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D5.3 Interim Profile of pre-service science teachers' attitudes and understanding of IBSE

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A. Background to this report

This report is a deliverable of Work Package 5 (WP5) 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 Pre-service Science Teachers Attitudes and Understanding of Inquiry Based Science Education

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Introduction

In light of the growing emphasis to implement inquiry based science education in the classroom, it is essential to make teachers more aware of the methods involved in executing inquiry effectively. Implementation of inquiry can be difficult as the vast majority of teachers have been taught themselves through more traditional direct transmission approaches and hence, may find it difficult to convert to a teaching approach they would never have used nor experienced before. Pre-service teachers are exposed to ideologies of IBSE during their teacher education programmes but in order to allow these teachers to eventually embrace inquiry as their own method of teaching, teacher educators must first become aware of their pre-service teachers current views and goals of education, views of good classroom practice and any challenges or anxieties they face. Understanding this makes teacher educators more aware to the needs of their participating teachers and in turn can allow them to provide the necessary support in order to help teachers overcome obstacles and develop their own practice. This report outlines the use of a paper and pencil teacher profiling instrument which made it possible to examine pre-service teachers' attitudes and beliefs about IBSE, teaching science and teaching science through inquiry and any concerns they may have in implementing it. Preliminary results are provided from recently administered questionnaires to cohorts of pre-service teachers from DCU, UNIPA and IPN outlining their current views and attitudes towards IBSE.

1. Evaluation Study

1.1 Teachers 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 a facilitator of learning rather than the source of all knowledge. The National Science Education Standards advocate that teachers

"create an environment in which they and 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 are paramount. According to Driver et al (1994 cited in Crawford 2000) (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 from didactic to inquiry practices can stem from deep-set personal beliefs and histories with their own education. Eick and Reed (2002) demonstrated how 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 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). Addressing and understanding these conceptions can inform teacher education programmes and may prepare teachers better to implement inquiry.

1.2 Development of the Questionnaire:

Many obstacles identified when implementing inquiry focus on teachers' personal beliefs, and attitudes towards teaching science as well as 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 examined 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 pre-service 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 were developed in a number of stages in order to acquire reliable and valid instrument. Initially the theoretical framework and rationale behind the questionnaire was developed in order to determine the focus the questions. Items were then selected and discussed by partners. Based on relevant discussions,, 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, where 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. Questions inviting teachers to discuss what they believe is involved in "Good teaching" were included in the section about teaching science. This was hoped to combat the fact that pre-service teachers have limited exposure to classrooms and in turn their actual classroom practice could not be determined.

It was hoped the nature of science could be addressed in the instrument created but a review of the research has indicated that teachers views of NOS cannot be encapsulated using a paper and pencil instrument (Lederman, Wade, & Bell, 1998).

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 pre-service teachers across several European countries whom completed the PTQ-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 Pre-service Teacher Questionnaire A (PTQ-A) is used to create an initial teacher profile at the first lecture in a module or semester devoted to inquiry. The term "inquiry" has been used in many different ways and therefore it was decided that the questionnaire should be distributed once participants have been informed on what the ESTABLISH view of inquiry is at the start of the inquiry college module/semester. This questionnaire takes between 10-15 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.

When each ESTABLISH partner administers the PTQ-A, they are required to record responses in the accompanying PTQ-A excel workbook which is then forwarded to the authors of this report for collection and analysis. All the background information responses are coded in this excel file. Similarly, each Likert-style question has 5 possible responses from "Strongly Disagree" to "Strongly agree" which are coded 1 to 5 respectively. Responses to open ended questions were reviewed by each national partner firstly to identify trends in answers and secondly to group responses under these trends after subsequent reviews. Teachers top concerns about teaching through inquiry are ranked. Each concern has a corresponding code number which is also added to the PTQ-A excel workbook.

This report is based on the responses to the PTQ-A received to date, which is 123 responses across 3 countries, as shown in Table 2.1

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

Partner	***Code***	***No. of Teachers***
DCU	DC14032012	37
	DC04042012	37
IPN	IP10042012	16
	IP11042012	16
	IP17042012	3
UNIPA	UN03042012	14

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
- 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.

Within some of these categories there are a number of question "groups". For example, there are a number of questions which correspond to "making science relevant to industry and phenomena outside the classroom", i.e., items 33, 37, 38, 39, 40 and 41. The responses to these questions were combined (or grouped) and 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

All other questions were treated individually under the appropriate categories.

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 a combination of all the PTQ-A datasets. This analyses the means of three or more independent variables in order to highlight any significant differences. ANOVA analyses the means of two 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 number of 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 each question (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 'very 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. In this report however, there are no comparisons made with very experienced pre-service teachers as only one respondent from an overall cohort of 123 people considered themselves to be very experienced with IBSE. 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 also 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. Pre-service teacher profile results

3.1 Overview of sample

In total, responses were analysed from 123 pre-service teachers, from 3 different ESTABLISH partners. Table 3.1 shows the details of this group in terms of numbers of teachers from each partner, the age range and gender. 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 21 years, the majority are female (76%) and they vary in teaching experience from no experience in classrooms to up to one years teaching experience.

When asked to rank their own experience of inquiry, the majority of the teachers indicated that they had 'some experience' (51%), while 46% classified themselves as 'beginner' in IBSE and 1% were 'very experienced' (see Table 3.2). Table 3.2 also shows the experience level within each data set.

Table 3.1 Overall responses to PTQ-A, including age range and gender. (N/D data not included in response)

Country	*Number of Teachers*	*Age Range*				*Gender*		
		18-22	*23-27*	*28+*	*N/D*	*Male*	*Female*	*N/D*
DCU	74	94%	4%	1%	1%	55%	45%	0%
IPN	35	43%	46%	11%	0%	23%	77%	0%
UNIPA	14	65%	14%	14%	7%	0%	100%	0%
TOTAL	123	76%	17%	6%	1%	40%	60%	0%

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

Country	*Number of Teachers*	*Weeks of Teaching Experience*					*Experience with IBSE*			
		0	*2-4*	*36*	*1 Year*	*N/D*	*Beginner*	*Experienced*	*Very Experienced*	*N/D*
DCU	74	0%	100%	0%	0%	0%	35%	64%	0%	1%
IPN	35	34%	0%	0%	3%	63%	51%	46%	0%	3%
UNIPA	14	0%	0%	100%	0%	0%	86%	7%	7%	0%
TOTAL	123	10%	60%	11%	1%	18%	46%	52%	1%	1%

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 teacher, or the extent of teaching experience. The age range and the extent of teaching experience is shown in Figure 3.1 for the overall group of pre-service teachers from the combined data set that categorize themselves as beginners in IBSE, with some experience and very experienced in IBSE, respectively. The ratio of male to female teachers within the "Beginners" and "Some experience" experience levels was approximately the same (Figure 3.2).

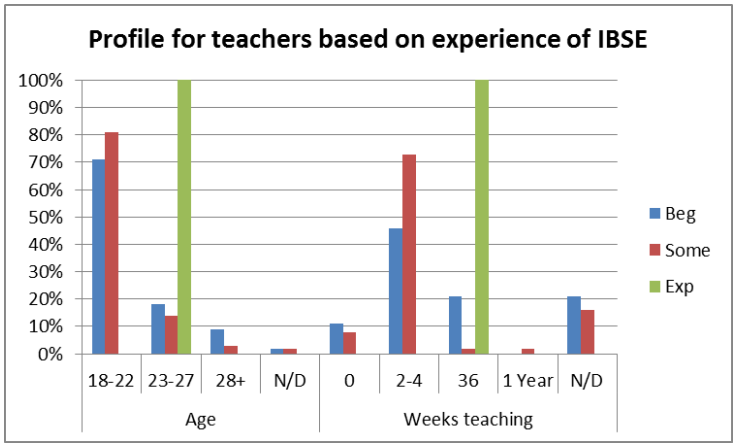


Figure 3.1 **Age profile and range of teaching experience for teachers self-classified as beginners, those with some experience and those very experienced in IBSE.**

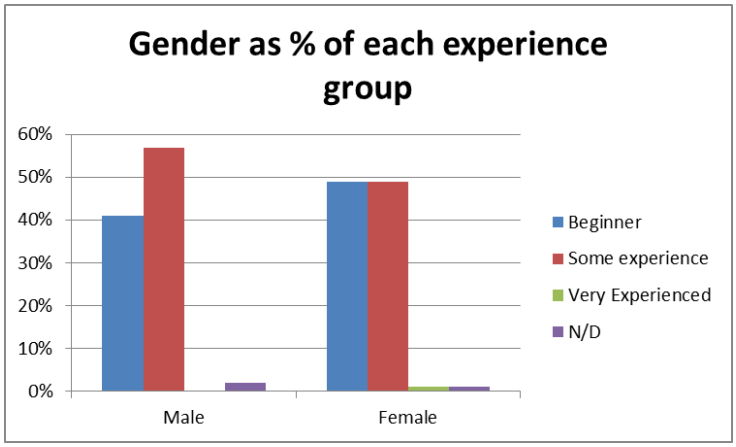


Figure 3.2 **Proportion of male and female teachers at each experience level (N/D data not included in responses)**

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 their understanding of inquiry and their understanding of the role of the teacher and student in an inquiry classroom in questions 11-13 in the PTQ-A. A majority of 59% of pre-service teachers indicated that they did fully understand inquiry based science education. 68% also felt that they understand their role as a teacher in an inquiry classroom and 71% understood the role of the student (Table 3.3).

