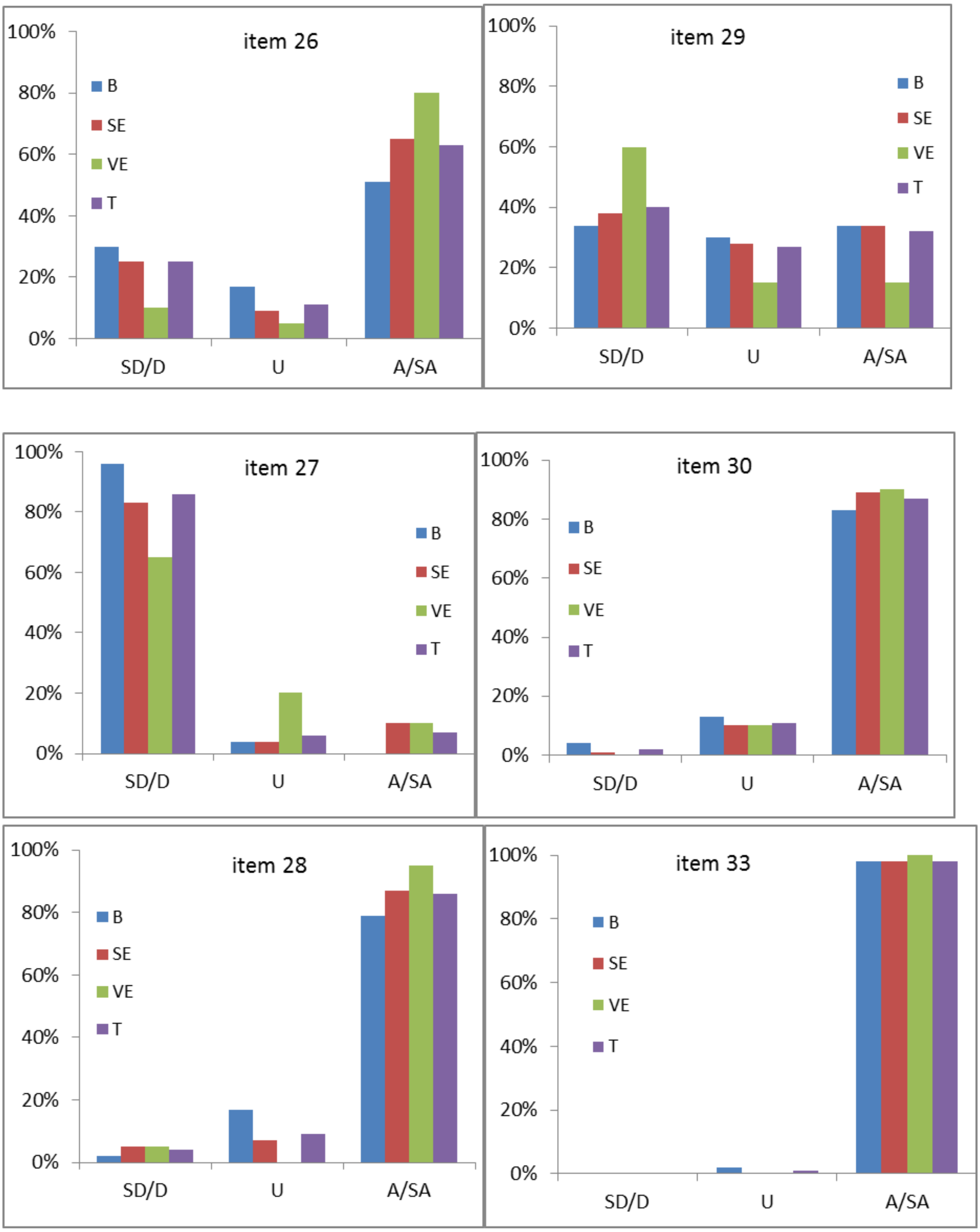

Figure 3.5 Percentage frequency of response to teachers' views of good teaching.

3.3.2 Science as a Static Body of Knowledge

(Statement items 21, 22, 42, 43 and 45 – Appendix A)

These five items (*items 21, 22, 42, 43 and 45)* examined teachers' level of agreement with statements regarding aspects of the nature of science and their implementation in actual classrooms. Teachers were firstly asked to indicate their level of agreement with scientific theories as 'constant unchanging bodies of knowledge' and on scientific knowledge as 'primarily knowing facts' (*items 21, 22*).

Almost three-quarters of the group disagreed with the statement that scientific theories are 'constant unchanging bodies of knowledge' *(item 21),* but the remainder (24%) were uncertain or agreed with this statement *(Table 3.7)*. No statistical differences were identified among teachers of different experience level or gender.

Additionally, over half (51%) of the beginners group agreed that scientific knowledge is 'primarily knowing facts', compared with 27% of the some experience group and only 15% of the experienced group *(item 22, Table 3.7)*. These differences were statistically significant (B/SE=3.13/2.54, p=0.006; B/VE=3.13/2.00, p=0.001). These results may indicate that beginners have a more factual approach to science than the other groups. naive view of the nature of science and may reduce science to merely knowledge of facts.

In relation to classroom practice, all of the very experienced group of teachers stated that their students 'often' or 'almost always' learn how science can be part of their out-of-school lives (in contrast to 63% of the some experienced group and 47% of the beginners). A proportion of the beginners group (24%) almost never/seldom lead students to learn that views of science have changed over time and that scientific knowledge could be questioned (19%) *(items 43, 45; Table 3.7)*. This is clearly indicating that the experienced teachers are more familiar with the nature of science and bring that into the classroom, whereas the beginners have a more limited view of science and this is what is implemented in the classroom. There was no significant difference among males and females from these data.

Table 3.7 Teacher responses to views of science as a static body of knowledge

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
21. Scientific theories (e.g. atomic theory) are constant unchanging bodies of knowledge.	B	68%	13%	15%	4%	2.33
	SE	74%	10%	13%	3%	2.14
	VE	80%	5%	15%	0%	1.75
	Total	**74%**	**10%**	**14%**	**2%**	**2.15**
22. Scientific knowledge is primarily focused on knowing facts	B	36%	11%	51%	2%	3.13
	SE	57%	15%	27%	1%	2.54
	VE	75%	10%	15%	0%	2.00
	Total	**54%**	**13%**	**32%**	**1%**	**2.65**
Statement item	**Group**	**AN/S****	**S****	**O/AA****	**N/D****	**Mean**
42. Students learn how science can be a part of their out-of-school life.	B	13%	40%	47%	0%	3.43
	SE	11%	25%	63%	1%	3.62
	VE	0%	0%	100%	0%	4.4
	Total	**10%**	**27%**	**63%**	**0%**	**3.65**
43. Students learn that the views of science have changed over time.	B	24%	38%	38%	0%	3.19
	SE	11%	38%	50%	1%	3.50
	VE	5%	35%	60%	0%	3.65
	Total	**14%**	**38%**	**48%**	**0%**	**3.43**
45. Students learn that scientific knowledge can be questioned.	B	19%	49%	32%	0%	3.23
	SE	9%	49%	40%	2%	3.42
	VE	5%	30%	65%	0%	3.85
	Total	**11%**	**47%**	**41%**	**1%**	**3.42**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined*

*** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

3.3.3 Teaching Science as an accumulation of facts:

(*Statement items 23, 24, 32, 44, 46, 67 and 68 – Appendix A)*

This set of items *(items 23, 24, 32, 44, 46, 67 and 68)* deals with the focus of the activities in the classroom when teaching science and how students communicate with one another about what they are learning.

Most of the teachers (90%) disagreed with the statement that 'developing students specific content knowledge is much more important than developing their thinking and reasoning processes,' regardless of their level of experience *(item 23; Table 3.8)*. However, there was approximately even agreement (39%) and disagreement (42%) to the statement that their goal as a teacher was 'the transfer of factual knowledge to the students,' with more of the beginner group of teachers in agreement (47%) than the experienced group (30%) *(item 32; Table 3.8)*. This question may have been answered in an ambiguous fashion as the role of the assessment has not been clarified here – if the national assessment focuses on rewarding factual knowledge, then it is reasonable to assume that teachers would focus on factual knowledge as the goal of teaching. Therefore, further analysis or teacher interviews may be useful to clarify the teachers´ answers to this specific question.

A similar range of responses was given for the statement 'if a student investigation leads to an unexpected result, I always tell the students the right answer/result' *(item 67; Table 3.8)* with 38% of the overall group disagreeing and 47% agreeing. Even though 60% of the beginners group agreed with this statement in contrast to 30% of the experienced group *(Table 3.8)*, this difference was not statistically significant. There was a significant difference between male and female respondents who were very experienced with inquiry, with males agreeing more with this statement in comparison to females (M/F=4.00/2.71, p=0.032). Within the experienced group, a greater proportion was uncertain in their responses compared to the other two groups. Again the data is suggesting that the beginner group of teachers may be more focused on the 'right' answer to an investigation rather than the process of the investigation.

In relation to classroom activities, half of the teachers (50%) felt that teaching is not more effective when all students are doing the same activity at the same time *(item 24),* but also half of them admitted that they would find it difficult to manage a classroom where each student group is doing different activities *(item 68)*. However, this differed significantly based on their level of experience with the beginners more strongly admitting difficulty in classroom management (B/SE = 3.59/2.52, p=0.000; B/VE=3.59/2.20, p=0.000) *(Table 3.8)*. There were no significant differences between SE and VE. This suggests that teachers, particularly beginners, may require additional support in this area of classroom management to develop practices in inquiry based instruction.

Involving students in explaining their ideas to each other is an important activity for involving and engaging students within the classroom. While only 29% of teachers stated that their students were almost never/seldom asked to explain their ideas, only 12% stated that their students did not pay attention to each other's ideas *(items 44, 46; Table 3.8)*. There were no significant differences based on level of experience, so this is a very positive aspect to build on. This indicates that student ideas are considered important within the science classroom and that student dialogue is happening. These can hopefully be developed as the starting point for the investigations or basis for inquiry practices. There was difference in terms of gender with male teachers using these practices more often than females (M/F=4.20/3.13, p=0.023).

Table 3.8 Teacher responses to teaching science as an accumulation of facts.

