Development, Validation and Use of the Beliefs About Science and School Science Questionnaire (BASSSQ)

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Abstract

The purpose of this study was to develop a questionnaire that would serve to identify teachers’ beliefs about the nature of science, in order to provide greater insight into ways in which those views affect teaching practices. This study is part of a larger study that is investigating the influence of teachers’ philosophical perspectives on the constructivist nature of the classroom learning environment. The conceptual development of the Beliefs About Science And School Science Questionnaire (BASSSQ) draws on the philosophy of science to distinguish between objectivist and postmodern views of science. The BASSSQ was trialled in 27 junior high school classes in Western Australia. The validity and viability of the questionnaire were examined using a multiple perspective approach, including statistical reliability tests and interviews. The results suggest that the internal consistency is not entirely satisfactory across all scales. Interviews of teachers who responded to the BASSSQ indicated that teachers’ responses are influenced by (1) their philosophical perspectives which, in turn, can cause them to equate ‘science’ with ‘school science’, and (2) the curriculum context that serves as a referent.

INTRODUCTION

The way in which people interpret events are influenced by their constructs, schema, beliefs and understandings (Nespor, 1987; Pajares, 1992). The beliefs that people hold colour the way in which individuals recall old information and process new information.

A variety of educational beliefs have been identified and studied by researchers, including beliefs about: self efficacy; epistemology; the role of a classroom teacher; specific subjects and how they should be taught; how students learn; and discipline and student control (Pajares, 1992). This study recognises the worth of these beliefs but it is concerned primarily with the beliefs teachers hold about the nature of science and science teaching.

Past research into teachers' beliefs about the nature of science have included both qualitative and quantitative approaches. Much of the research has concentrated on the use of interviews and classroom observation, such as the work of Bussis, Chittenden and Amerel (1976) who used coded interviews to record constructs that appeared to be operating.

A number of studies into teachers' beliefs of the nature of science have focused essentially on the collection of qualitative data (Brickhouse, 1991; Duschl & Wright, 1989; Lantz & Kass, 1987). These studies have focused on individual teachers and students and have provided valuable insights into individual teacher's beliefs and their associated practices.

Quantitative methods of data collection have included instruments, designed to measure teachers’ beliefs, such as the Attitude-Toward-Education-Scale, developed by Kerlinger (1967) and the Nature of Science Scale, developed by Kimball (1968). Another valuable tool which provides a quantitative insight into teachers' views of the nature of science is Kelly’s Repertory Grid Technique (Duffy, 1977; Lakin & Wellington, 1994; Munby, 1982). Developed from Kelly’s Personal Construct theory, this method provides quantitative data regarding teachers constructs in addition to qualitative descriptions.

To examine students' views of topics associated with Science-Technology-Society, Aikenhead (1987; Aikenhead & Ryan, 1992) developed the Views on Science-Technology-Society (VOSTS). This instrument was developed as a result of ambiguities associated with standardised testing. The VOSTS makes use of paragraph type responses from students which are analysed. By eliciting students’ ideas as opposed to numerical scores, ambiguities related to the interpretations of statements were revealed.

CONCEPTUAL FRAMEWORK

The purpose of this paper is to present the results of a study in which we developed and examined the viability of the Beliefs About Science and School Science Questionnaire (BASSSQ) and raise issues concerning the influence of teacher beliefs about the nature of science have on constructivist teaching practices. The conceptual framework of the study is discussed in terms of teachers’ beliefs.
Teacher Beliefs

The importance of teachers' beliefs in the process of reform cannot be under-estimated. According to Nespor (1987), two teachers may have a similar knowledge of science but teach in very different ways because teachers' beliefs are more powerful than their knowledge in shaping the way in which they teach.

Research has shown that difficulties concerning the implementation of innovations in the classroom are related to the resistant nature of teachers' beliefs (Munby, 1982; Nespor, 1987; Nisbett & Ross, 1980). In addition, studies have shown that older beliefs are the most resistant to change because, when they are tested, individuals tend to recall information, however conflicting, in a way that will sustain their own beliefs (Pajares, 1992). It is not surprising, then, that teachers tend to modify new science curricular to make them more compatible with their own established beliefs regarding their role in the classroom (Duschl & Wright, 1989; Olson, 1981, 1982; Tobin & Gallagher, 1987), and, that classroom instruction and teacher practices are consistent with the beliefs that teachers hold (Duschl & Wright, 1989; Gudmundsdottir, 1991; Janesick, 1982; Kagan, 1992; Lantz & Kass, 1987).