There was a significant difference between the answers given for beginners and for those with some experience with inquiry across all three questions. Based on the mean response, beginners scored between 2 and 3 suggesting that while some felt they do understand inquiry, as well as their role and the role of the students, there are others who are less sure. Those with some experience with inquiry mainly disagreed with questions 11-13 suggesting they had a better grasp on inquiry based teaching practices because of their level of experience with the methodology (Figure 3.3).

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

Statement item		SD/D*	U*	A/SA*	N/D*	Mean
11. I don't fully understand inquiry based science education	B	39%	36%	23%	2%	2.75
	SE	75%	17%	8%	0%	2.17
	VE	0%	0%	100%	0%	5.00
	T	59%	25%	15%	1%	**2.44**
		SD/D*	**U***	**A/SA***	**N/D***	**Mean**
12. I don't fully understand my role as a teacher in an inquiry classroom	B	57%	21%	20%	2%	2.56
	SE	78%	13%	8%	1%	2.13
	VE	0%	0%	100%	0%	4.00
	T	68%	16%	14%	2%	**2.32**
		SD/D*	**U***	**A/SA***	**N/D***	**Mean**
13. I don't fully understand the role of the students in an inquiry classroom	B	63%	21%	14%	2%	2.38
	SE	80%	16%	4%	0%	2.05
	VE	0%	0%	100%	0%	4.00
	T	71%	18%	10%	1%	**2.21**

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

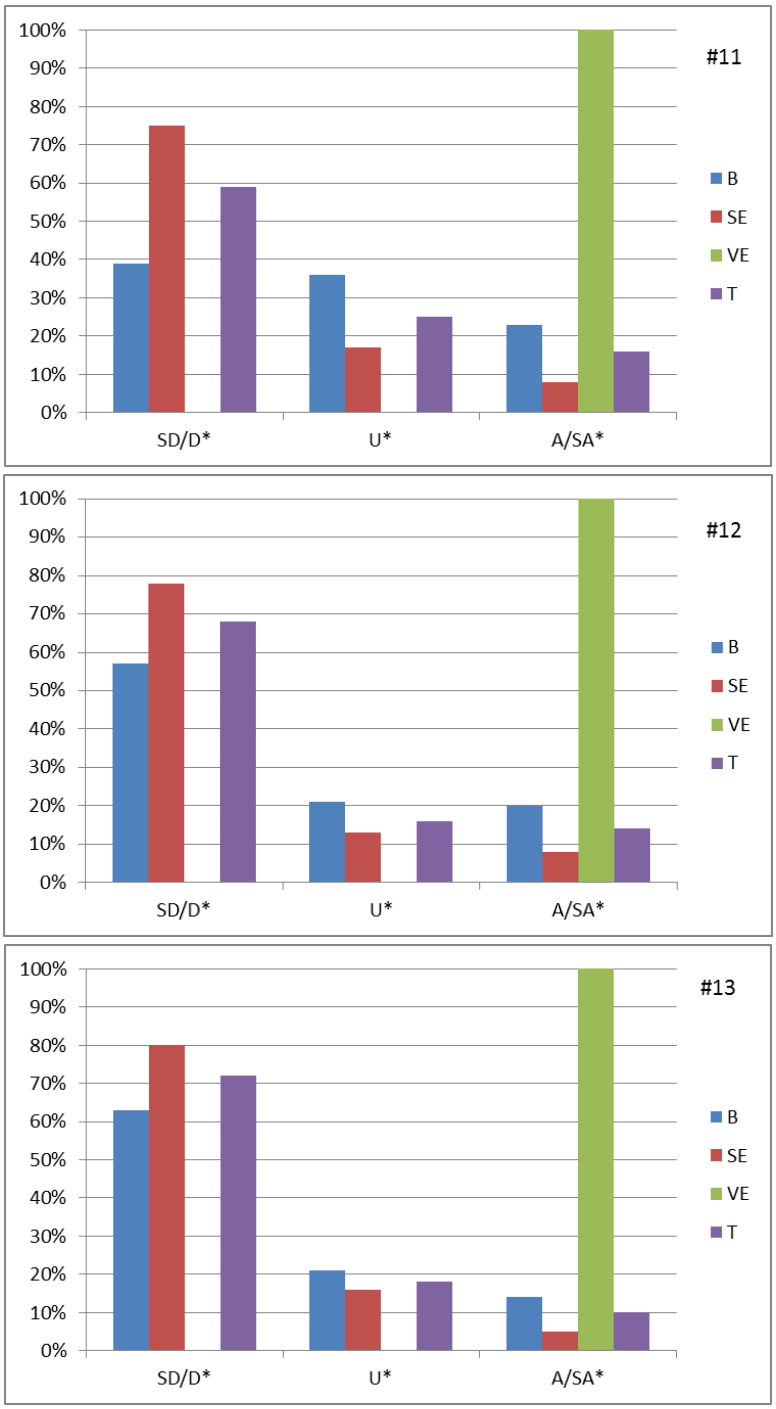


Figure 3.3. **Teacher responses to understanding of inquiry (items 11, 12 and 13)**

3.2.2 View 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 (Table 3.4 and Figure3.4).

Classroom Time: (Item 14)

Nearly half of pre-service teachers felt that inquiry does not take up too much classroom time to implement, 23% felt that it did, while 36% were unsure. This also appears to be dependent on pre-service teachers level of experience with IBSE, as all the VE group felt that inquiry did

not take too much time but the beginners and those with some experience differed significantly (B/SE=2.95/2.51, p=0.017). There were no significant differences seen between male and female responses.

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

Two thirds of pre-service teachers thought that inquiry methods are suitable to achieve the aims of their curricula compared to only 10% who thought the opposite (Item 15). In question 25, pre-service teachers are asked to provide their opinion on the statement, "It would be easy to teach the curriculum using inquiry based methods". Only 23% indicated it was easy to cover the curriculum using inquiry (item 25), even though 65% thought it was suitable to do so (item 15, Table 3.4). 21% of the group felt it was too difficult to do cover the curriculum using inquiry. Male teachers tended to disagree with this statement more than females suggesting females may have found it easier to cover the curriculum using inquiry based teaching practices (M/F=2.81/3.19, p=0.005). This can also be seen even within the beginners group where women agree more with this item in comparison to men (M/F=2.70/3.17, p=0.018)

Teaching Method: (Item 17)

41% of pre-service teachers indicated that inquiry based teaching could be their main teaching methodology. However, another 40% are unsure about this and 18% state that it will never be their main teaching method (Table 3.4). There were no significant differences evident based on gender or experience level.

Students: (Item 16 and 31)

Just over half of pre-service teachers disagreed that inquiry is only suitable for very capable students compared to 19% who agreed with this statement. Females disagreed significantly more strongly to this item than males (M/F=2.80/2.34, p=0.026).

In a related item (item 31), two thirds of respondents felt that students do not need to know a lot of facts in order to participate in inquiry activities. Only 12% felt otherwise and there were no significant differences evident based on gender or experience level.