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
23. Developing students' specific content knowledge is much more important than developing their thinking and reasoning processes.	B	94%	0%	6%	0%	1.98
	SE	88%	5%	5%	2%	1.92
	VE	90%	5%	5%	0%	1.80
	Total	**90%**	**4%**	**5%**	**1%**	**1.93**
24. Teaching is more effective when all students are doing the same activity at the same time.	B	36%	28%	36%	0%	2.96
	SE	56%	17%	26%	1%	2.53
	VE	50%	35%	15%	0%	2.58
	Total	**50%**	**22%**	**27%**	**1%**	**2.68**
32. My goal is to transfer factual knowledge to the students.	B	38%	15%	47%	0%	3.02
	SE	41%	19%	36%	4%	2.88
	VE	60%	10%	30%	0%	2.45
	Total	**42%**	**17%**	**39%**	**2%**	**2.86**
67. If a student investigation leads to an unexpected result I always tell the students the right answer/result.	B	25%	15%	60%	0%	3.38
	SE	41%	12%	44%	3%	2.97
	VE	40%	30%	30%	0%	3.05
	Total	**38%**	**15%**	**47%**	**0%**	**3.13**
68. I find it difficult to manage a classroom where each student group is doing different activities.	B	30%	8%	60%	2%	3.59
	SE	55%	23%	21%	1%	2.52
	VE	75%	0%	25%	0%	2.20
	Total	**50%**	**16%**	**33%**	**1%**	**2.79**
Statement item	**Group**	**AN/S****	**S***	**O/AA****	**N/D****	**Mean**
44. Students ask each other to explain their ideas.	B	38%	28%	34%	0%	2.94
	SE	27%	39%	32%	2%	3.02
	VE	15%	45%	40%	0%	3.40
	Total	**29%**	**37%**	**33%**	**1%**	**3.06**
46. Students pay attention to each other's ideas.	B	13%	53%	32%	2%	3.30
	SE	13%	41%	45%	1%	3.37
	VE	10%	40%	45%	5%	3.58
	Total	**12%**	**45%**	**41%**	**2%**	**3.37**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined; ** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

3.3.4 Making Science Relevant:

(Statement items 33, 37, 38, 39, 40 and 41 – Appendix A)

This set of question items focussed on teachers' attitudes to relating classroom science to phenomena outside the classroom and to the industrial world. The responses to these question items *(items 33, 37, 38, 39, 40 and 41)* were combined into one value, representing the response to 'making science relevant.' Within the question grouping, teachers were asked to indicate their level of agreement/disagreement with statements focussing on the relationships between classroom practice, science industry and phenomena in the outside world. Statement items are:

33. Good teachers encourage student discussion on scientific topics relevant to everyday life
37. I want my students to know about the latest developments and applications of science and engineering
38. I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom
39. I often show students the relevance of science in industry
40. My students understand the importance of science and technology for our society
41. If I had more information about industrial processes, I would use it in my teaching.

Responses to each of these items were coded from 1 to 5, with 5 indicating strong agreement with the statement. The individual responses to each item were summed and then divided by the number of questions to give an averaged response to this group of questions. A value of 5 indicates a teacher who strongly agrees with all the above statements.

This group of teachers had a mean score of 4.02 *(Table 3.9)* suggesting they were positively making these connections in their classrooms, with little variation of the means based on experience and gender. The beginners group however indicated significantly less agreement with the statement 'I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom' in comparison to the some experienced and experienced groups, again showing the greater lack of applied knowledge in the beginner group *(item 38, Table 3.10).* This will be further discussed in Section 3.6. There were no other significant differences between teacher groups for the other question items in this grouping. The data for this set of items is given in Table 3.10 and depicted graphically in Figure 3.6.

Table 3.9 Mean score for question grouping relating to teachers making science relevant to phenomena beyond the classroom.

	Mean			
Question item Grouping	**Overall group**	**Beginner**	**Some Experience**	**Very Experienced**
Making Science Relevant	4.02	4.10	3.95	4.28

Mean is based on a 1-5 scale with 5 relating to teaching practices where science relevance is important in the classroom and 1 where these practices are unimportant.

Table 3.10 Individual item responses from question grouping 'making science relevant'

Statement item	Group	SD/D	U	A/SA	N/D	Mean
33. Good teachers encourage student discussion on scientific topics relevant to everyday life.	B	0%	2%	98%	0%	4.40
	SE	0%	0%	98%	2%	4.42
	VE	0%	0%	100%	0%	4.70
	Total	**0%**	**1%**	**98%**	**1%**	**4.45**
37. I want my students to know about the latest developments and applications of science and engineering.	B	2%	0%	98%	0%	4.40
	SE	2%	5%	93%	0%	4.29
	VE	0%	0%	95%	5%	4.63
	Total	**3%**	**3%**	**94%**	**0%**	**4.36**
38. I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom.	B	7%	38%	55%	0%	3.64
	SE	13%	15%	70%	2%	3.73
	VE	0%	0%	100%	0%	4.30
	Total	**10%**	**20%**	**70%**	**0%**	**3.77**
39. I often show students the relevance of science in industry.	B	6%	13%	81%	0%	4.21
	SE	20%	11%	68%	1%	3.60
	VE	20%	10%	70%	0%	3.80
	Total	**16%**	**11%**	**72%**	**1%**	**3.81**
40. My students understand the importance of science and technology for our society.	B	7%	40%	53%	0%	3.62
	SE	12%	25%	62%	1%	3.60
	VE	0%	20%	80%	0%	3.95
	Total	**9%**	**29%**	**62%**	**0%**	**3.65**
41. If I had more information about industrial processes, I would use it in my teaching.	B	2%	4%	94%	0%	4.32
	SE	4%	13%	83%	0%	4.03
	VE	0%	10%	90%	0%	4.30
	Total	**3%**	**10%**	**87%**	**0%**	**4.15**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined*

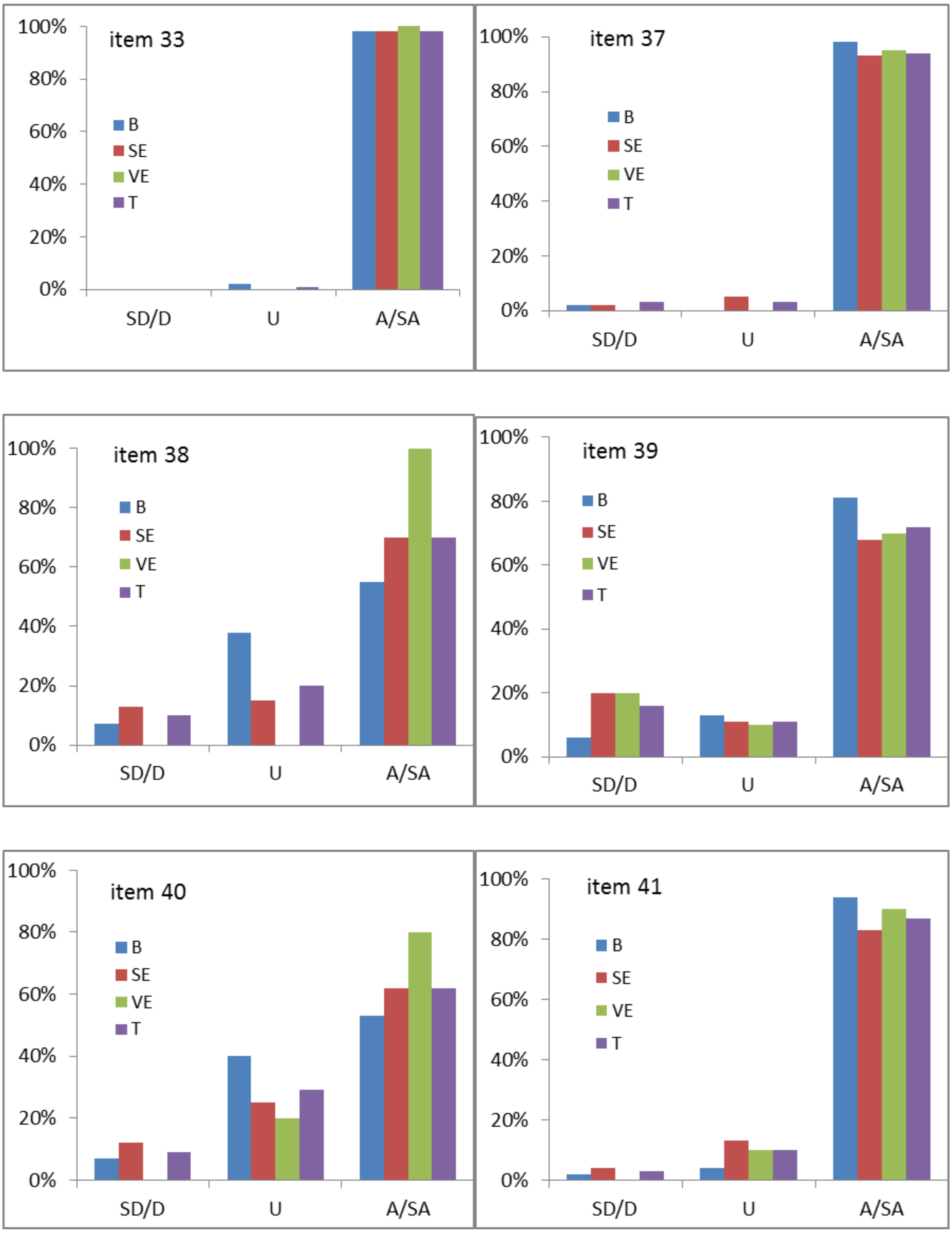

Figure 3.6 Response to teachers' views of making science relevant

3.4 Classroom Practice

This section of the profile instrument focussed on determining the extent of occurrence of particular practices within the classroom, which could be used to determine the extent of student involvement in inquiry activities. These questions were from the PSI-T questionnaire (Campbell, Abd-Hamid, & Chapman, 2010) and are grouped into 5 sections, based loosely on the main activities involved in the inquiry process, namely: asking research questions, designing investigations, conducting investigations, collecting data and drawing conclusions. Responses from each question item were coded, particular groupings are summed and then averaged as before. Eighteen out of twenty of the items in this section are coded positively with 1 representing "almost never" and 5 representing "almost always." Two items (items 51 and 56) however are coded negatively, such that 1 represents "almost always" and 5 represents "almost never." Importantly, teachers were asked to consider a particular class group when they were completing this section so therefore the responses should closely reflect their classroom practice.

3.4.1 Asking Research Questions.

(Statement items 47, 48, 49, 50)

In this group of questions *(items 47-50)*, teachers were asked to indicate how often practices relating to the use of student questions occurred, i.e., students formulating and generating investigative questions, student questions becoming the focus of laboratory work and time given to developing student questions.

The overall mean response from teachers was 2.78 with a significant difference between beginners' responses and very experienced teachers' responses (B/VE=2.60/3.20, $p= 0.011$) *(Table 3.16).* Differences with the SE group were not significant. There were no overall significant gender effects and no significant differences between male and female teachers irrespective of teaching experience. It is clear that student questions are not used extensively by any group of teachers and much less so by beginners. This is an important area to build on in teacher education programmes on inquiry based science education.

Responses to each of the individual items in this section are given in Table 3.11 and graphically in Figure 3.7. No significant differences were noted for the individual items based on teachers' level of experience, except for item 50 which relates to time devoted to refining student questions for investigations with beginners (62%) indicating that they are involved in this activity 'almost never/seldom' in comparison to the experienced group of whom 35% were involved 'often/almost always'.