Past studies have found that resistance to a constructivist perspective can be attributed, in part, to the image that teachers hold about the nature of science as these beliefs influence the way in which science is taught (Brickhouse, 1991; Lakin & Wellington, 1994). Traditional or objectivist views of science have been associated with teacher dominated modes of instruction (Apple, 1979; Giroux, 1981) and, according to Taylor (1990, 1993), when the practices of science teachers are governed by an objectivist image of the nature of science, it is difficult for a constructivist perspective to become reality within the classroom.

Teacher beliefs about the nature of science influences the way science is portrayed to students through the interpretation and implementation of the curriculum (Gallagher, 1989; Tobin and Gallagher, 1987). It is likely that those teachers who view the nature of science in a traditional sense (i.e., Baconian terms), will tend to highlight the collecting and analysing of data involved in theory building, whilst teachers who view the nature of science in Kuhnian terms may tend to focus more on the discontinuity and irrational elements within the history of science.

The BASSSQ is based on two sets of opposing perceptions related to teachers' beliefs about the nature of science: 'tentative and changing or true and unchanging' (Tobin, Kahle & Fraser, 1990, p 7); and whether the process of scientific inquiry is influenced by human perceptions or is a set method, free of human bias. These sets of perceptions can be thought of as forming a continuum on which teachers' beliefs can be mapped, providing an insight into teachers' views of the nature of science and identifying possible barriers to constructivist reform in school science.

THE BASSSQ

The BASSSQ forms part of a larger, ongoing cross-national study of determinants of science learning environments in Taiwan and Australia. The BASSSQ was developed to provide a quantifiable large-scale portrayal of teachers' beliefs about the nature of science and school science, which could be used as a springboard from which subsequent teacher interviews, discussions and classroom observations could take place. The qualitative and quantitative data could then be used to determine correlations between the philosophical stance of teachers and constructivist practices present in the classrooms. In addition, the BASSSQ was designed to provide a heuristic device that teacher-researchers can use as a means of reflecting on, and improving, their own teaching practices.

Design

The BASSSQ is based on a two-dimensional model (one axis representing the teacher's view of science and the other representing the teacher's view of school science) ranging on a continuum from an objectivist to a postmodern view of the nature of science.
Objectivist View of Science

At one end of the continuum lies the objectivist image of science, which is grounded in the Empiricist tradition established during the Enlightenment period (seventeenth to eighteenth Century). At this time, science was conceived as a means of revealing the natural laws of God that regulated a 'clockwork' universe and a new emphasis was placed on controlling and manipulating nature. It was during this period that the Baconian, logico-empiricist belief, that the only way of gaining scientific knowledge was through the application of inductive methods, took hold.

Bacon, in effect, argued that a true scientist uses value-neutral experimental observation, free from the illusions and myths of the past, that yield incontestable facts about nature. Bacon proposed a set method by which scientists can produce theories that eliminate human subjectivity and guess-work. In this way, scientific knowledge is regarded as existing independently of inquirers in a hierarchical form. Bacon considered scientific thinking as largely deductive and involving propositional logic, thereby ruling out rash generalisations. Bacon's induction methods, according to Richards (1987), prescribed the analyses of masses of presuppositionless data about the world, followed by a generalisation. This method would guarantee the growth of knowledge and underwrite the honesty and intellectual integrity of the discipline.

Postmodern View of Science

At the other end of the continuum is the postmodern view of science which is grounded in the New Physics and contemporary philosophies of science, articulated by philosophers such as Feyerabend (1978a), Kuhn (1962) and Polanyi (1962) during the latter half of the twentieth century.

According to Kuhn (1962), the absence of a shared observational perspective on the data means that we no longer can say that scientists operating from different paradigms see the same thing. There is no access to the world and no classification of objects independent of human activity and conceptualisation. Paul Feyerabend (1965) goes further to say that classification from different points of view may be unable to find any neutral ground on which to communicate. That thought patterns are not mutually translatable, and their theories are not strictly comparable because they are talking of different things.