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**	32%	34%	32%	2%	2.95
	SE	45%	38%	16%	1%	2.51
	VE	100%	0%	0%	0%	2.00
	T	**41%**	**35%**	**23%**	**1%**	**2.69**
15. The use of inquiry is appropriate to achieving the aims of the curriculum.	**B**	7%	30%	61%	2%	3.62
	SE	13%	19%	67%	1%	3.71
	VE	0%	0%	100%	0%	5.00
	T	**10%**	**24%**	**65%**	**1%**	**3.69**
16. Inquiry based teaching is only suitable for very capable students.	**B**	61%	12%	25%	2%	2.51
	SE	45%	41%	14%	0%	2.55
	VE	100%	0%	0%	0%	1.00
	T	**53%**	**27%**	**19%**	**1%**	**2.53**
17. Inquiry will never be my main teaching method.	**B**	32%	43%	23%	2%	2.87
	SE	48%	38%	14%	0%	2.53
	VE	100%	0%	0%	0%	2.00
	T	**41%**	**40%**	**18%**	**1%**	**2.69**
25. It is easy to teach the curriculum using inquiry based teaching.	**B**	20%	59%	20%	1%	3.00
	SE	22%	55%	22%	1%	3.02
	VE	0%	0%	100%	0%	5.00
	T	**20%**	**55%**	**23%**	**2%**	**3.04**
31. Students need to know a lot of facts before they can participate in inquiry activities.	**B**	70%	18%	12%	0%	2.29
	SE	63%	23%	13%	1%	2.37
	VE	0%	100%	0%	0%	3.00
	T	**65%**	**21%**	**12%**	**2%**	**2.33**

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

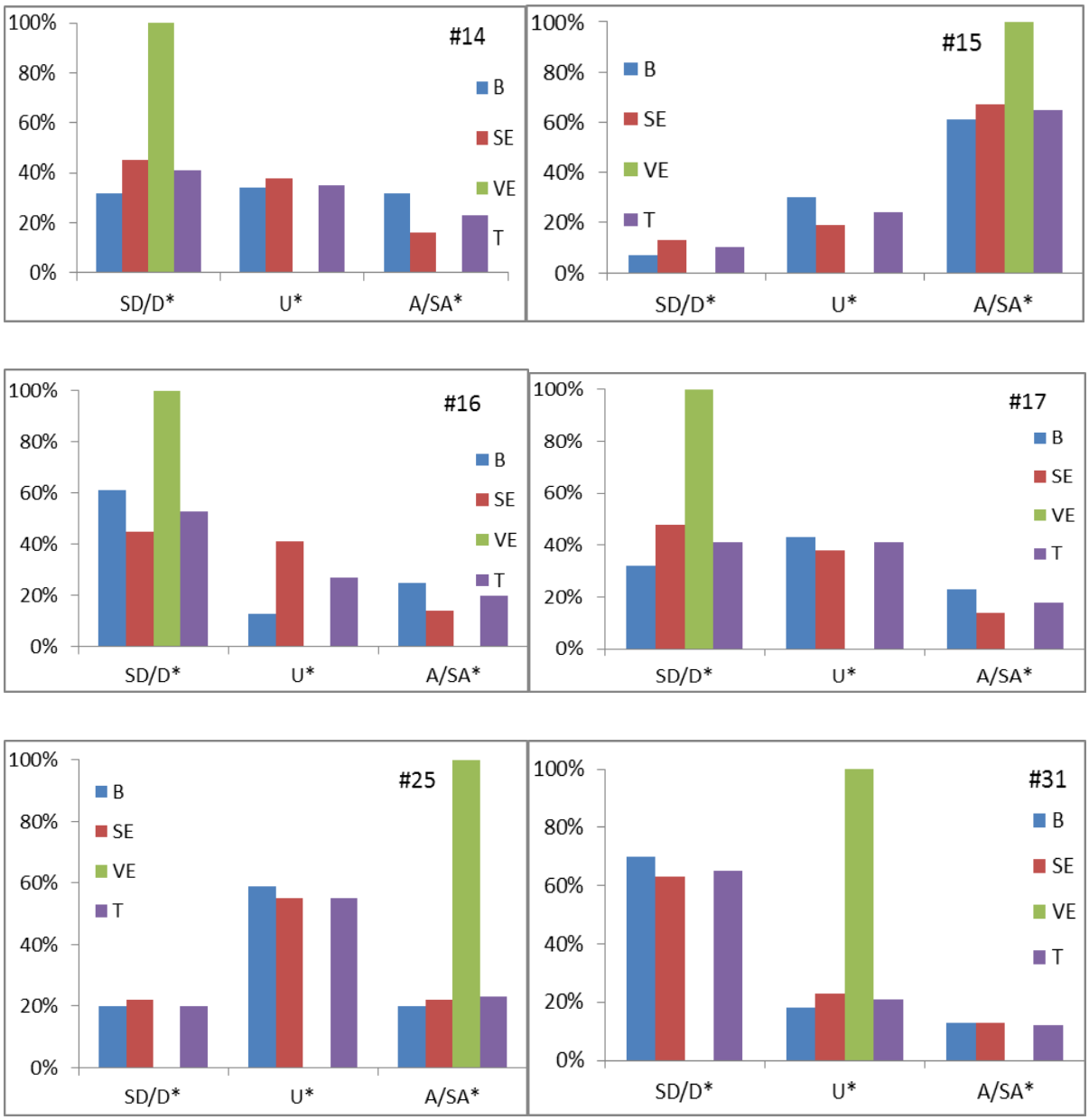


Figure 3.42b **Teacher responses to views of inquiry (items 14, 15, 16, 17, 25 and 31)**

3.3 Attitudes to Teaching Science

3.3.1 Views 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)* elicited 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 could be used to represent the extent of agreement with practices that would feature in inquiry based teaching. Therefore the collective value for each of these questions was determined for each teacher and then the value averaged over the 6 questions giving an averaged response per group of questions per teacher. These averages per teacher were then collated together to give the mean response for the group.

The mean score for these pre-service teachers was 3.86 suggesting they held views of "good teaching" that are associated with inquiry teaching. There was no significant difference between teachers groups based on experience These groups had mean scores of 3.82 and 3.88 respectively (Table 3.5).

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

Question item group	***Mean performance***			
	overall group	***Beginner***	***Some Experience***	***Very Experienced***
View of Good Science Teaching	3.85	3.81	3.88	3.50

Examining the detail of the responses made to each individual statement item within this question grouping, (Table 3.6 and Figure 3.5), there is strong agreement by all teachers that "good teachers use student questions to guide their teaching." (*item 28*), 'good teachers allow students to develop their own investigation/research questions' *(item 30)* and 'good teachers encourage student discussion on scientific topics relevant to everyday life' *(item 33).* There is a greater level of uncertainty in the overall group as well as with beginners and teachers with some experience with IBSE to the statement that 'good teachers present facts and then explain them" (*item 29*). The use of higher order questions has strong agreement by those with some experience of IBSE but 50% of the beginners 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 or of the role of higher order questions in 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**	50%	7%	41%	2%	2.84
	SE	20%	16%	59%	5%	3.52
	VE	0%	100%	0%	0%	3.00
	T	**33%**	**12%**	**51%**	**4%**	**3.21**
27. Good teachers focus on curriculum content only.	**B**	82%	13%	4%	1%	1.73
	SE	89%	8%	3%	0%	1.91
	VE	100%	0%	0%	0%	2.00
	T	**86%**	**10%**	**3%**	**1%**	**1.82**
28. Good teachers use student questions to guide their teaching.	**B**	0%	5%	95%	0%	4.18
	SE	2%	12%	86%	0%	4.03
	VE	0%	0%	100%	0%	4.00
	T	**1%**	**9%**	**90%**	**0%**	**4.10**
29. Good teachers present facts and then explain them.	**B**	30%	22%	48%	0%	3.20
	SE	34%	28%	36%	2%	3.00
	VE	0%	0%	100%	0%	5.00
	T	**33%**	**24%**	**42%**	**1%**	**3.09**
30. Good teachers allow students to develop their own investigation/research questions.	**B**	0%	4%	96%	0%	4.25
	SE	3%	5%	92%	0%	4.17
	VE	0%	0%	100%	0%	5.00
	T	**2%**	**4%**	**94%**	**0%**	**4.23**
33. Good teachers encourage student discussion on scientific topics relevant to everyday life.	**B**	0%	4%	96%	0%	4.52
	SE	2%	3%	95%	0%	4.39
	VE	0%	0%	100%	0%	4.00
	T	**1%**	**3%**	**96%**	**0%**	**4.46**

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

Figure 5 Percentage frequency of responses to teachers' views of good teaching.