Table 3.11 Responses to items in question grouping 'asking research questions'

Statement item	Group	AN/S**	S*	O/AA**	N/D**	Mean
47. Students formulate questions which can be answered by investigations	B	36%	34%	28%	2%	2.85
	SE	34%	38%	27%	1%	2.93
	VE	20%	35%	45%	0%	3.25
	Total	**33%**	**37%**	**29%**	**1%**	**2.94**
48. Student research questions are used to determine the direction and focus of the lab.	B	53%	41%	6%	0%	2.32
	SE	49%	31%	18%	2%	2.55
	VE	20%	55%	25%	0%	3.00
	Total	**46%**	**37%**	**16%**	**1%**	**2.54**
49. Students framing their own research questions are important.	B	28%	47%	23%	2%	2.91
	SE	24%	30%	44%	2%	2.25
	VE	20%	35%	45%	0%	3.50
	Total	**25%**	**35%**	**38%**	**2%**	**3.16**
50. Time is devoted to refining student questions so that they can be answered by investigations.	B	62%	30%	8%	0%	2.30
	SE	51%	31%	16%	2%	2.49
	VE	25%	40%	35%	0%	3.15
	Total	**51%**	**32%**	**16%**	**1%**	**2.52**

*** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

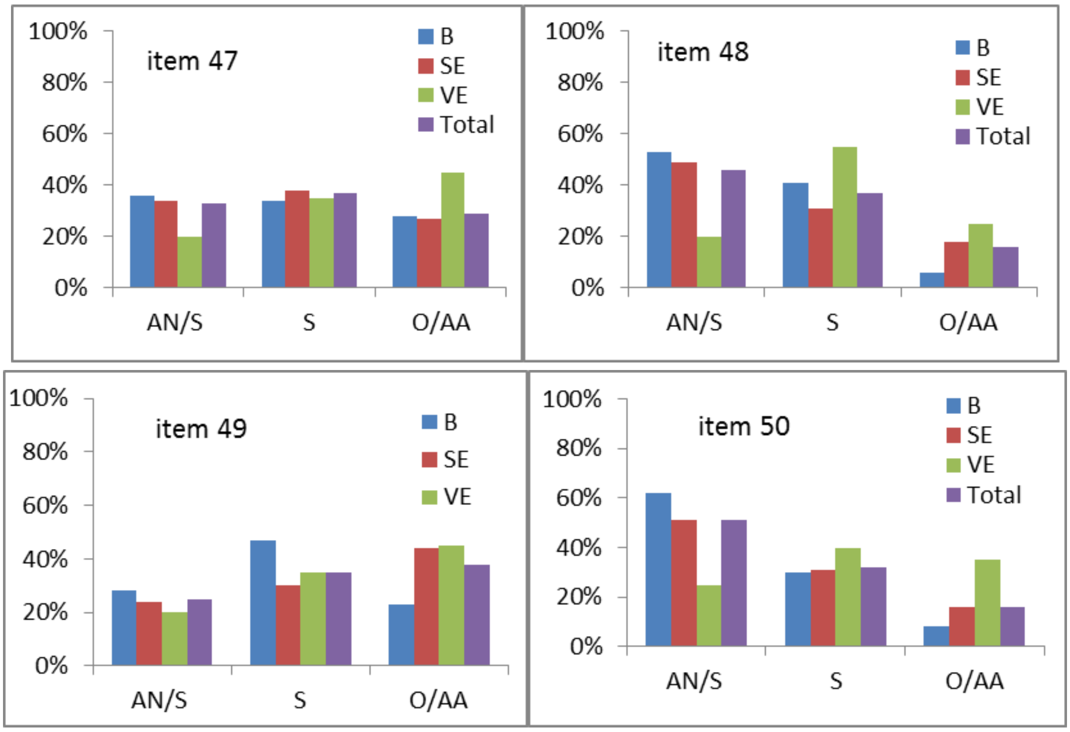

Figure 3.7 Response to 'asking research questions' , AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always.

3.4.2 Designing Investigations.

(Statement items 51, 52, 53, 54)

This group of questions *(items 51-54)* centred on how often teachers allow their students to design, critique and justify their own investigation procedures. The mean score of the group was 2.54 suggesting that students were involved only 'sometimes' or "seldom" in designing, critiquing and justifying their own investigation procedures *(Table 3.16).*

Based on teachers' level of experience with inquiry, there was a significant difference seen in responses, with beginners only 'seldom' involving students in such practices (B/SE=2.10/2.57, p=0.000; B/VE=2.10/3.40, p=0.000). This difference between beginners and experienced teachers was evident for each individual question within this group of questions (Table 3.12 and Figure 3.8), implying that the experienced teachers tend to allow more student involvement in designing investigations than the beginner teachers. The experienced group have an overall mean of 3.40, indicating that they are involved 'sometimes' to 'often' in allowing students to design and critique their own experimental procedures. Further expansion of this point could be developed with teacher interviews, to determine the extent of time that teachers spend in facilitating students designing investigations.

Table 3.12 Responses to individual items focusing on 'designing investigations'

Statement item	Group	AN/S*	S*	O/AA*	N/D*	Mean
51. Students are given step-by-step instructions before they conduct investigations.	B	4%	7%	87%	2%	4.52
	SE	5%	30%	63%	2%	3.80
	VE	30%	40%	25%	5%	2.90
	Total	**8%**	**24%**	**65%**	**3%**	**3.90**
52. Students design their own procedures for investigations.	B	83%	13%	4%	0%	1.72
	SE	48%	41%	10%	1%	2.52
	VE	15%	45%	40%	0%	3.35
	Total	**54%**	**33%**	**12%**	**1%**	**2.39**
53. Students engage in the critical assessment of the procedures that are employed when they conduct investigations	B	53%	30%	17%	0%	2.62
	SE	30%	51%	18%	1%	2.87
	VE	10%	25%	60%	5%	3.83
	Total	**34%**	**42%**	**23%**	**1%**	**2.91**
54. Students justify the appropriateness of the procedures that are employed when they conduct investigations.	B	47%	30%	19%	4%	2.62
	SE	43%	38%	17%	2%	2.66
	VE	10%	45%	40%	5%	3.47
	Total	**40%**	**37%**	**20%**	**3%**	**2.75**

** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

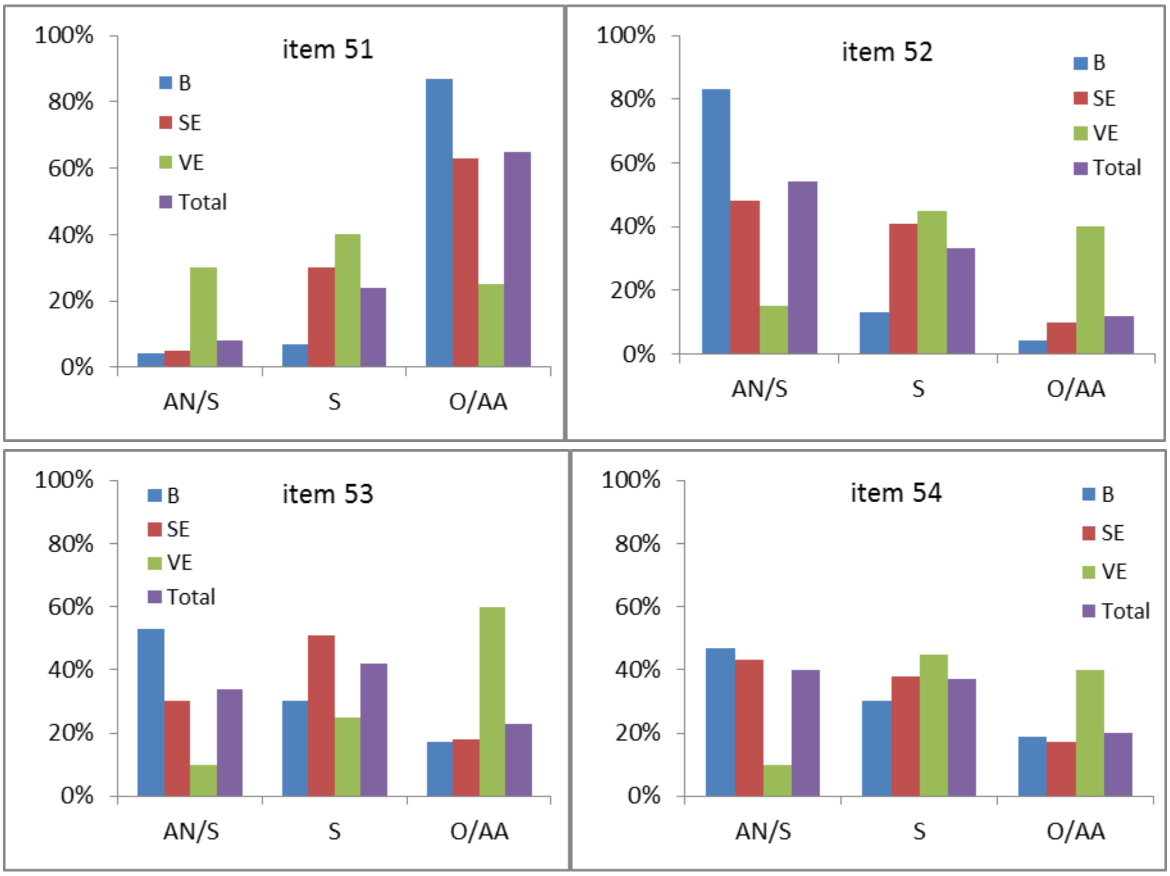

Figure 3.8 Response to 'designing investigations', AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always.

3.4.3 Conducting Investigations

(Statement items 55-58)

This group of questions *(items 55-58)* focuses on students' active participation in the conduction of their own investigations. Responses were rated from 1 to 5, with 5 representing student participation almost always. The mean of the overall group was 3.43 suggesting they at least 'sometimes' allow these practices to occur in their classrooms *(Table 3.16).*

Beginners and teachers with some experience had similar mean scores of 3.32 and 3.41, respectively, but they differed significantly to teachers who were experienced with inquiry, who had a mean score of 3.73 (B/VE= 3.32/3.73, p=0.032; SE/VE=3.41/3.73, p=0.035). This is very positive in that all teachers suggest that students are active in the investigative process at least 'sometimes' with the greater experienced group tending to involve the students more 'often'.

Data for each individual item in this set is given in Table 3.13 and shown graphically in Figure 3.9.

Table 3.13 Responses to individual items 'conducting investigations'.