Kuhn’s (1962) paradigm-led philosophy of science identifies all methods of inquiry in science as legitimate and are to be justified in relation to the context of the investigation. Scientific inquiry, according to O’Hear (1990), is shaped ineluctably by human values. Where followers of inductive philosophy, such as Francis Bacon, assumed a distinction between theory and observation, in recent philosophy there is no pure observational level that stands free of theoretical ideas. Therefore, scientific inquiry becomes shaped by human values, scientific observation is theory-laden, and scientific inquiry can affect that which is being observed.

Where Baconian induction and positivists were restricted to knowledge that was observable, according to O’Hear (1990), contemporary philosophies in science are embracing metaphysics. It would appear that science

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Figure 1. The Two Dimensions of the BASSSQ
does give us knowledge of things and processes that cannot be observed (such as atoms and gravity which we will never see but which cannot be falsified), and these are becoming claims to knowledge as science extends its concerns for understanding and prediction beyond the observable.

Postmodern views of science highlight the context dependence of scientists' methods of inquiry. Unlike the Baconian view of science, there is no single correct scientific method, but rather the method will alter according to the investigation.

Postmodern views of science emphasise the critical self-reflective nature of scientists' thinking. Scientists, by necessity, must constantly examine the viability of their findings against the constraints of the natural world and, in addition, use consensus-building to legitimate the nature of what is classed as knowledge (Davies, 1989; Feyerabend, 1978b; Gleik, 1992; Kuhn, 1962; Lakatos, 1970; Lyotard, 1993; Polya & Prosch, 1975; Toulmin, 1972).

**The Questionnaire Structure**

The BASSSQ was designed to measure two dimensions of teachers' beliefs: (1) beliefs concerning the teacher's view of the nature of science, and (2) beliefs concerning the teacher's view of the nature of school science. Thus, the questionnaire comprises two parts: *Teacher's View of Science* and *Teacher's View of School Science*. Each of the two parts comprises two sub-scales: *Inquiry Process* and *Epistemological Status*. The sub-scale *Inquiry Process* is a measure of teachers' beliefs about the processes involved in gaining scientific knowledge. Teachers' perceptions are measured along a continuum that determines the extent to which they understand the process of generating knowledge from an objectivist view, which advocates a set method that is objective and therefore free of human bias or a post modern view, which perceives the process of inquiry as context dependent and influenced by human perceptions. An example of an item in this sub-scale is Item 1, ‘Scientific observations are affected by scientists' values and beliefs’.

The sub-scale *Epistemological Status* measures teachers' beliefs about the status or certainty of scientific knowledge. Teachers' beliefs are measured on a continuum from an objectivist view, which portrays science as a body of objective knowledge which is unproblematic and representing the absolute truth, to a post-modern view which recognises the need to continuously examine and re-examine the viability of scientific knowledge. An example of an item in this sub-scale is Item 12, ‘Scientific knowledge is tentative’.

Because we wished to provide teachers with a meaningful context within which they could respond the items were not randomly mixed or distributed in the traditional 'cyclic' order of learning environment questionnaires (Taylor, Dawson & Fraser, 1995). Instead, we grouped the items in their respective sub-scales. A Likert-type response scale was used to enable teachers to indicate the frequency of actual or desired occurrence of teaching activities. The items were scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often and Almost Always, with the exception of those items underlined which were scored in reverse. The Appendix provides a copy of the questionnaire administered to the sample of 27 teachers. Table 1 indicates the items associated with each scale and sub-scale.