3.3.2 Science as a static body of knowledge

(Statement items 21 and 22 – Appendix A)

These two question items incorporated aspects of the nature of science whereby teachers were asked to indicate their level of agreement on the tentative nature of science and whether

science is mainly centred on knowing facts. Just over half of the pre-service teachers disagreed that scientific theories were constant unchanging bodies of knowledge but one third felt the opposite; scientific theories were beyond doubt.

Similarly, over 50% felt that science was primarily focussed on knowing facts but 32% of teachers felt the opposite (Table 3.7 and Figure 3.6). There was a significant difference between responses from males and females for this item whereby males tended to disagree more with this as their mean score was 2.47 compared to females who had a mean score of 2.91 (M/F=2.47/2.91, p=0.043). This was also the case for the male and female beginners ($M_{beginner}/F_{beginner}$=2.30/3.14, p=0.022).

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	41%	20%	39%	0%	2.84
	SE	59%	11%	30%	0%	2.53
	VE	0%	100%	0%	0%	3.00
	T	51%	16%	33%	0%	2.67
22. Scientific knowledge is primarily focused on knowing facts	B	55%	9%	36%	0%	2.84
	SE	56%	16%	28%	0%	2.63
	VE	0%	0%	100%	0%	5.00
	T	56%	12%	32%	0%	2.73

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

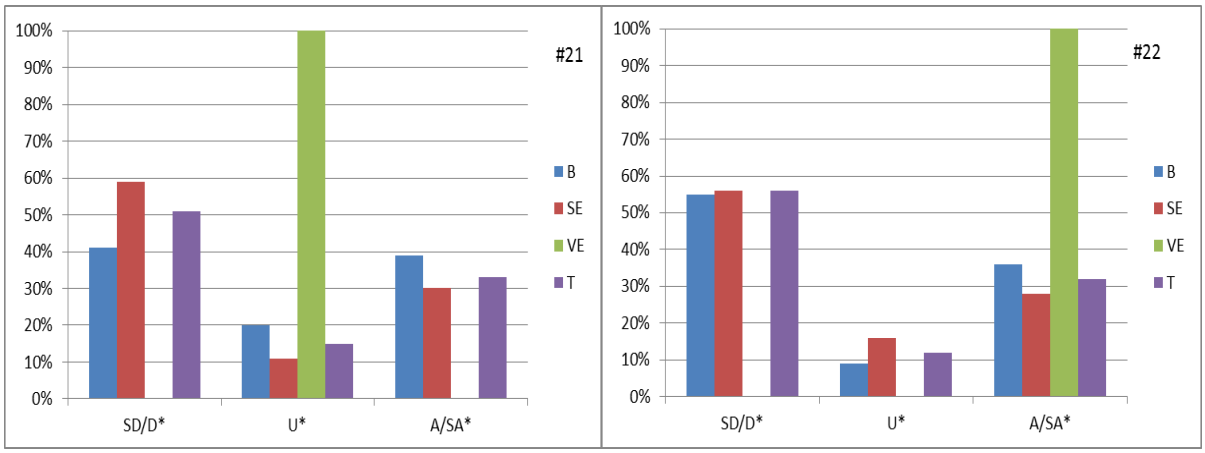


Figure 3.6 Teacher responses to views of science as a static body of knowledge.

3.3.3 Teaching Science as an accumulation of facts

(Statement items 23, 24, 32, 42 and 43 – Appendix A)

This set of items *(items 23, 24, 32, 42, and 43)* 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 (Table 3.8 and Figure 3.7).

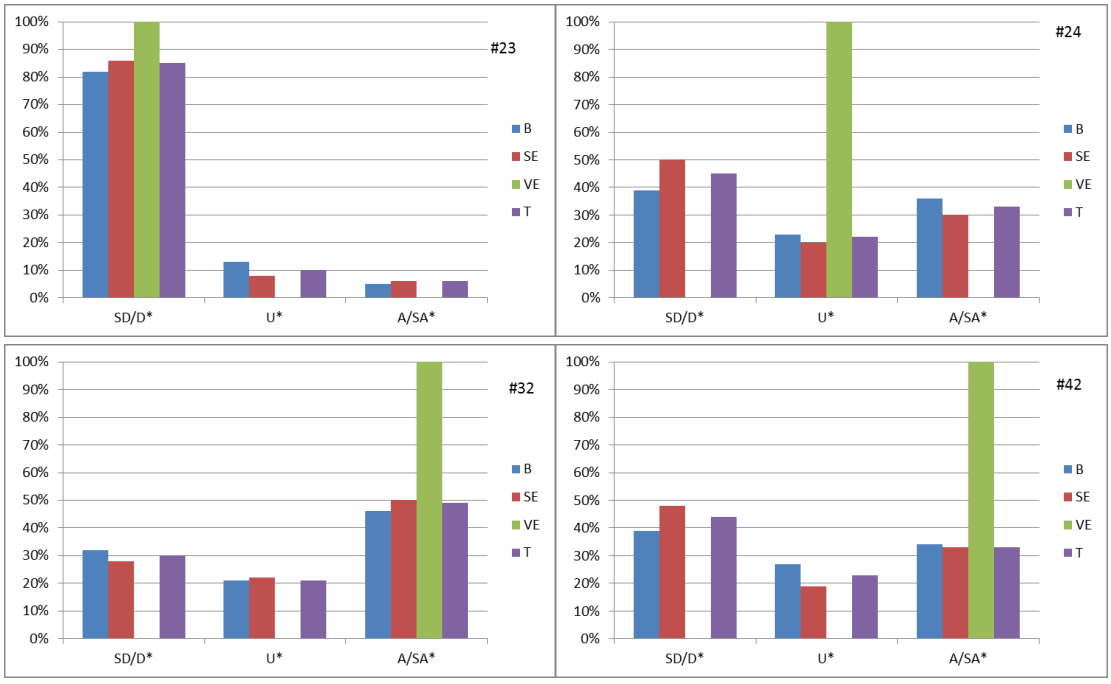
A majority of 85% of the teachers felt that developing students' specific content knowledge is not more important than developing their thinking and reasoning skills (Item 23). Female pre-service teachers also disagreed significantly more strongly compared to male teachers (M/F=2.16/1.73, p=0.004).

However the majority of 49% felt that it was their goal as a teacher to transfer factual knowledge to their students (Item 32). 30% disagreed with this and 21% are unsure. There was a mixed response from pre-service teachers about whether they should always tell students the right answer or result to an investigation that led to unexpected results. 33% felt they should always do this, whereas 44% felt they should not. There was also a mixed response to items on the questionnaire that dealt with inquiry classroom management. One third of pre-service teachers admitted that teaching is more effective when all of the students are doing the same activity at the same time but 45% disagreed with this. Teachers with some experience showed a significant difference in their answer to this statement based on their gender with females disagreeing more so than men (M/F=3.14/2.33, p=0.004). Similarly, 36% of the overall group felt that they would find it difficult to manage a classroom where each student group was doing different activities. This compared to 38% who were comfortable with such a classroom setting, leaving 26% unsure.

Table 3.8 Teacher responses to view of teaching science on a factual basis

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	82%	13%	5%	0%	1.86
	SE	86%	8%	6%	0%	1.95
	VE	100%	0%	0%	0%	1.00
	T	**85%**	**10%**	**5%**	**0%**	**1.90**
24. Teaching is more effective when all students are doing the same activity at the same time.	B	39%	23%	36%	2%	2.96
	SE	50%	20%	30%	0%	2.69
	VE	0%	100%	0%	0%	3.00
	T	**45%**	**22%**	**32%**	**1%**	**2.81**
32. My goal is to transfer factual knowledge to the students.	B	32%	22%	46%	0%	3.14
	SE	28%	22%	50%	0%	3.22
	VE	0%	0%	100%	0%	5.00
	T	**30%**	**21%**	**49%**	**0%**	**3.20**
42. If a student investigation leads to an unexpected result I always tell the students the right answer/result.	B	39%	27%	34%	0%	2.91
	SE	48%	19%	33%	0%	2.80
	VE	0%	0%	100%	0%	4.00
	T	**44%**	**23%**	**33%**	**0%**	**2.85**
43. I find it difficult to manage a classroom where each student group is doing different activities.	B	39%	16%	45%	0%	3.11
	SE	33%	33%	34%	0%	3.00
	VE	0%	100%	0%	0%	3.00
	T	**36%**	**26%**	**38%**	**0%**	**3.03**

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



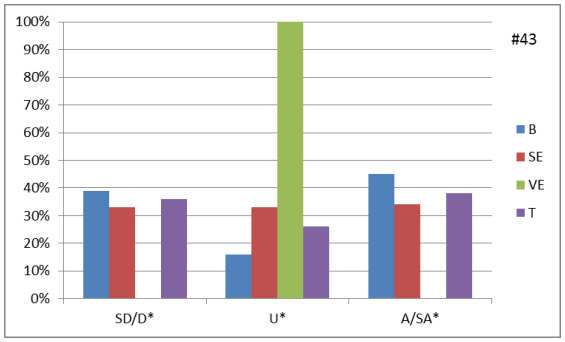


Figure 3.7 **Teacher responses to view of teaching science on a factual basis**

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 were:

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 averaged, giving one value for responses to this group of questions. A value of 5 indicates a teacher who is strongly agreeing with these statements.