Statement item	Group	AN/S**	S**	O/AA**	N/D**	Mean
55. Students conduct their own procedures of an investigation.	B	77%	13%	6%	4%	2.22
	SE	43%	45%	10%	2%	2.54
	VE	15%	45%	35%	5%	3.21
	Total	**50%**	**35%**	**12%**	**3%**	**2.53**
56. The investigation is conducted by the teacher in front of the class.	B	47%	17%	36%	0%	2.70
	SE	33%	43%	22%	2%	2.76
	VE	30%	60%	10%	0%	2.65
	Total	**37%**	**37%**	**25%**	**1%**	**2.73**
57. Students actively participate in investigations as they are conducted	B	0%	30%	70%	0%	4.11
	SE	3%	15%	81%	1%	4.10
	VE	0%	15%	85%	0%	4.35
	Total	**2%**	**19%**	**78%**	**1%**	**4.13**
58. Each student has a role as investigations are conducted.	B	19%	21%	60%	0%	3.68
	SE	17%	18%	63%	2%	3.74
	VE	10%	10%	80%	0%	4.00
	Total	**17%**	**18%**	**64%**	**1%**	**3.75**

*** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

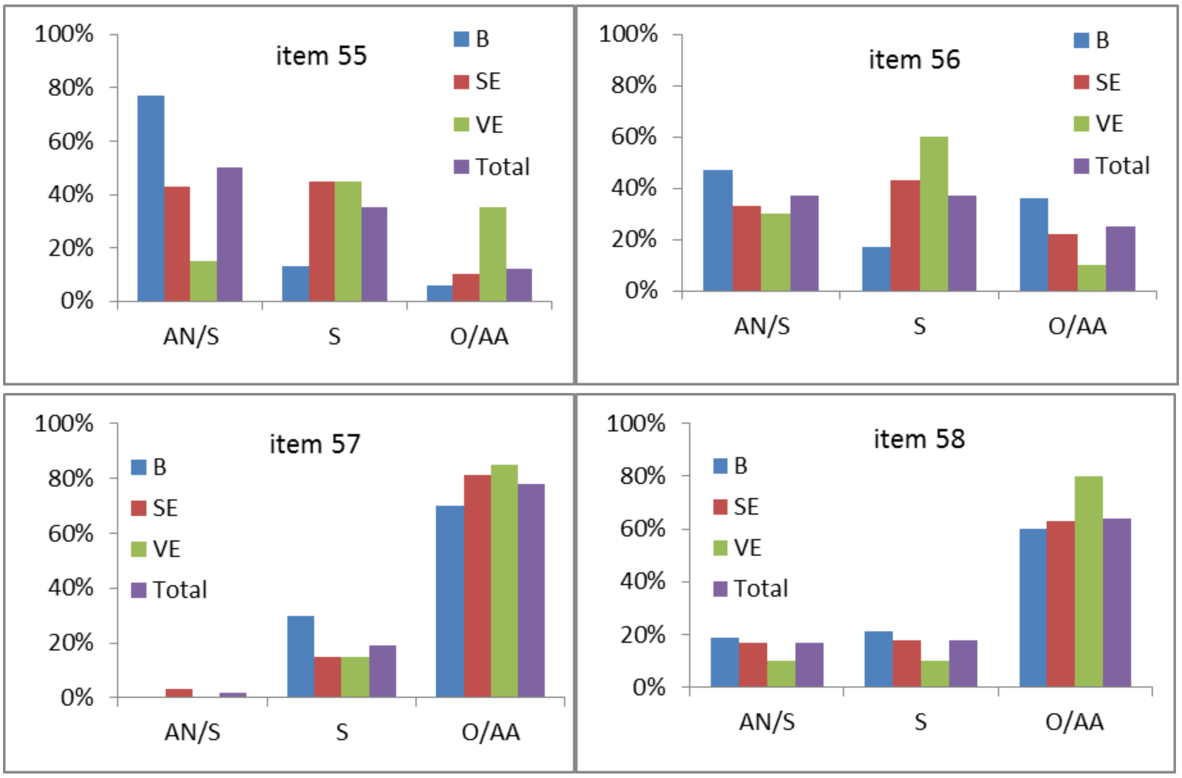

Figure 3.9 Response to 'conducting investigations'; AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always.

The significant difference between responses to item 55 from beginner and experienced teachers indicates that students in the experienced teacher's classroom are more frequently involved in conducting their own procedures in an investigation In the remainder of the items, there are no significant differences based on level of experience.

3.4.4 Collecting Data.

(*Statement items 59-62).*

When conducting investigations, a key learning opportunity for students is to decide on what data should be collected, why it needs to be collected and how it should be collected. This group of questions *(items 59-62)* determines the frequency of time that students are allowed to make these decisions. Responses were rated from 1 to 5, with 5 indicating that students have control of these decisions 'almost always'. The mean value obtained is 3.09 suggesting that students are given this control 'sometimes' within the classroom *(Table 3.16).*

There was a significant difference between beginners and very experienced teachers (B/VE= 2.90/3.47, p=0.011), suggesting that the more experienced inquiry teachers allow students to decide on data collection more frequently than beginners. There was a significant difference also seen between male and female respondents with some experience with IBSE. Females with some experience had significantly higher mean performance suggesting that they at least "sometimes" encourage these practices in their classrooms compared to their male equivalents (M/F=2.83/3.20, p=0.025). Interestingly the opposite was true for experienced male and female teachers, where males appeared to use these practices significantly more frequently than females (M/F=4.05/3.28. p=0.032).

Responses to individual items in this group of questions are given in Table 3.14 and are graphically represented in Figure 3.10. There were no statistically significant differences among teachers based on their different levels of inquiry experience. For all items, the experienced teacher seemed to allow their students to be involved in the respective activity more frequently than the beginner group.

Table 3.14 Responses to individual items 'collecting data'.

Statement item	Group	AN/S**	S*	O/AA**	N/D**	Mean
59. Students determine which data to collect.	B	34%	47%	19%	0%	2.81
	SE	40%	37%	20%	3%	2.77
	VE	20%	45%	35%	0%	3.32
	Total	**37%**	**41%**	**22%**	**0%**	**2.85**
60. Students take detailed notes during each investigation along with other data they collect.	B	38%	24%	38%	0%	2.98
	SE	22%	29%	47%	2%	3.42
	VE	20%	40%	40%	0%	3.32
	Total	**27%**	**29%**	**43%**	**1%**	**3.27**
61. Students understand why the data they are collecting is important.	B	7%	55%	38%	0%	3.47
	SE	9%	32%	57%	2%	3.60
	VE	0%	30%	70%	0%	3.85
	Total	**7%**	**39%**	**53%**	**1%**	**3.59**
62. Students decide when data should be collected in an	B	66%	25%	9%	0%	2.32
	SE	45%	40%	13%	2%	2.62

investigation.	VE	30%	40%	30%	0%	3.11
	Total	**49%**	**36%**	**14%**	**1%**	**2.59**

*** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined*

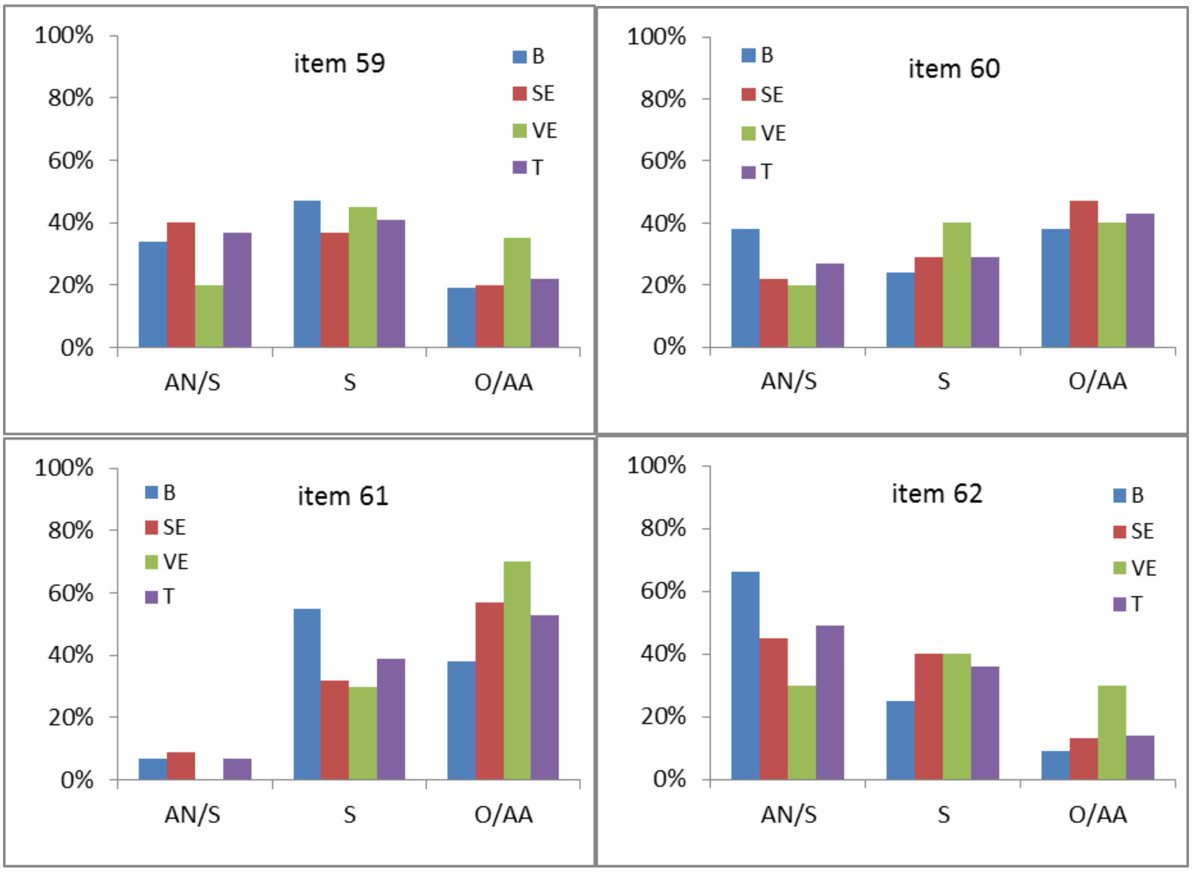

Figure 3.10 Response to 'collecting data'
AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always.

3.4.5 Drawing Conclusions.

(Statement items 63-66).

Within this group of questions *(items 63-66),* teachers were asked to indicate how often their students draw conclusions, interpret evidence, use scientific knowledge and justify conclusions, by themselves, after conducting investigations. Responses were rated from 1-5, with 5 suggesting that the teachers stated that their students are involved in these activities 'almost always.' The mean score was 3.25, which suggests that this practice occurs 'sometimes' to 'often' within their classrooms *(Table 3.16).*

Based on the mean responses, these practices occurred much more frequently with experienced teachers, who indicated the practice as 'often' occurring while beginners indicated 'sometimes' occurring. Those with some experience were closer to the beginners (B/VE=2.96/3.83, p=0.000; B/SE=2.96/3.28, p=0.051; SE/VE=3.28/3.83, p=0.002). Experienced teachers in inquiry more frequently encouraged their students to draw and justify their own conclusions to investigations using their scientific knowledge.