<table>
<thead>
<tr>
<th>BASSSQ Scales</th>
<th>Item Allocation</th>
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</thead>
<tbody>
<tr>
<td><strong>Teacher's View of the Nature of Science</strong></td>
<td></td>
</tr>
<tr>
<td>Inquiry Process</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Epistemological Status</td>
<td>11 12 13 14 15 16 17 18 19 20</td>
</tr>
<tr>
<td><strong>Teacher's View of the Nature of School Science</strong></td>
<td></td>
</tr>
<tr>
<td>Inquiry Process</td>
<td>21 22 23 24 25 26 27 28 29 30 31</td>
</tr>
<tr>
<td>Epistemological Status</td>
<td>32 33 34 35 36 37 38 39 40 41</td>
</tr>
</tbody>
</table>

* Underlined items refer to an objectivist viewpoint and are scored in reverse.
METHODOLOGY

This paper reports the preliminary findings of a study designed to investigate the reliability, viability and conceptual strength of the BASSSQ. In doing so, we combined quantitative and qualitative research approaches, as recommended by Fraser (1988) and Howe (1988). Using this multiple perspectives approach, the study aimed to determine the validity of the BASSSQ for use in survey research and its viability as an interpretive research tool. The steps involved included:

Step 1  An initial test of scale homogeneity was conducted in which a philosophy student was asked to place the 52 items (mixed up for the exercise) into scales and to explain the reasons for the choices.

Step 2  A pilot study involved 10 practising school science teachers (attending postgraduate studies at Curtin University), three of whom were interviewed subsequently about their responses to the questionnaire.

Step 3  A modified, 41-item version of the questionnaire was responded to by another science teacher who was then interviewed.

Step 4  The BASSSQ was administered to 27 junior high school science teachers from Western Australian government schools.

Step 5  Analysis of the survey data collected from the 27 teachers was used to determine the statistical reliability of the questionnaire, using two criteria: internal consistency and discriminant validity.

Step 6  The conceptual integrity of the BASSSQ was investigated further through interviews with six of the 27 teachers who had responded to the questionnaire. During the interviews, teachers were asked to explain the reasons for their responses. Teachers were encouraged to discuss their philosophical stance towards the nature of science. The explanations were then used to determine whether items had been interpreted in keeping with our original intentions.

The interview transcripts were analysed using an interpretive approach (Erikson, 1986), during which we considered both confirming and disconfirming evidence. We have presented the results of these interviews in the narrative form of ‘stories’, in an attempt to capture the essence of the human elements that were evident in the interviews. The use of stories has become an increasingly popular source of insight into human nature (Carter, 1993; Clandinin, 1992; Shulman, 1992). We considered stories to be the most explicit means of conveying the results of the interviews.

RESULTS

The results of our developmental research are discussed in relation to each of the following methodological steps:

- Initial Test of Homogeneity;
- Pilot Study and Modifications;
- Reliability and Validity of the BASSSQ; and
- Conceptual Integrity and Viability of the BASSSQ.

Initial Test of Homogeneity

As an initial step, the homogeneity of each scale was assessed to ensure that each item in a scale referred to a common concept. To determine the homogeneity of each scale, an experienced teacher of school science, who is currently a graduate student conducting research in the field of philosophy of science education, was asked to allocate each of the 52 mixed items to the four existing sub-scales. We noticed that the graduate student interpreted some items differently to the way in which we had intended, and placed them into different scales. As well, she found ambiguities in some items which led to confusion regarding their placement. Subsequently, the items were either omitted or reworded to optimise membership of their respective scales.

Pilot Study and Modifications

In the next step, a 46-item version of the questionnaire was administered to 10 experienced school science teachers who are studying currently at the postgraduate level. The teachers were asked to indicate any difficulties they experienced when responding to the items and to write their comments directly on the questionnaire. Three of the teachers also were interviewed to discuss the items which appeared to be
Problematic. Deliberation over individual items helped us to determine why items were ambiguous or otherwise problematic.

The wording of some items caused concern. For example, the word 'fun' in the item: "If students are having fun during science experiments, science learning will be limited" was considered to be ambiguous. Teachers were unsure whether this term referred to students being off-task or enjoying learning. The item was modified to be more explicit but continued to cause difficulties and was later omitted. Other items which contained ambiguous concepts (e.g., the notion of 'discovery learning', in the item "In science classes, a weakness of discovery investigations is getting students to come up with the right answers") also were omitted. Interpretation difficulties arose from the use of negatively-worded items such as "Scientific knowledge cannot be proven", and these were changed to make them easier to answer using the frequency response scale.

Thus, changes were made to items in response to input from 10 experienced school science teachers. The modified version of the questionnaire was next responded to by another experienced school science teacher (who had not seen the earlier version of the questionnaire) and the subsequent interview indicated that there were no apparent ambiguities. His interpretations of the items were consistent with our intentions and his questionnaire responses seemed to be consistent with his view of science.