The data for this set of items is given in Tables 3.9, 3.10 and depicted graphically in Figure 3.8. For the overall, pre-service teachers had a mean score of 4.04 suggesting they were making connections and understood the importance of making relationships between science and phenomena beyond the classroom. There were no significant differences to reposnses to this item based on gender or experience level with IBSE..

Table 39 Mean score for question grouping relating to teachers making science relevant to phenomena beyond the classroom.

Question item Grouping	*Mean – overall group*	*Mean - Beginner*	*Mean - Some Experience*	*Mean - Very Experienced*
Making Science Relevant	4.04	3.95	4.10	4.17

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

Table 3.10 Individual item responses from question grouping "Making Science Relevant".

Statement item		SD/D	U	A/SA	N/D	Mean
33. Good teachers encourage student discussion on scientific topics relevant to everyday life.	B	0%	4%	96%	0%	4.52
	SE	2%	3%	95%	0%	4.39
	VE	0%	0%	100%	0%	4.00
	T	1%	3%	96%	0%	4.46
37. I want my students to know about the latest developments and applications of science and engineering.	B	3%	18%	79%	0%	3.91
	SE	2%	14%	84%	0%	4.05
	VE	0%	0%	100%	0%	4.00
	T	3%	15%	82%	0%	3.99
38. I can easily relate scientific concepts in the curriculum to phenomena beyond the classroom.	B	7%	38%	52%	3%	3.54
	SE	2%	36%	61%	1%	3.73
	VE	0%	100%	0%	0%	3.00
	T	4%	37%	57%	2%	**3.65**
39. I often show students the relevance of science in industry.	B	9%	18%	73%	0%	3.91
	SE	3%	9%	88%	0%	4.08
	VE	0%	0%	100%	0%	4.00
	T	6%	13%	81%	0%	**4.01**
40. My students understand the importance of science and technology for our society.	B	2%	9%	89%	0%	4.20
	SE	2%	3%	95%	0%	4.34
	VE	0%	0%	100%	0%	5.00
	T	1%	6%	93%	0%	**4.29**
41. If I had more information about industrial processes, I would use it in my teaching.	B	7%	38%	54%	1%	3.62
	SE	5%	14%	81%	0%	4.02
	VE	0%	0%	100%	0%	5.00
	T	6%	26%	67%	1%	**3.83**

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

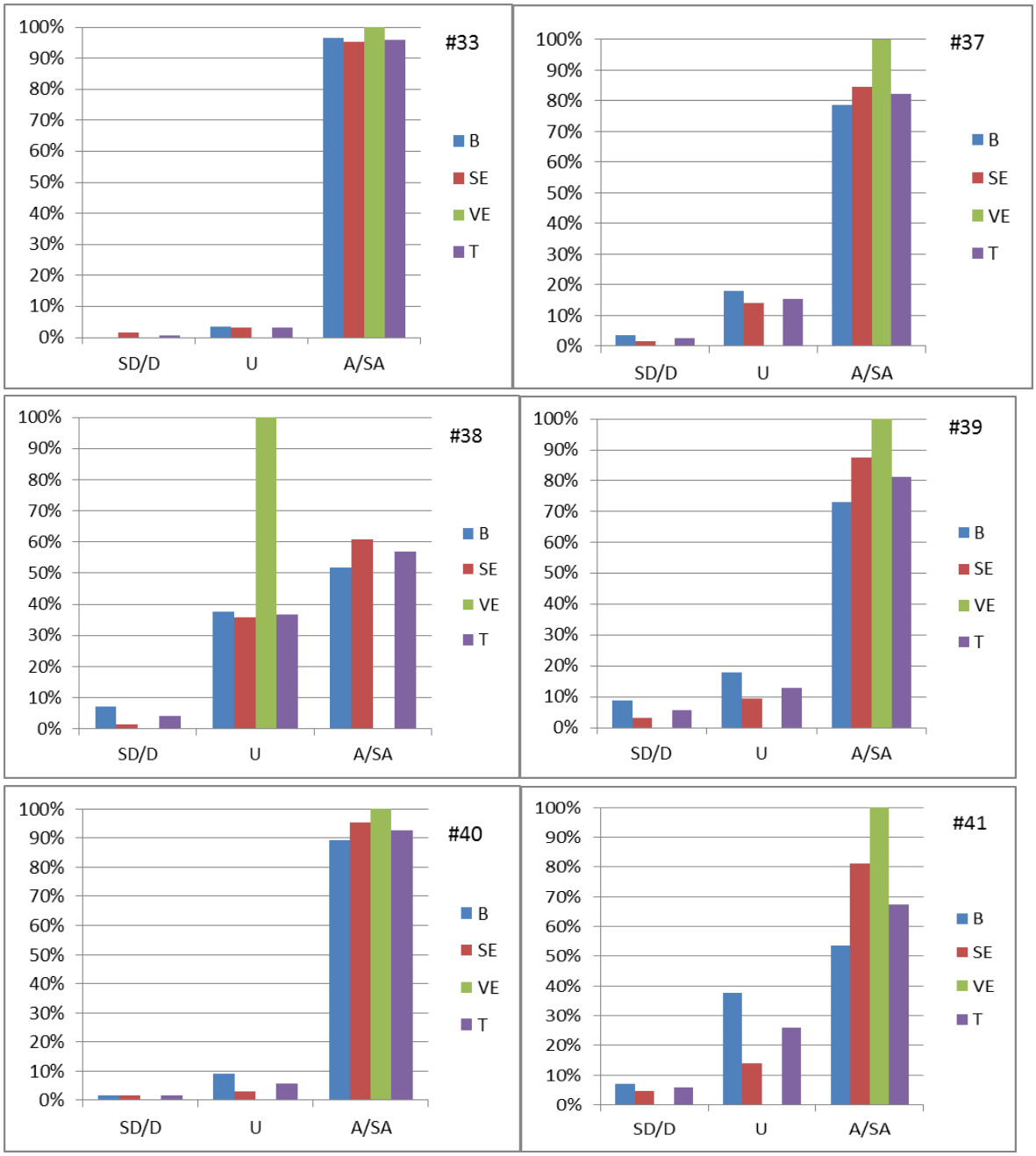


Figure 3.8 **Response to teachers' views of making science relevant.**

3.4 Attitudes to Change

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

In item 34 respondents are required to indicate how happy they were with their current teaching practices. Over half of the pre-service teachers were uncertain in their responses which may be indicative of their lack of experience within classrooms. Only 28% were satisfied with their current practice (Table 3.11 and Figure 3.9). There was a significant difference based on gender whereby females appeared more satisfied with their teaching practices compared to males (M/F=3.04/3.30, p=0.033). Similarly, females with some experience with inquiry were also more satisfied with their teaching compared to their male counterparts (M/F=3.07/3.47, p=0.023).

Almost all (97%) of pre-service teachers were open to trying new methodologies (Item 35). There were significant differences in the level of agreement with this item based on the experience level of the respondent with those having some experience with IBSE agreeing more strongly compared to beginners (B/SE=4.36/4.59, p=0.025). Females agreed more strongly with this item compared to males also (M/F=4.35/4.61, p=0.013) and this was also true for female beginners compared to male beginners ($M_{beginners}$ /$F_{beginners}$ =4.15/4.48, p=0.045).