This trend is clear for all statement items in this group of questions – see Table 3.15 and graphical representation of responses in Figure 3.11. For each statement item, the very experienced group of teachers allow students to be involved in that particular activity more frequently than those with some experience, who also allow the activity more frequently than the beginner group. Each of these differences were also statistically significant.

Table 3.14 Responses to individual items 'drawing conclusions'.

Statement item		AN/S**	S*	O/AA**	N/D**	Mean
63. Students develop their own conclusions for investigations.	B	32%	28%	40%	0%	3.17
	SE	17%	31%	51%	1%	3.48
	VE	0%	5%	95%	0%	4.20
	Total	**19%**	**27%**	**53%**	**1%**	**3.48**
64. Students consider a variety of ways of interpreting evidence when making conclusions.	B	53%	30%	17%	0%	2.60
	SE	36%	41%	21%	2%	2.89
	VE	5%	55%	40%	0%	3.45
	Total	**37%**	**39%**	**23%**	**1%**	**2.87**
65. Students connect conclusions to scientific knowledge	B	17%	51%	32%	0%	3.19
	SE	13%	38%	48%	1%	3.45
	VE	0%	25%	75%	0%	3.80
	Total	**12%**	**40%**	**47%**	**1%**	**3.42**
66. Students justify their conclusions.	B	36%	36%	28%	0%	2.94
	SE	25%	31%	43%	1%	3.25
	VE	5%	35%	60%	0%	3.85
	Total	**26%**	**33%**	**40%**	**1%**	**3.23**

** AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always; N/D = not determined

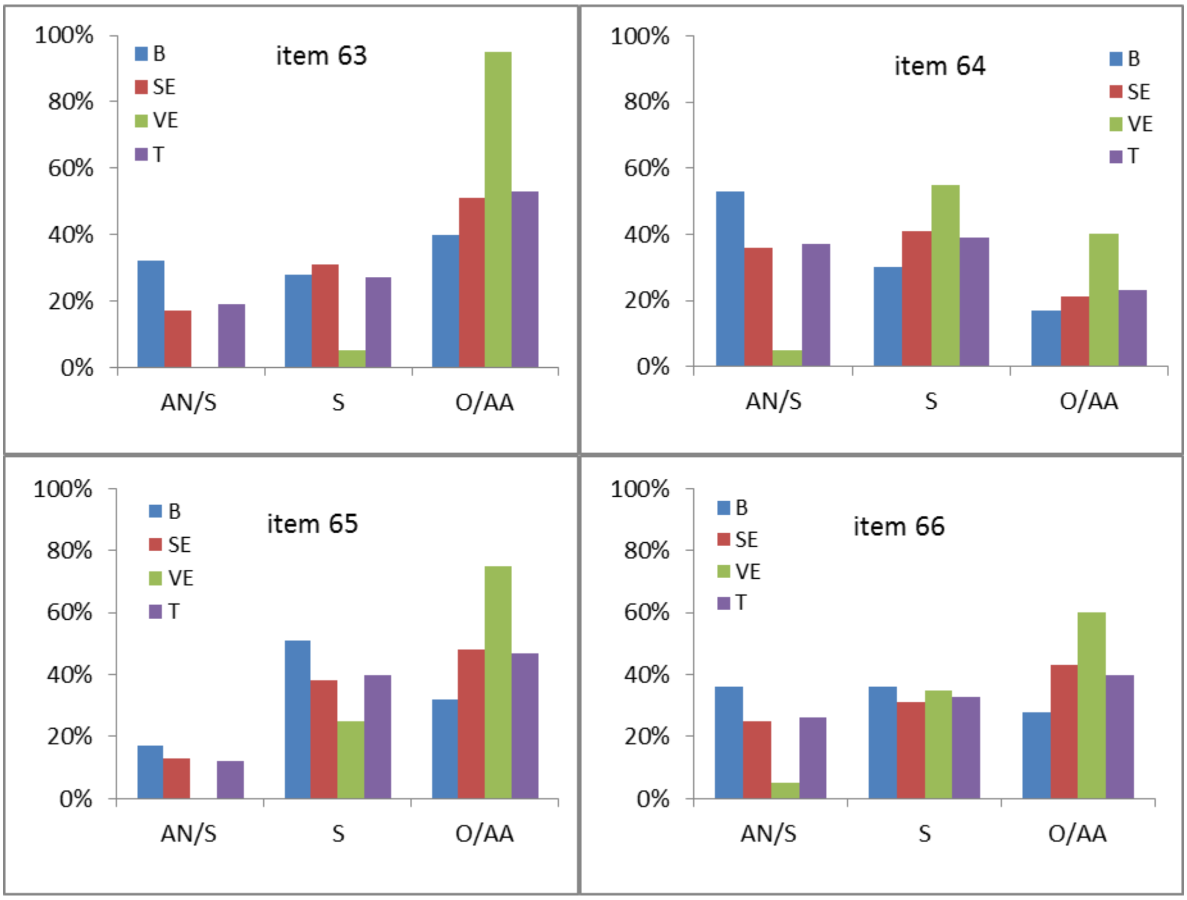

Figure 3.11 Response to 'drawing conclusions'.
AN/S = Almost Never/Seldom; S = sometimes; O/AA = often/almost always.

3.4.6 Summary of classroom practice

Teachers responded to these sets of question items in relation to a particular class group and were asked to indicate the frequency of implementation of a number of practices within their classroom. Therefore, this section can provide a good indication of the actual classroom practice of the teachers in relation to inquiry activities. Table 3.16 summarises the mean result from combined responses to each group of questions and Figure 3.12 presents graphically the same information.

From the table, it is clear that the mean responses tend to be around the middle of the scale 1-5, i.e., they are implemented 'sometimes'. Note that this is the mean value associated with the particular set of questions and therefore must be interpreted with caution. However, looking at the experience level of the teachers, it is clear that in all groups of questions, the inquiry type activities are implemented more frequently by the experienced group than by the beginner group. The experienced teacher has his/her students more involved in the inquiry practices of asking research questions, designing investigations, conducting investigations, collecting data and drawing conclusions. This indicates that teachers' rating of themselves as 'experienced in IBSE' corresponds to their classroom practice. Differences in practice between the experienced teacher and the beginner are particularly evident in terms of designing investigations and drawing conclusions. Again, these areas require a good knowledge of science and beginners may be more unsure in this area.

Table 3.16 Mean results of combined responses to each question group on classroom practice

Question Grouping	Overall Mean	Mean -Beginner	Mean - Some Experience	Mean - Very Experienced
Asking Research Questions	2.78	2.60	2.79	3.20
Designing Investigations	2.54	2.10	2.57	3.40
Conducting Investigations	3.43	3.32	3.41	3.73
Collecting Data	3.09	2.90	3.11	3.47
Drawing Conclusions	3.25	2.96	3.28	3.83

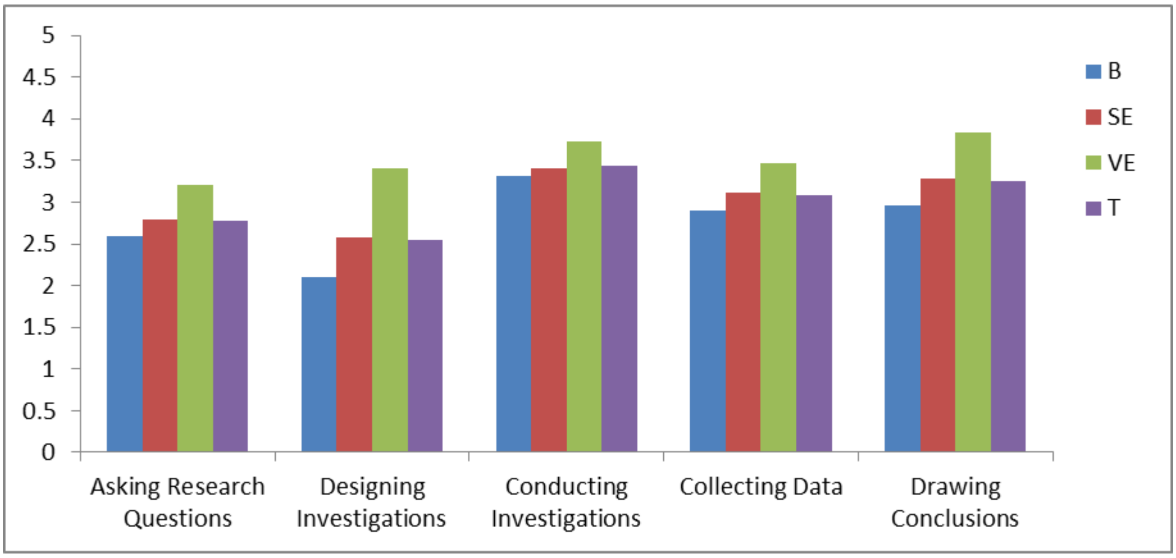

Figure 3.12 Mean results of combined responses to each question group on classroom practice; (1 represents "almost never" and 5 represents "almost always")

A further positive aspect of the data is that it clearly indicates that all groups of teachers have students conducting investigations at a frequency of 'sometimes' to 'often', which is very encouraging for development of inquiry activities.

3.5 Attitudes to Change

(*Statement items 34, 35 and 36 – Appendix A)*

The teachers who completed this questionnaire were all attending ESTABLISH workshops focusing on inquiry based science teaching, suggesting that this group were open to trying different methodologies in their teaching. This was true for almost everyone in the group (*item 35, Table 3.17).*

However, only less than half of the total group of teachers (45%) were happy with their current method of teaching (*item 34, Table 3.17)*. This proportion was 70% for the experienced group, 45% of those with some experience and only 36% of the beginners in inquiry (*item 34, Table 3.17 and Figure 3.13)*. This seems to suggest that the more experienced teachers in inquiry were happier with their teaching methods than those who were still beginners in inquiry!

The process of changing from one teaching method to another can be quite daunting and teachers must be prepared to face this challenge. Most teachers among this group (86%) were not apprehensive about changing their current teaching methods; however with the beginner group of teachers, this proportion fell to 68% (*Table 3.17 and Figure 3.13)*. Again, this indicates the need for support and guidance especially for the beginner group when introducing different teaching methods.