Reliability and Validity of the BASSSQ

The revised 41-item version of the BASSSQ was administered to 27 junior high school science teachers in Western Australian government schools. Through contacts with the heads of science departments in these schools, voluntary participation on the part of teachers was elicited. These teachers’ responses to the questionnaire were analysed to help determine its reliability. Data analysis was undertaken to generate statistics for internal consistency reliability and discriminant validity.

The internal consistency (Cronbach's alpha reliability coefficient) of each scale was determined to provide an indication of the extent to which the items of each scale measured a common concept. The alpha reliability coefficient of this early version of the BASSSQ varied between 0.51 and 0.81 (see Table 3), revealing that at least one of the scales had a less than satisfactory internal consistency.

The mean correlation of each scale with other scales was used as a convenient index of discriminant validity which could help to determine whether each scale measures a unique concept. The resultant correlation coefficients (reported in Table 3) ranged between 0.12 and 0.52, showing a relatively high degree of individuality for one scale, whilst three scales have a relatively high degree of commonality or overlap.

This statistical evidence suggested that further conceptual problems existed with some of the items.

Table 2
Internal Consistency (Cronbach's Alpha Reliability Coefficient) and Relative Independence of the BASSSQ Scales (N=27)

<table>
<thead>
<tr>
<th>BASSSQ Scale</th>
<th>Number of items</th>
<th>Alpha Reliability</th>
<th>Mean Correlation with Other Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher's View of Science</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process of Scientific Inquiry</td>
<td>8</td>
<td>0.51</td>
<td>0.41</td>
</tr>
<tr>
<td>Epistemological Status</td>
<td>8</td>
<td>0.71</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Teacher's View of School Science</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process of Scientific Inquiry</td>
<td>8</td>
<td>0.81</td>
<td>0.12</td>
</tr>
<tr>
<td>Epistemological Status</td>
<td>8</td>
<td>0.70</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Conceptual Integrity and Viability of the BASSSQ
In the next stage, we interviewed six of the 27 teachers who had responded to the 41-item questionnaire and who had volunteered to be involved. In depth, semi-structured interviews were conducted with these teachers to determine the conceptual integrity and viability of the BASSSQ. Based on an analysis of the results of these interviews we developed the following interpretive assertion, the evidence for which is presented in the form of stories and interpretive commentary. All teachers' names reported here are pseudonyms.

**Assertion**

Teachers’ responses to the BASSSQ are influenced by:
- their particular philosophical orientation which, in turn, can cause them to equate ‘school science’ with ‘science’, and
- the curriculum context that serves them as a referent.

**Story 1: Stan the Philosopher**

Stan was the first person to reply to our request for an interview. We were eager to speak to him because his responses to the BASSSQ were quite different from the other 26 teachers’ responses. They indicated that he had a strongly post-modern view of the nature of science.

When we arrived at Stan’s school, we were immediately impressed by the turn of the century architecture and the general atmosphere of the school. If ever a school had a nice ‘feel’ about it, this one certainly did. We were ushered from the original, historic section of the school, into a modern wing which housed, among other things, the school’s science faculty room. It was here, over a cup of coffee, that we discussed Stan’s interpretations of his BASSSQ responses.

Stan had been teaching science, predominantly biology, at the same school for some time and was enthusiastic about his vocation. He opened the discussion by explaining that he had studied philosophy during a recent postgraduate programme and we found, throughout the interview, that his keen interest in philosophy of science had a strong influence on his thinking.

Although we structured the interview around Stan’s previous responses to the BASSSQ items, we found that, on a number of occasions, we digressed into a general conversation regarding various philosophical issues associated with the items. We spent a most enjoyable hour discussing Stan's interpretations of the items and his philosophical views and found that, in most cases, both were similar to our own. For example, during one diversion, we discussed the certainty of scientific knowledge in relation to teaching, and Stan voiced his view that:

...we [teachers] have to appreciate that there is no whole outside body of knowledge that's static. We've got to appreciate that in ten years time it could be very different.