Despite the majority of teachers being open to trying new methodologies, only 66% were comfortable changing their current teaching practice in item 36 (Table 3.11 and Figure 3.9). Females more strongly disagreed that they are apprehensive changing their current teaching practices in comparison to males as they scored 1.88 and 2.44 respectively (M/F=2.44/1.88, p=0.002). This is also true for female and male beginners whereby the female beginners disagreed more strongly with this item compared to male beginners ($M_{beginners}$ /$F_{beginners}$ =2.65/1.82, p=0.004).

Table 3.11 Teachers responses to attitudes to change.

Statement item		SD/D*	U*	A/SA*	N/D*	Mean
34. I am happy with my current teaching methods.	B	11%	64%	18%	7%	3.06
	SE	10%	48%	34%	8%	3.29
	VE	0%	0%	100%	0%	4.00
	T	10%	56%	28%	6%	3.69
35.I am open to trying different methodologies in my teaching	B	0%	6%	89%	5%	4.36
	SE	0%	2%	98%	0%	4.59
	VE	0%	0%	100%	0%	5.00
	T	0%	3%	95%	2%	3.71
36. I feel apprehensive about changing my current teaching practice.	B	61%	20%	12%	7%	2.13
	SE	61%	28%	5%	6%	2.13
	VE	100%	0%	0%	0%	2.00
	T	62%	24%	8%	6%	3.67

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

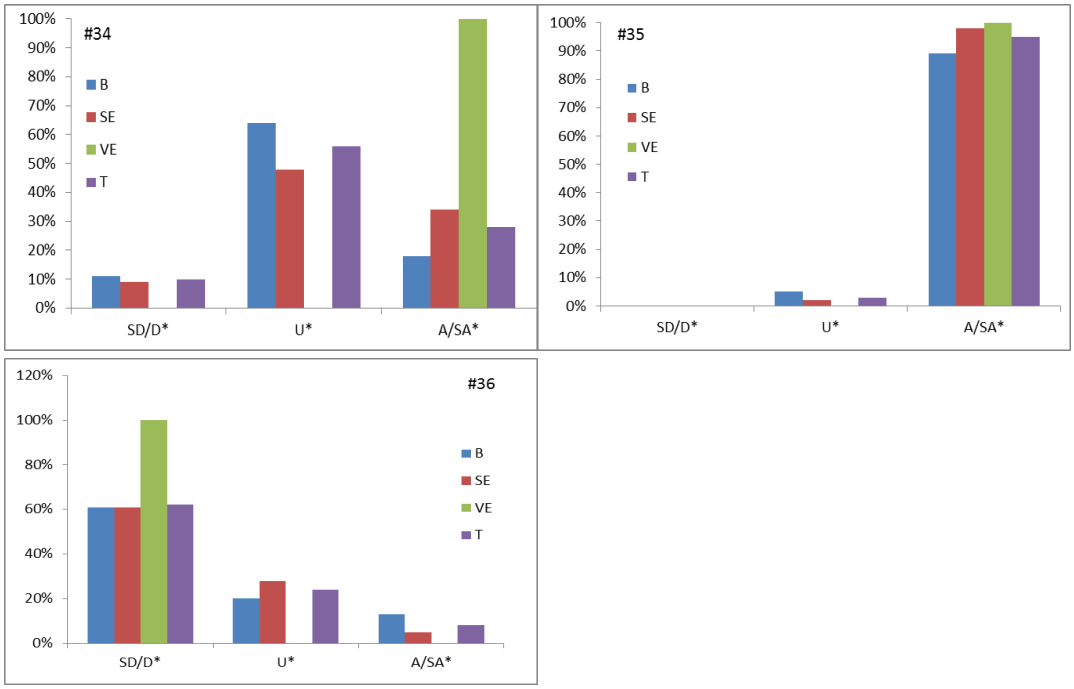


Figure 3.9 **Teacher responses to attitudes to change.**

3.5 Self-confidence in Scientific Knowledge

(Statement items 38, 45 and 46 – Appendix A)

To probe pre-service teachers self-confidence in their scientific knowledge, responses from three particular question items are considered together, namely:

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

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

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

Over half of pre-service teachers felt that they can easily make relationships between scientific concepts and phenomena beyond the classroom but 37% were unsure of their ability to do so (Table 3.12 and Figure 3.10). Despite nearly half admitting they have enough scientific content knowledge to implement an inquiry lesson effectively, 71% admitted they would be uncomfortable with teaching areas of science they have limited knowledge of. In relation to the question item 46 above, beginners agreed significantly more strongly than those with some experience as they scored 3.98 and 3.51 respectively (B/SE=3.98 and 3.51, p=0.009).

Table 3.12 **Teacher responses to items concerning self-confidence in scientific knowledge**

Statement item		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%	52%	3%	3.54
	SE	2%	36%	61%	1%	3.73
	VE	0%	100%	0%	0%	3.00
	T	4%	37%	57%	2%	3.69
45. I have sufficient knowledge of science to implement an inquiry lesson effectively	B	20%	43%	36%	1%	3.18
	SE	14%	28%	58%	0%	3.47
	VE	0%	100%	0%	0%	3.00
	T	16%	35%	48%	1%	3.71
46. I am uncomfortable with teaching areas of science that I have limited knowledge of.	B	7%	11%	79%	3%	3.98
	SE	23%	11%	64%	2%	3.51
	VE	0%	0%	100%	0%	5.00
	T	16%	11%	71%	2%	3.67

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

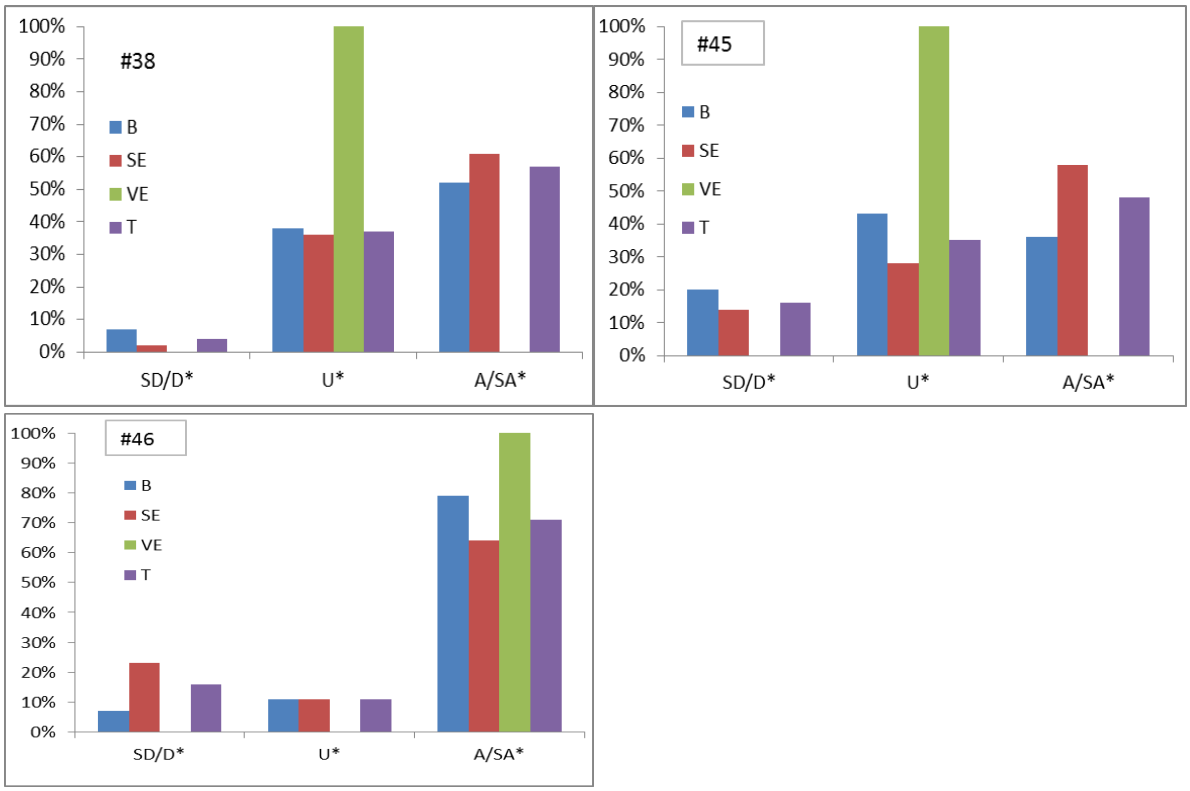


Figure 3.10 **Teacher responses on items concerning self-confidence in scientific knowledge.**

3.6 Self-confidence 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 stated previously, teachers are divided on their opinion about how well they would cope with a classroom where student groups are working at different activities. 36% felt that they could easily manage such a classroom environment whereas 38% felt otherwise (item 43). Nearly two thirds of the pre-service teachers felt that they know how to ask higher order questions to promote thinking (item 47); however, 71% of them felt that they would be uncomfortable asking questions in their classroom where they are unsure of the answers themselves (item 48). That said, 56% disagreed with the statement "If I don't know the answers to students questions I would feel inadequate as a teacher" but 30% agreed with this statement (Table 3.13 and Figure 3.11). There were no significant differences based on gender or level of experience in this item group.