Table 3.17 Teacher responses to attitudes to change (items 34, 35, 36)

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
34. I am happy with my current teaching methods.	B	24%	40%	36%	0%	3.13
	SE	25%	27%	45%	3%	3.22
	VE	15%	15%	70%	0%	3.79
	T	**24%**	**29%**	**45%**	**2%**	**3.26**
35.I am open to trying different methodologies in my teaching	B	0%	0%	100%	0%	4.73
	SE	1%	1%	98%	0%	4.51
	VE	5%	0%	95%	0%	4.68
	T	**1%**	**1%**	**98%**	**0%**	**4.59**
36. I feel apprehensive about changing my current teaching practice.	B	68%	13%	19%	0%	2.38
	SE	93%	3%	4%	0%	1.84
	VE	95%	0%	5%	0%	1.53
	T	**86%**	**5%**	**9%**	**0%**	**1.96**

** SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined.*

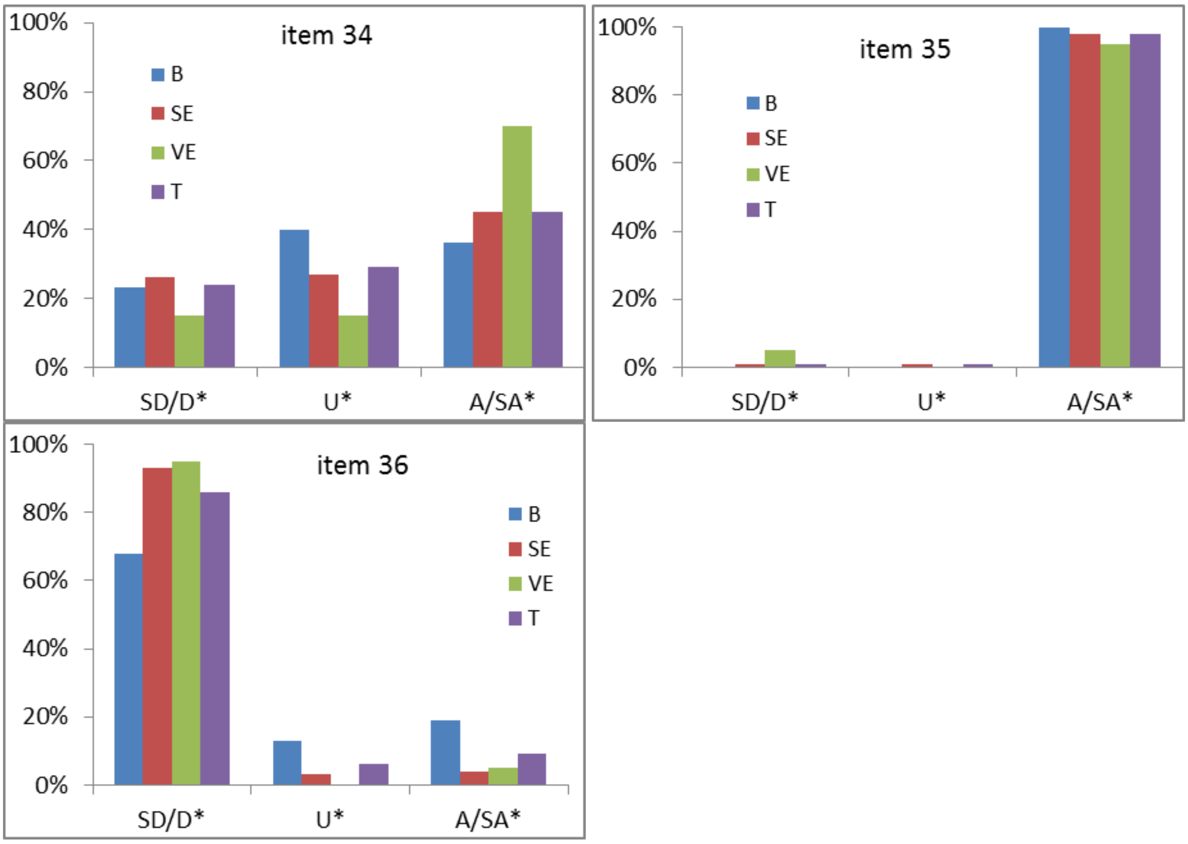

Figure 3.13 Teacher responses to attitudes to change (items 34, 35, 36)

3.6 Self-confidence in Scientific Knowledge.

(Statement items 38, 70 and 71 – Appendix A).

Earlier in this report (Section 3.3 Teaching Science), there were some clear suggestions that the experienced teacher in IBSE seemed to have a fuller understanding of the nature of science and the place of science in the wider society. To probe this further, responses from three particular questions were considered together, namely:

38. 'I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom'

70. 'I have sufficient knowledge of science to implement an inquiry lesson effectively'

71. 'I am uncomfortable with teaching areas of science that I have limited knowledge of'.

A majority of 70% of teachers felt that they were capable of making relationships between scientific concepts and phenomena beyond the classroom *(items 38, Table 3.18)*; however, this percentage fell from 100% of the experienced group to 70% of the some experienced and 55% of the beginners *(Table 3.18 and Figure 3.14).* These differences were statistically significant (B/VE=3.65/4.30, p=0.000; SE/VE=3.68/4.30, p=0.000).

Although nearly 70% of all teachers felt that they have sufficient knowledge of science to implement an inquiry lesson effectively, nearly half felt that they were uncomfortable teaching areas of science that they have limited knowledge of *(items 70, 71; Table 3.18).* Examining this on the basis of experience, the experienced teacher stated that they had sufficient knowledge (90%) and they were not uncomfortable with limited knowledge (75%) *(Table 3.18 and Figure 3.14).* However, 77% of the some experienced group have sufficient knowledge in comparison to only 38% of the beginners (B/VE=3.38/4.30, p=0.000; SE/VE=3.73/4.30, p=0.006). Within the beginners group, there was a gender effect with males agreeing more strongly that they had sufficient knowledge in science than female teachers (M/F=3.88/3.28, p=0.009). The beginner group of teachers were also more uncomfortable with teaching science that they have limited knowledge of (60%) in comparison to the some experienced group (45%) and the experienced group (20%). Mean differences between these groups are not significant *(item 71, Table 3.18 and Figure 3.14).*

Scientific inquiry requires teachers and students to explore science in a way that may take them beyond what they already know. When teachers are afraid to go beyond their limits and unwilling to investigate deeper into problems, then this will impact students' learning.

Table 3.18 Teacher responses on items self-confidence in scientific knowledge (items 38, 70, 71)

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
38. I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom.	B	7%	38%	55%	0%	3.65
	SE	14%	15%	70%	1%	3.68
	VE	0%	0%	100%	0%	4.30
	Total	**10%**	**20%**	**70%**	**0%**	**3.77**
70. I have sufficient knowledge of science to implement an inquiry lesson effectively	B	4%	58%	38%	0%	3.38
	SE	12%	11%	77%	0%	3.73
	VE	0%	10%	90%	0%	4.30
	Total	**9%**	**24%**	**67%**	**0%**	**3.69**

71. I am uncomfortable with teaching areas of science that I have limited knowledge of.	B	30%	10%	60%	0%	3.35
	SE	45%	10%	45%	0%	2.92
	VE	75%	5%	20%	0%	2.85
	Total	**41%**	**10%**	**49%**	**0%**	**3.04**

* SD/D = strongly disagree/disagree; U =uncertain; A/SA = agree/strongly agree; N/D = not determined.

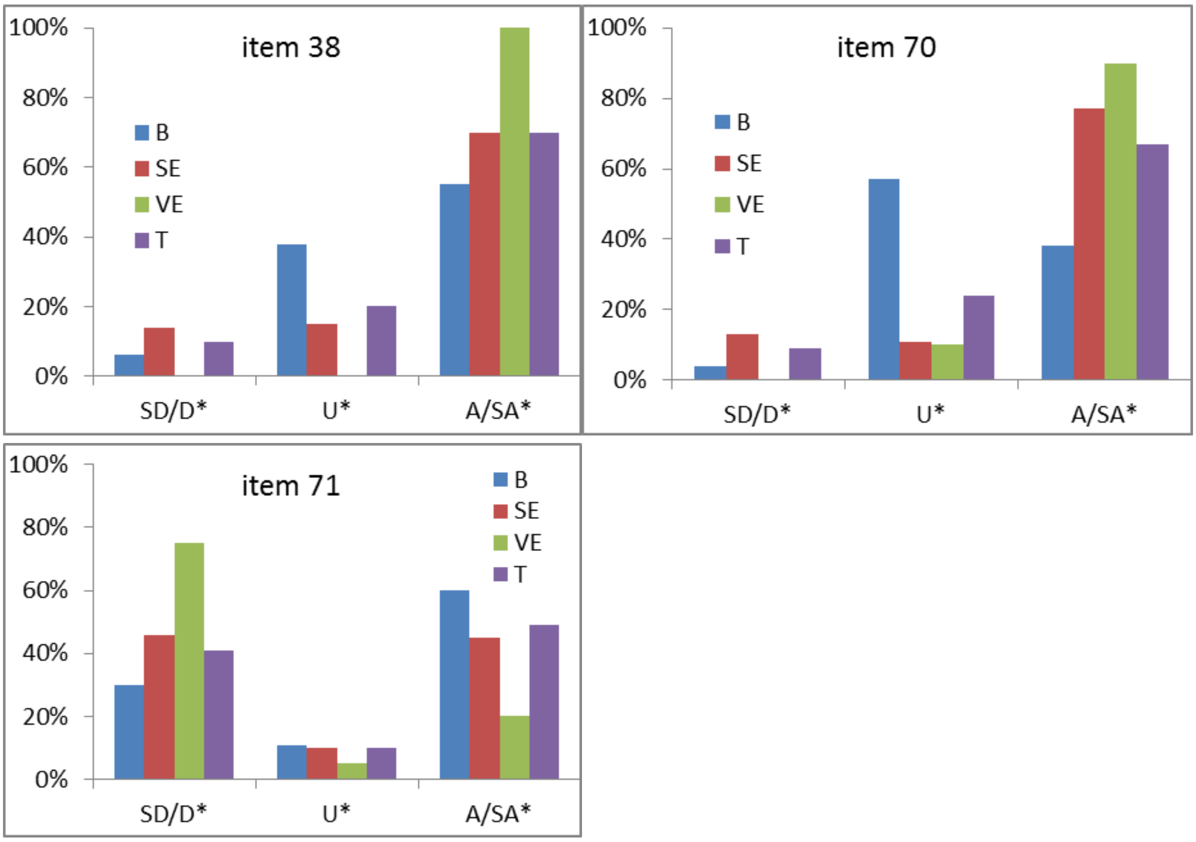

Figure 3.14 Teacher responses on items self-confidence in scientific knowledge (items 38, 70, 71)

3.7 Self-confidence in Teaching Through Inquiry

(Statement items 68, 69, 72 and 73 – Appendix A)

This section briefly examines teachers' self confidence with particular aspects of teaching, i.e., managing different activities within the classroom, asking high order questions, asking and dealing with questions where the teacher is unsure of the answer. As discussed previously (Section 3.3.3), 50% of the teachers do not find it difficult to manage a classroom where student groups are conducting different activities *(item 68, Table 3.19 and Figure 3.15)*. However, this was significantly different based on teachers' level of experience in IBSE. Thus, beginners in IBSE more strongly admitted difficulty in classroom management (B/SE = 3.59/2.52, p=0.000; B/VE=3.59/2.20, p=0.000) compared to those with experience *(item 68, Table 3.19 and Figure 3.15)*.