[Interview 1, p. 3]

Stan’s explanations convinced us that he had interpreted most of the items of the BASSSQ in the way in which we had intended. For example, when he was asked to explain what he understood by Item 6, ‘When making observations scientists eliminate their values and beliefs’, Stan explained:

I'm sure that we see what we want to see quite often. In any endeavour, whether it's science or whatever, I think there is underlying notions of what we think should be the results, and our observations are probably influenced by them.

[Interview 1, p. 6]

A further example was when Stan explained that he responded 'almost always' to Item 13, "Students should be taught that there is a distinction between theory and observation", because:

...observations are constrained by the underlying theory that they [scientists] have.

[Interview 1, p. 3]
There were a couple of items that Stan had interpreted differently to the way we had intended, such as, Item 8, "Scientific investigation starts with observations of nature" (to which he had responded 'almost always'). In this case, Stan explained his response:

"I don't think that scientific inquiry starts with someone sitting back in a chair thinking about what problems they might be able to solve."

[Interview 1, p. 2]

Stan had construed the item as a decision about whether scientific investigation comes about through action or inaction, whereas we had intended the item to reflect a theory-free method of scientific inquiry associated with more traditional views of science.

At the end of the interview, we decided that any discrepancies between Stan's interpretations and our own were minor and easily amended. We were satisfied that, on the whole, Stan's interpretations were consistent with our intentions. Afterwards, we quietly congratulated ourselves on the development of a questionnaire that was readable by teachers and that had a high degree of conceptual integrity.

At this point we were unaware of any major potential difficulties with the questionnaire or, for that matter, the atypical nature of the teacher we had interviewed. Stan's interview was the first of six, and we discovered that not all teachers interpreted the items as consistently as Stan had done. The interviews that followed revealed trends regarding teachers' mind-sets that caused us to reconsider our interview with Stan.

**Story 2: The Hot Phone Call**

An urgent message on my desk informed me that one of the teachers had some queries regarding the questionnaire. When I telephoned the teacher, Les, I found that he was angry:

I'm not keen on being reduced to a number, but I must say I get pretty mad when they're [questionnaires] full of ambiguities...and if there are ambiguities I cannot state what I really know to be correct, then I throw up my hands and say 'I wish I wasn't looking at this'.

[Interview 2, p. 1]

Throughout the telephone conversation, Les mentioned ambiguities he saw in various items and, in response, I tried to explain what the original intentions had been.

One of his first questions was: "what occurs in science and what should occur’ are two different things, which is it?". His question threw me, as I could not work out which item he was referring to. It wasn't until Les referred me to ‘the top of the first page’ that it dawned on me. He had read the instructions at the top of each sheet of the questionnaire but had not made a distinction between the two parts of the questionnaire: ‘Teachers’ Views of Science’ and ‘Teachers’ Views of School Science’. As a result, he was unsure as to whether the term ‘science’ (which appears in many items) referred to “science lessons or general science outside of school”.

My attempt to explain the distinction we had made between science and school science was not met with the positive reaction I had expected. Rather, Les proceeded to raise other queries related to his frustrated confusion regarding what was being asked by the questionnaire:

[Item 14] “Scientific knowledge can be proven” - to whose satisfaction? To scientists’ satisfaction, or to laymens’ satisfaction, or to my satisfaction?... I want to know things like this.

[Item 15] “Scientific knowledge changes with changes in situations?” What sort of situations are you talking about? Situations within the community, within cultures, within the scientific community?

[Interview 2, p. 3]

Les continued to express his dissatisfaction with the questionnaire. Whilst he apologised for "all the red comments" he had written over it, he remained convinced that I had wasted his time for no good reason. It wasn't until the end of the conversation that his attitude changed towards both the questionnaire and me.

At this stage, I felt that I had nothing to lose, and asked if I could explain what I had originally sought to achieve with the questionnaire. Hesitantly (possibly because I was demanding yet more
of his valuable time), he agreed and I proceeded to explain the background and philosophical framework of the questionnaire. It was at this stage that his disposition toward me altered dramatically.

Oh...I understand where you're coming from a bit better now.... I think that [will] help me to be able to put more accurate meanings to the questions you're asking....Well I feel like I have got back to a person rather than a questionnaire I can't cope with.