Table 3.13 **Teacher responses to items concerning self-confidence in teaching through inquiry.**

Statement item	Group	SD/D*	U*	A/SA*	N/D*	Mean
43. I find it difficult to manage a classroom where each student group is doing different activities.	B	39%	16%	45%	0%	3.11
	SE	33%	33%	34%	0%	3.00
	VE	0%	100%	0%	0%	3.00
	T	36%	26%	38%	0%	3.69
44. I am unsure how to ask students higher order questions that promotes thinking.	B	52%	16%	32%	0%	2.77
	SE	64%	17%	19%	0%	2.45
	VE	100%	0%	0%	0%	2.00
	T	59%	16%	25%	0%	3.71
47. If I don't know the answers to students questions I feel inadequate as a teacher.	B	52%	9%	38%	1%	2.75
	SE	58%	19%	23%	0%	2.59
	VE	0%	0%	100%	0%	5.00
	T	56%	14%	30%	0%	3.67
48. I am uncomfortable with asking questions, in my class, where I am unsure of the answer myself.	B	16%	13%	70%	1%	3.69
	SE	16%	13%	70%	1%	3.71
	VE	0%	0%	100%	0%	4.00
	T	16%	12%	71%	1%	3.65

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

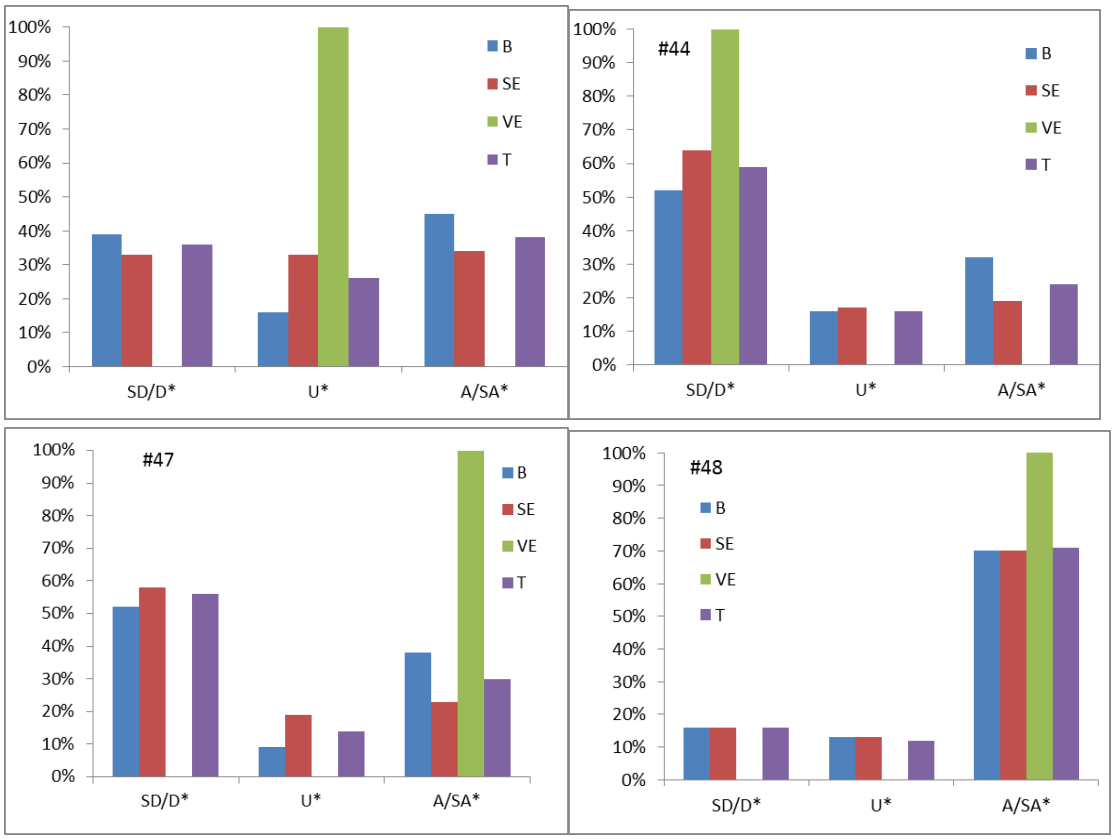


Figure 3.11 **Teacher responses on items concerning self-confidence in teaching through inquiry.**

3.7 Teacher concerns about teaching through inquiry

Teachers were asked to select and rank the top three challenges that they felt they 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 3.14 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. 30% of all the teachers ranked 'Lack of time to implement inquiry' as the number 1 challenge that they faced in implementing inquiry.

Table 3.14 Challenges to teaching by inquiry

Challenge	Ranking of Challenge			Total
	1	2	3	
Lack of time to implement inquiry	30%	19%	14%	63%
Curriculum constraints	10%	15%	10%	35%
Lack of equipment/assistance in school laboratories	9%	23%	15%	46%
Lack of supportive school management	3%	7%	6%	16%
Classroom management issues	16%	8%	12%	37%
Limited scientific content knowledge to use inquiry effectively	8%	7%	7%	22%
Limited knowledge of teaching by inquiry	15%	3%	15%	33%
Assessment methods for inquiry	4%	11%	11%	26%
Limited knowledge of ICT as used in inquiry	0%	2%	7%	9%
Other (Please list):	2%	0%	0%	2%
None of the above – I teach by inquiry	0%	0%	0%	0%
BLANK	2%	3%	6%	11%

Overall, the highest ranked challenge listed by 63% of teachers within their top three, was a "Lack of time to implement inquiry" followed by "Lack of equipment/assistance in school laboratories" (46%), and "Classroom management issues" (37%), "Curriculum constraints" (35%) and "Limited knowledge of teaching by inquiry" (33).

Figure 3.12 indicates the challenges indicated by beginners, those with some experience and very experienced.