The majority of teachers were confident with asking questions in their classrooms. The majority (71%) overall felt that they knew how to ask higher order questions *(item 69)*. However, this was again more of a problem for the beginner group, with only 23% of the beginners agreeing that this was an issue for them (B/VE=2.54/1.80, p=0.004) *(item 69, Table 3.19 and Figure 3.15)*. 84% overall felt that they would not feel inadequate as a teacher, if they didn't know the answers to student questions *(item 72)* and 70% felt they would have no problem asking questions in their class, where they were unsure of the answer themselves *(item 73, Table 3.19)*. There were no statistically significant differences based on experience or gender *(Table 3.19 and Figure 3.15)* suggesting that these classroom practices are not related to experience in inquiry, but they are good teaching practices!

Table 3.19 Teacher responses on items self-confidence in teaching through inquiry (items 68, 69, 72, 73)

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
68. I find it difficult to manage a classroom where each student group is doing different activities.	B	30%	8%	60%	2%	3.59
	SE	55%	24%	21%	0%	2.52
	VE	75%	0%	25%	0%	2.20
	Total	**50%**	**16%**	**33%**	**1%**	**2.79**
69. I am unsure how to ask students higher order questions that promotes thinking.	B	60%	17%	23%	0%	2.54
	SE	72%	11%	16%	1%	2.22
	VE	90%	5%	5%	0%	1.80
	Total	**71%**	**12%**	**17%**	**0%**	**2.28**
72. If I don't know the answers to students questions I feel inadequate as a teacher.	B	79%	8%	13%	0%	1.92
	SE	88%	5%	7%	0%	1.83
	VE	75%	5%	20%	0%	2.15
	Total	**84%**	**6%**	**10%**	**0%**	**1.89**
73. I am uncomfortable with asking questions, in my class, where I am unsure of the answer myself.	B	62%	21%	15%	2%	2.28
	SE	73%	13%	14%	0%	2.15
	VE	75%	10%	15%	0%	2.15
	Total	**70%**	**15%**	**14%**	**1%**	**2.19**

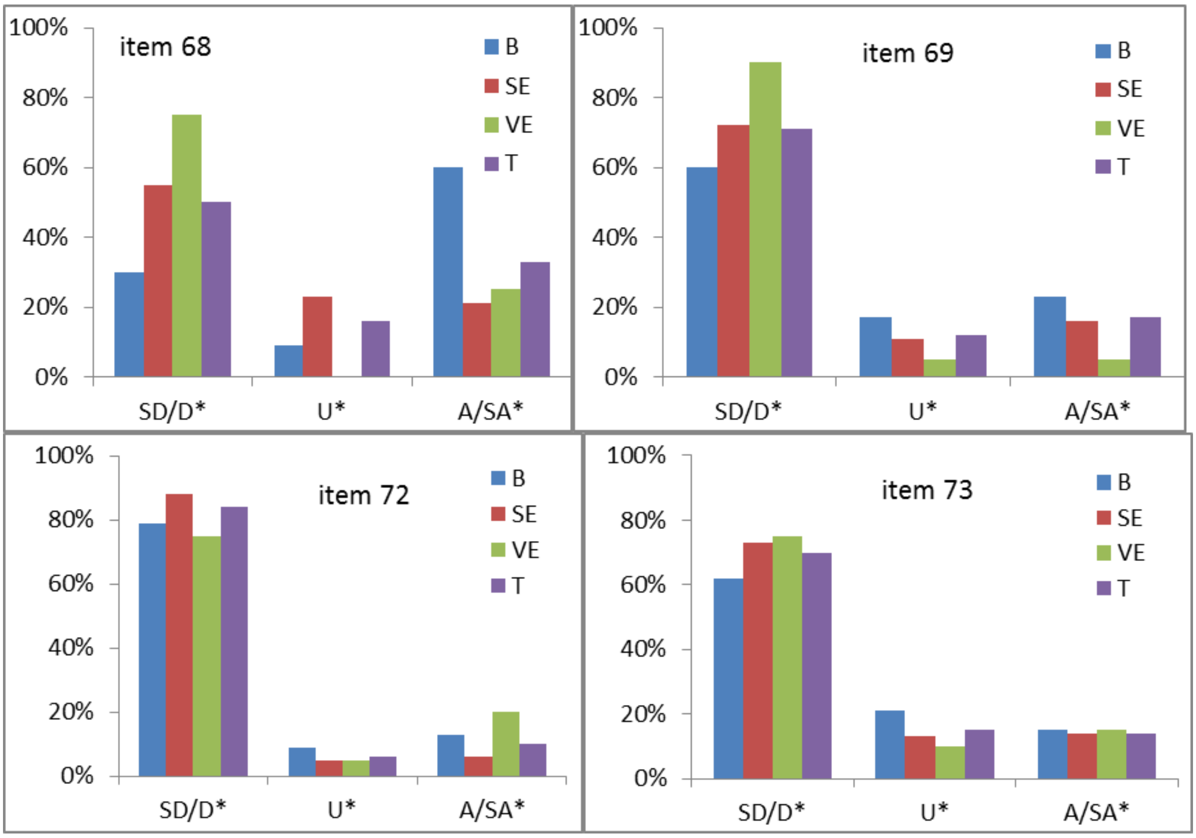

Figure 3.15 Teacher responses on items self-confidence in teaching through inquiry (items 68, 69, 72, 73)

3.8 Teacher Concerns about teaching through Inquiry

Teachers were asked to select and rank the top three challenges that they usually faced in relation to implementing inquiry based teaching. Space was provided for them to add in any additional challenges that were not already listed; however, few were added. Table 3.20 shows the percent of the teachers who ranked a particular item as first, second or third; only the top three choices are indicated; e.g. 38% of all the teachers ranked ‘Lack of time to implement inquiry’ as the number 1 challenge that they faced in implementing inquiry.

Table 3.20 Challenges to teaching by inquiry

Challenge	Ranking of Challenge			Total
	1	2	3	
Lack of time to implement inquiry	38%	29%	12%	80%
Lack of equipment/assistance in school laboratories	18%	18%	17%	53%
Curriculum constraints	20%	19%	6%	44%
Limited knowledge of teaching by inquiry	6%	7%	12%	25%
Classroom management issues	4%	8%	10%	22%
Assessment methods for inquiry	2%	5%	8%	16%
Limited knowledge of ICT as used in inquiry	1%	5%	6%	12%
Lack of supportive school management	3%	4%	2%	9%
Limited scientific content knowledge to use inquiry effectively	3%	1%	2%	6%

Other (Please list):....	1%	1%	5%	6%
None of the above – I teach by inquiry	1%	0%	1%	2%
BLANK	2%	4%	18%	25%

Only 83% of the teachers responded fully to this question. From their responses, lack of time to implement inquiry, was the most common challenge for teaching by inquiry, listed by 80% of the respondents and it was ranked as the biggest challenge by 38% of them. Lack of assistance/equipment in school laboratories and curriculum constraints were the next two highest ranked challenges.

These challenges were ranked highest by each teacher group also - beginners, teachers with some experience and very experienced teachers with IBSE - suggesting that these are the main challenges that teachers face when implementing inquiry and that they do not vary with experience (Figure 3.16). Figure 3.16 shows the ranking of all the challenges by the different teacher groups – note the total presented is the percent of that cohort that ranked the particular challenge as one of their top three challenges.

Both the beginners group and those with some experience rank 'limited knowledge of ICT as used in inquiry' as an important challenge and all three groups of teachers rank 'classroom management issues' as also important. The remaining challenges listed received <20% support, except 'lack of supportive school management' which was rated by the beginner group mainly.

Other issues that were listed by small numbers of teachers included 'student ability', 'limited access to ICT', 'limited access to lab, constantly moving to class and no assistance to help', 'lack of energy to teach inquiry', 'group size', 'finding really good questions/areas which are appropriate'.

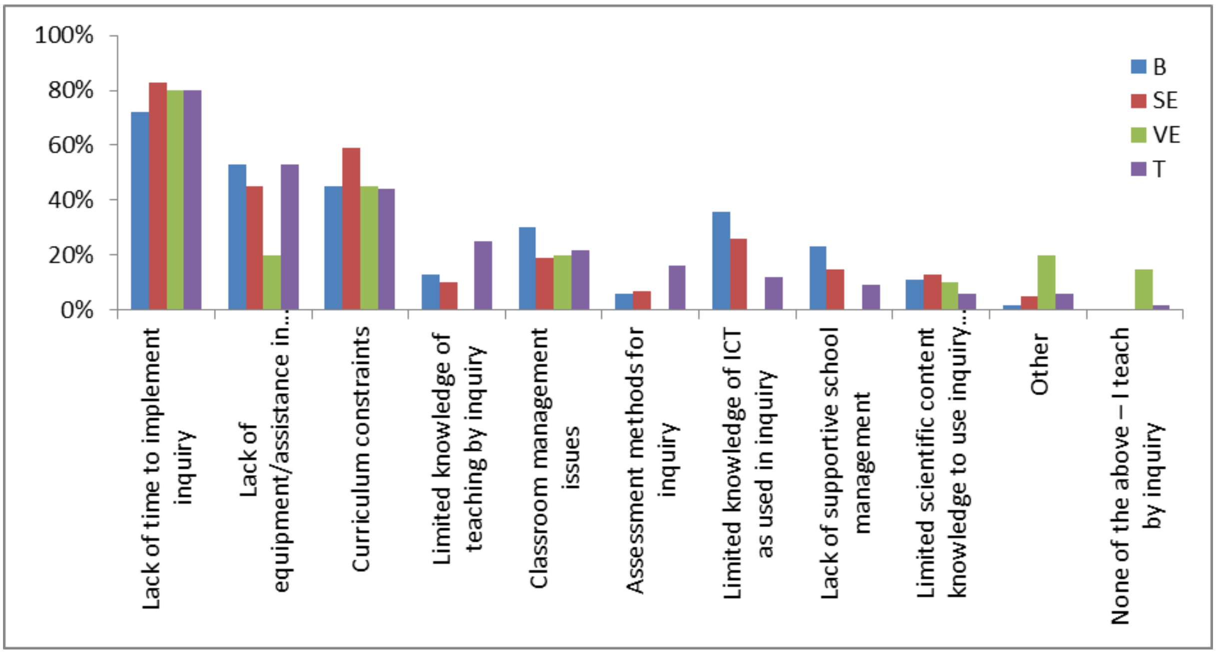

Figure 3.16 Top three challenges faced by teachers to implementing inquiry

4. Main Characteristics of Teachers – building a profile

From the data collected from this instrument, it is clear that there are clear distinctions among the teachers based on their level of experience in inquiry based teaching methods.

It is important to note that teachers rated themselves in terms of their experience level in inquiry from 'a complete beginner' to 'have some experience' and to 'very experienced' in IBSE.