[Interview 2, p. 4]

When Les's subsequent responses to the questionnaire arrived in the mail, the 'red comments' were crossed out but legible. It was obvious that initially he had been unimpressed and angered at the apparent waste of his time. But there also were comments in black pen that he had written after our telephone conversation. These were complementary and wished me luck in my future studies.

The telephone conversation and Les's initial responses to the questionnaire made us wonder how many other teachers felt that we had wasted their time and how many had not understood the items as we had intended.

The conversation with Les led us to re-consider our interview with Stan, particularly the role of his philosophical orientation in responding to the questionnaire. Stan's interpretations of the items, especially his ability to distinguish between 'science' and 'school science', could have been a result of his philosophical mind-set.

If so, then it seemed likely that the 10 teachers in the pilot study had interpreted items in keeping with our intentions because they had responded with philosophical mind-sets similar to ours. We posed the question: 'Was it the case that teachers, such as Les, who weren't studying at the university, would be more likely to respond from an alternative perspective, one which could lead to quite different interpretations of the items?'

Subsequent teacher interviews appeared to confirm our assertion that teachers' responses might vary according to their philosophical orientations. We interviewed Rick who, like Stan, responded from a philosophical orientation and interpreted the items in ways similar to ours.

However, we also interviewed teachers (e.g., Sheila, Pam, Clint) who responded from what we have termed a school science perspective. The responses of these teachers were often very different from those who responded with a philosophical orientation (e.g., Stan, Rick). For example, with Item 11, "Scientific knowledge gives a true account of the world", Stan responded 'seldom' and Sheila responded 'sometimes'. Stan explained the reason for his response as:

When somebody leans on a tree, the only reason that they know that there's a tree there is because of sense impressions....they're receiving information which isn't necessarily true information...our senses might be wrong.

[Interview 1, p. 4]

Whereas Sheila, who responded from a school science context, that:

Basically I keep going into the class and they're [students] saying things. They're telling me their views and observations...and I'll get two observations from the kids, two accounts of what actually happens.

[Interview 3, p. 2]

It seemed to us that teachers with a philosophical perspective were more likely to distinguish between science and school science and, thus, interpret the items in ways we had intended. This assertion was supported further when we interviewed Pam.

Story 3: Oops!

Pam rang to say that she was available for an interview in the last week of school. She requested to be interviewed over the phone as she felt she would be more comfortable and it would take up less of her time.

I had organised to ring Pam during this particular morning and set up my tape recorder so that it would pick up the conversation over the speaker phone. When I got through to Pam, I immediately felt uncomfortable talking into the ‘box’. My conversation was stilted and, whilst Pam did not appear to feel uneasy, it took me some time to get used to speaking into the phone.
From the beginning of the conversation it was obvious that Pam had not responded to the BASSSQ from a philosophical orientation. The explanations she gave for her responses confused me and, whilst I realised that she was using the classroom as the context for her explanations, it did nothing to help me determine why she had responded in that way.

It wasn’t until we were well into the interview that I realised that Pam had responded to the two parts of the questionnaire — ‘Teachers View of Science’ and ‘Teachers View of School Science’ — as ‘actual’ and ‘preferred’ forms of teachers’ views of school science. To compound the matter, Pam later explained to me that she had responded as she perceived the students would respond. In other words, she had attempted to double guess students' responses to the questionnaire.

I was disappointed and could not imagine how Pam had misread the instructions to the extent that she had. Whilst I did not feel that the interview would be of any use from this stage on, I felt compelled, through good manners, to continue as I had planned.

From that point, we discussed the interview as an ‘actual’ and ‘preferred’ form of teachers' views of school science. Nevertheless, I found that other difficulties were highlighted as a result. Pam’s interview responses indicated that her responses to the items also were framed by the curriculum context: that she had in mind:

...an ideal class in the final year with major exams coming up would be quite different to a more junior class.

...biology lessons lend themselves more to constructivist approaches than human biology lessons.

[Interview 6, pp. 2, 3]

Pam felt that different science courses lent themselves to different ‘ideal’ classrooms and explained that if she had responded from a teacher perspective (rather than a student perspective) then her responses to items would have been different had she viewed herself as a senior high school teacher rather than a junior high school teacher.