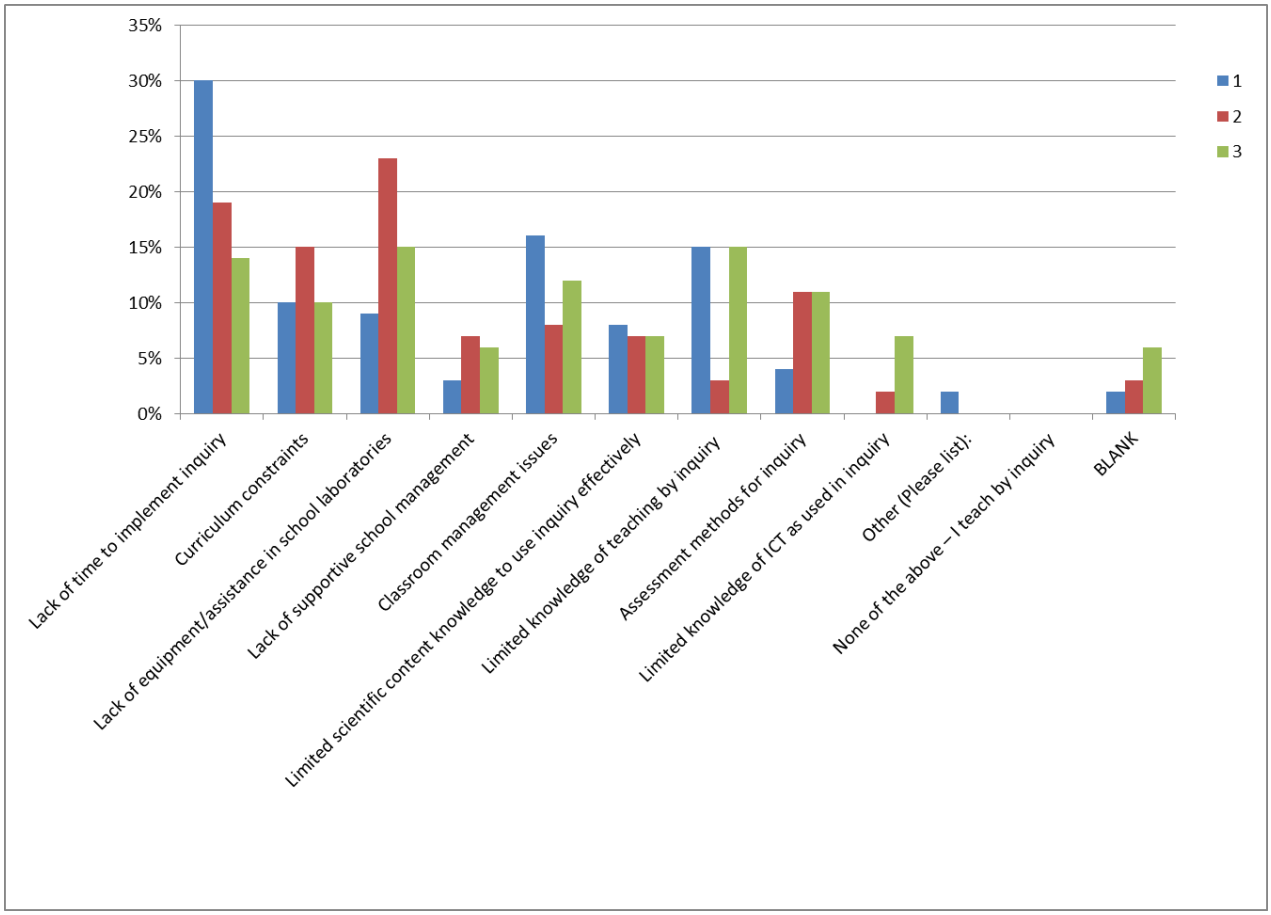


Figure 3.12 **Challenges to teaching by inquiry**

4. Main Characteristics of Pre-service Teachers – building a profile

From the data collected from this instrument, it is clear that there are clear distinctions between 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 from 'a complete beginner' to 'have some experience' to 'very experienced' in IBSE. Unfortunately as only one pre-service teacher listed themselves as "very experienced" and subsequently admitted to not understanding IBSE fully nor their role nor the role of the student in an inquiry classroom, this data was not deemed relevant enough to act as a comparison between the other experience levels. The 'some experience' group shared many similarities with the beginners group. By looking at the overall group, we can identify the issues that these teachers face regardless of their level of experience and draw appropriate conclusions. The groups of pre-service teachers varied in their level of exposure to classroom environments from no experience to up to one year in the classroom. They were equally divided between having some experience with inquiry based science education and being complete beginners to the practice. The general trend suggested that while some may not fully understand IBSE they have a good understanding on the roles of the teacher and student in an inquiry classroom.

Two out of five pre-service teachers are enthusiastic about using inquiry teaching practices in the future but one in five indicate they will never use it at all. The remainder are unsure, perhaps due to their limited experience of teaching practice in the classroom. Many admit to being unsure about their level of satisfaction with their current teaching practices which may also be related to their lack of school experience. Two thirds of pre-service teachers believe inquiry is a suitable method of instruction to cover the curriculum in their country but only one quarter finds it easy to do so. The majority of these teachers however, find that students themselves do not need to know a lot of facts nor do they need to be extremely capable students in order to participate in inquiry activities and that it is suitable for students of all capabilities.

Many teachers still consider the transfer of factual knowledge as an important factor in their teaching and that science is primarily focussed on knowing facts.

There were mixed opinions to classroom management issues dealing with group work and student led classrooms where the teacher is not the main focus. While many felt that teaching is easier and more effective when all students are doing the same activity at the same time, there were just as many that found this manageable in their own opinions.

Pre-service teachers understand the importance of making science relevant to the lives of their students outside the classroom as well as to industry. Similarly, pre-service teachers stated that they were open to trying new methodologies.

A majority of pre-service teachers are uncomfortable delving outside the limits of their own knowledge and despite the fact many felt they are capable of asking higher order questions, few would be secure in themselves to ask questions where they themselves didn't know the answer. That said over half would not consider themselves a failure as a teacher in a case where they were unsure of an answer to a student question.

Pre-service teachers' main concern about using inquiry based teaching is that it involves certain time constraints. Many also felt that schools or laboratories were not equipped enough to cater for open ended investigations that may need a variety of materials, instruments, and aid. Classroom management issues were also listed by many teachers as were constraints put on them by the

curriculum. They also considered that they themselves may have too limited knowledge of inquiry to be able to implement an inquiry lesson effectively.

References

TALIS 2008 Technical Report. (2010) OECD.

Abd-El-Khalick, F., Lederman, N., Bell, R., & Schwartz, R. (2001). Views of the Nature of Science Questionnaire (VNOS). Toward valid and meaningful assessment of learners conceptions of the Nature of Science. *Proceedings of the Annual Meeting of the Association for the Education of Teacher in Science.* Costa Mesa, CA.

Campbell, T., Abd-Hamid, N., & Chapman, H. (2010). Development of Instruments to Assess Teacher and Student Perceptions of Inquiry Experiences in Science Classrooms. *Journal of Science Education*, *21*, 13-30.

Crawford, B. (2000). Embracing the Essence of Inquiry: New Roles for Science Teachers. *Journal of Research in Science Teaching*, *37*, 916-937.

Eick, C. J., & Reed, C. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. *Science Teacher Education*, 86, 401-406.

ESTABLISH: European Science and Technology in ActionL Building Links with Industry, Schools and Home, European Community's Seventh Programme [FP7/2007-2013] under grant agreement no 244749, www.establish-fp7.eu, accessed 07 AUG 2012

King, D., Bellocchi, A., & Ritchie, S. M. (2008). Making Connections: Learning and Teaching Chemistry in Context. *Research in Science Education*, 365-384.

Lederman, N. G., Wade, P. D. & Bell, R. L. (1998). Assessing understandng of the nature of science: A historical perspective. In Willaim F. McComas (Ed.), *The nature of science in science education* (pp. 331-350). The Netherlands: Kluwer Academic Publishers.

Linn, M.C., Davis, E.A. & Eylon, B.-S. (2004). The scaffolded knowledge integration framework for instruction, in Internet environments for science education. In M. C. Linn, E .A. Davis, and P. Bell *Internet environments for science education* (pp. 47-72). Mahwah, NJ: Lawrence Erlbaum Associates

Lotter, C., Harwood, W. S. & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching*, *4*(9), 1318-1347.

National Research Council. (1996). *National Science Education Standards.* Washington, D.C.: National Academy Press.

Taylor, P. & Fraser, B. (1991). Development of an instrument for assessing constructivist learning environments. *Paper presented at the annual meeting of the American Research Association.* New Orleans, LA.

Appendix A

PRESERVICE 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. Year in University: _____**

5. University/Institution: _____

6. Previous qualification(s): _____

7. Previous Teaching Experience (Weeks spent teaching): _____

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

9. Future Teaching Level(s): lower second level ☐ upper second level☐ both ☐

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 your teaching time did 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 would be easy to teach the curriculum using inquiry based methods.					
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. Good teachers show students the relevance of science in industry					
40. Good teachers help 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. Teaching science

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

	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
42. If a student investigation leads to an unexpected result I should always tell the students the right answer/ result.					
43. I would find it difficult to manage a classroom where each student group is doing different activities.					
44. I am unsure how to ask students higher order questions that promotes thinking.					
45. I have sufficient knowledge of science to implement an inquiry lesson effectively					
46. I am uncomfortable with teaching areas of science that I have limited knowledge of.					
47. If I don't know the answers to students questions I would feel inadequate as a teacher					
48. I would be uncomfortable with asking questions, in my class, where I am unsure of the answer myself.					

Section E: Challenges in Inquiry Teaching

49. 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.

Section F: Specific Science Content

This section should include questions for the evaluation of science knowledge.

Many thanks for completing this questionnaire.