In most cases, the main differences were observed between the 'beginner' and the 'very experienced' teachers, and only these two categories will be summarised below. The some experienced group of teachers were more like the experienced group in some attributes and more like the beginners in others. However, by looking at the two extremes, interventions can be designed and implemented that also encompass the middle group.

The group of teachers that attended the ESTABLISH workshops covered the spectrum of ages and years of teaching experience of the teaching profession. Many of the attitudes shown by the teachers are very positive towards inquiry based teaching. Most of the teachers agreed that inquiry methods are appropriate to achieve the aims of their curriculum. As these teachers are from four different countries, then it is clear that inquiry methods fit in with the respective national science curricula. The inquiry method was also considered by most of the teachers to be suitable for all students regardless of ability and that the students did not need to have a lot of factual knowledge prior to being involved in inquiry.

Almost all the teachers expressed the view that good science teachers should allow students to develop their own research questions and encourage student discussion on scientific topics relevant to everyday life. However, the experienced group of teachers implemented these practices in their classrooms more frequently than the beginner group. The students in the beginners classroom only sometimes learnt that science was part of their out-of-school lives. So there is a mismatch between the beginners views of good teaching and its implementation.

All the teachers agreed that developing thinking and reasoning processes in students was more important than developing specific content knowledge. They all wanted their students to know about the latest developments and applications of science and engineering and agreed that if they had more information about industrial processes, then they would use them in their teaching. The beginner group however were more uncertain in relating scientific concepts in the curriculum to phenomena beyond the classroom.

In relation to classroom practice in terms of key aspects of inquiry, there were some practices that are common to all the teachers and others that differ depending on the experience level of the teacher. In all cases, teachers stated that their students were involved in conducting investigations and being active participants. However, the beginner teacher more often gives step-by-step instructions for conducting the investigation. For all the other inquiry activities of asking research questions, designing investigations, collecting data and drawing conclusions, while students were involved, they were involved more frequently by the experienced teacher than by the beginner.

Most of the teacher group were open to trying different methodologies in their teaching and were not apprehensive to change. Only the experienced group of teachers were happy with their current teaching method. The challenges that the teachers identified when implementing inquiry were the key challenges that have already been identified, i.e., lack of time to implement inquiry, lack of equipment or assistance, curriculum constraints and limited knowledge of inquiry. These concerns must be addressed within the teacher education programme.

Combining the data from the questionnaire, a general profile of the teachers based on their experience level in IBSE can be suggested.

The beginner teacher in IBSE can be of any age and can have few to many years of teaching experience. They do not fully understand inquiry based science education and have the following attributes in comparison to those experienced in inquiry:

- Are more sure of the student role in the inquiry classroom than the teacher role;
- Are uncertain about the time that inquiry takes in classroom and whether it would be their main teaching method;
- Believe that inquiry can be suitable for all students regardless of ability;
- Tendency towards views of good teachers as those who are bounded by curriculum;
- View science as static body of knowledge and more unsure of the nature of science;
- Adopt more factual approach to teaching science;
- Classroom management with different activities a potential issue;
- Lack scientific knowledge to relate classroom science to outside phenomena and to teach by inquiry
- More unsure of themselves in terms of their scientific knowledge base, their degree of comfort dealing with unknown within classroom
- Are not as happy with their current teaching method, but are willing to try other teaching methods but are more apprehensive about changing teaching methods.

4.1 Implications for Teacher Education Programme in IBSE

There are a number of specific recommendations that can be drawn from this data to support teachers in their development as inquiry teachers.

Teacher education programmes need to build on the strengths of the teachers and on their motivation and willingness to try different teaching methods to benefit their students. Many of them are already practicing elements of inquiry, so the teachers need support and help to recognise when they are actually doing inquiry.

Teachers need to develop an understanding of inquiry and also their role and that of the student within the inquiry classroom. As the group of teachers attending workshops will have varied experiences, it is important for them to be given time to share these experiences with their colleagues, particularly as the more experienced teachers in inquiry can share their ideas and practices with others within their local context. Also, the use of inquiry in attaining the aims of the curriculum and in helping students develop thinking and processing skills should be emphasised.

The nature of science and the non-static nature of science needs to be addressed within the workshop, maybe through the material developed within the units. Also providing information on industrial and everyday life contexts is important but it must be related to curriculum content.

Teachers need to be given opportunities to develop their confidence in the process of science and the process of inquiry, so that they can implement inquiry activities where students take on a leading role, e.g., in developing research questions etc. Teachers need to build their confidence in science process. e.g., in interpreting data, drawing conclusions, generating further research questions.

The challenges noted in the previous section must be addressed, e.g., time to implement inquiry within curriculum constraints and perceived lack of resources. Classroom management within an inquiry classroom needs to be addressed particularly when student groups are involved in different activities.

While all aspects of the inquiry process must be introduced within the workshops, a key area for teachers is the starting point, i.e., generating research/investigation questions and how to help students to develop such questions.

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Appendix A INSERVICE TEACHER QUESTIONNAIRE - A

This questionnaire examines inquiry based teaching as part of the ESTABLISH project. Your participation is greatly appreciated.

Section A: Background Information

1. Name: ______________________________ **2. Age:** ______________________________

3. Sex: Male ☐ Female ☐ **4. School:** ______________________________

5. Type of school: All boys ☐ All girls ☐ Mixed ☐

6. Years of Teaching Experience: ______________________________

7. Do you have technical assistance available in your school? Y: ☐ N: ☐

8. Qualification(s):______________________________

9. Teaching Subject(s):
Integrated Science ☐ Chemistry ☐ Physics ☐ Biology ☐ Maths ☐

10. In your experience with inquiry based teaching do you consider yourself: (Tick appropriate box)

- A complete beginner ☐
- To have some experience ☐
- Very experienced ☐

Section B. My Views of Inquiry

Please indicate your level of agreement with each of the following statements.

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
11.I don't fully understand inquiry based science education.					
12.I don't fully understand my role as a teacher in an inquiry classroom.					
13. I don't fully understand the role of the students in an inquiry classroom.					
14.I think inquiry takes up too much classroom time for me to implement.					
15.The use of inquiry is appropriate to achieving the aims of the curriculum.					
16.Inquiry based teaching is only suitable for very capable students.					
17.Inquiry will never be my main teaching method.					

18. In your opinion, what are the benefits of inquiry based teaching?

____
____
____
____

19. If you have used inquiry based teaching, what percentage of teaching time do you spend using it?

____
____

20. Give an example of how you have used inquiry based teaching.

____
____
____

Section C. Attitudes and views towards science and teaching science:

Please indicate your level of agreement with each of the following statements.

In my opinion…	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
21. Scientific theories (e.g. atomic theory) are constant unchanging bodies of knowledge.					
22. Scientific knowledge is primarily focused on knowing facts					

In my opinion, when teaching science...	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
23. Developing students' specific content knowledge is much more important than developing their thinking and reasoning processes.					
24. Teaching is more effective when all students are doing the same activity at the same time.					
25. It is easy to teach the curriculum using inquiry based teaching.					
26. Good teachers ask higher order questions.					
27. Good teachers focus on curriculum content only.					
28. Good teachers use student questions to guide their teaching.					
29. Good teachers present facts and then explain them.					
30. Good teachers allow students to develop their own investigation/research questions.					
31. Students need to know a lot of facts before they can participate in inquiry activities.					
32. My goal is to transfer factual knowledge to the students.					
33.Good teachers encourage student discussion on scientific topics relevant to everyday life.					
34.I am happy with my current teaching methods.					
35.I am open to trying different methodologies in my teaching.					
36.I feel apprehensive about changing my current teaching practice.					
37.I want my students to know about the latest developments and applications of science and engineering.					
38.I can easily relate scientific concepts in the curriculum to					

phenomena beyond the classroom.					
39.I often show students the relevance of science in industry.					
40.My students understand the importance of science and technology for our society.					
41.If I had more information about industrial processes, I would use it in my teaching.					

Section D. Classroom Practice/Classroom Environment

Select a class group in your mind. In relation to this class group, for each of the following statements, please indicate the frequency of implementation:

Class group: ________________ **Age Group:______________** **Subject:____________________**

	Almost never	Seldom	Some-times	Often	Almost always
42.Students learn how science can be a part of their out-of-school life.					
43.Students learn that the views of science have changed over time.					
44.Students ask each other to explain their ideas.					
45.Students learn that scientific knowledge can be questioned.					
46.Students pay attention to each other's ideas.					
47.Students formulate questions which can be answered by investigations. *					
48. Student research questions are used to determine the direction and focus of the lab. *					
49. Students framing their own research questions are important. *					
50. Time is devoted to refining student questions so that they can be answered by investigations. *					
51. Students are given step-by-step instructions before they conduct investigations. *					
52. Students design their own procedures for investigations. *					
53. Students engage in the critical assessment of the procedures that are employed when they conduct investigations. *					
54. Students justify the appropriateness of the procedures that are employed when they conduct investigations. *					
55. Students conduct their own procedures of an investigation. *					
56. The investigation is conducted by the teacher in front of the class. *					
57. Students actively participate in investigations as they are conducted. *					
58. Each student has a role as investigations are conducted. *					
59. Students detemine which data to collect. *					
60. Students take detailed notes during each investigation along with other data they collect. *					

61. Students understand why the data they are collecting is important. *					
62. Students decide when data should be collected in an investigation. *					
63.Students develop their own conclusions for investigations.*					
64. Students consider a variety of ways of interpreting evidence when making conclusions. *					
65. Students connect conclusions to scientific knowledge. *					
66. Students justify their conclusions. *					

Section E: Teaching Science

Please indicate your level of agreement with each of the following statements.

	Strongly disagree	Disagree	Uncertai n	Agree	Strongly agree
67. If a student investigation leads to an unexpected result I always tell the students the right answer/result.					
68. I find it difficult to manage a classroom where each student group is doing different activities.					
69. I am unsure how to ask students higher order questions that promotes thinking.					
70. I have sufficient knowledge of science to implement an inquiry lesson effectively					
71. I am uncomfortable with teaching areas of science that I have limited knowledge of.					
72. If I don't know the answers to students questions I feel inadequate as a teacher					
73. I am uncomfortable with asking questions, in my class, where I am unsure of the answer myself.					

Section F: Challenges in Inquiry Teaching

74. Teachers may face a variety of challenges in implementing inquiry-based teaching. Please **rank** your TOP THREE challenges, as they apply to you, starting with 1 as your biggest concern:

Lack of time to implement inquiry	
Curriculum constraints	
Lack of equipment/assistance in school laboratories	
Lack of supportive school management	
Classroom management issues	
Limited scientific content knowledge to use inquiry effectively	

Limited knowledge of teaching by inquiry	
Assessment methods for inquiry	
Limited knowledge of ICT as used in inquiry	
Other (Please list):	
None of the above – I teach by inquiry	

Many thanks for completing this questionnaire.

* With permission from Principles of Scientific Inquiry – Teacher (PSI-T) by Campbell, Abd-hamid and Chapman (2010)