This story reveals that, when responding to the two parts of the questionnaire (i.e., Teacher’s View of Science, Teacher’s View of School Science), yet another teacher had not differentiated between science and school science. Initially, we were surprised that this error could be made because we were sure that the instructions on the questionnaire distinguished clearly between the two. In hindsight, however, it seems that, for science teachers, the term ‘science’ can evoke a strong image of their daily school science activities, thus blurring the distinction between the two parts of the questionnaire. Reflection on our telephone conversation with Les indicated that he had experienced a similar confusion:

Ideally, ‘what occurs in science and what should occur’ are two different things. Which one are you trying to ask for?

[Interview 2, p. 1]

Although we had considered initially that the misinterpretations had arisen from teachers’ failure to have read the instructions on the questionnaire (which they had received in the mail), a subsequent interview with Clint revealed that he too had not distinguished between science and school science. His interview, alongside Pam's, highlighted the need for clearer contextual cues that would assist teachers to consider the BASSSQ items from a philosophical orientation.

Even in the case of Stan's interview, there was an instance when he indicated that the curriculum context had influenced his responses. In relation to the item which stated 'Scientific observations are effected by scientists' values and beliefs', Stan explained that:

It wouldn't be the same [response] if you were doing quantitative type work though...measuring invertebrates in the underwater system in Perth or something like that.

[Interview 1, p. 6]

Whilst the findings were disappointing because they reduced the conceptual strength of the instrument, they also were heartening in so far as they revealed not insurmountable difficulties with the mechanics of the questionnaire. The interviews indicated that to ensure the questionnaire is viable we need to help teachers respond from philosophical orientations.
CONCLUSION

The interviews raised important issues regarding the teachers' readings of the BASSQ. It appears that teachers who respond to the BASSQ from a philosophical perspective are more likely to make the distinction between science and school science. These teachers are less likely to encounter confusion and frustration associated with misinterpreting the purpose and structure of the questionnaire. The 'hot phone call' from Les was a prime example of the frustration associated with interpreting items from only a school science perspective.

We found also that teachers' responses to items are framed by their curriculum contexts, and that these contexts can give rise to different responses to the same item by the same teacher. Depending on whether the teacher is thinking about junior or senior school science, or about biology, human biology or physics, her responses to specific items are likely to vary.

In order to increase the conceptual strength of the questionnaire (and, thus, the internal consistency of the scales), richer contextual information should be provided on the questionnaire that orients teachers' thinking towards a philosophical perspective and a specific curriculum context. The instructions should enable teachers to (1) understand readily the distinction between science and school science, and thus be able to distinguish meaningfully between the two parts of the questionnaire, and (2) focus on a specified curriculum context (e.g., junior biology) as a referent for their response to each item.

REFERENCES

Erickson, F. (1986). ‘Qualitative methods in research on teaching’. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed., pp. 119-159). NY: Macmillan.


### Appendix

**Your Views About What Occurs in Science**

Please indicate how often, in your opinion, each practice occurs in science.

<table>
<thead>
<tr>
<th>Process of Scientific Inquiry</th>
<th>Almost Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.* Scientific observations depend on what scientists set out to find.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Scientific inquiry involves challenging other scientists’ ideas.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Scientific observations are affected by scientists’ values and beliefs.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4.* Scientific inquiry involves thinking critically about one’s existing knowledge.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Intuition plays a role in scientific inquiry.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

| 6. When making observations, scientists eliminate their beliefs and values. | 1 | 2 | 3 | 4 | 5 |
| 7. Scientific observations are guided by theories. | 1 | 2 | 3 | 4 | 5 |
| 8. Scientific inquiry starts with observations of nature. | 1 | 2 | 3 | 4 | 5 |
| 9. Scientific investigation follows the scientific method. | 1 | 2 | 3 | 4 | 5 |
| 10. Scientific ideas come from both scientific and non-scientific sources. | 1 | 2 | 3 | 4 | 5 |

<table>
<thead>
<tr>
<th>Certainty of Scientific Knowledge</th>
<th>Almost Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Scientific knowledge gives a true account of the natural world.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. Scientific knowledge is tentative.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. Scientific knowledge is relative to the social context in which it is generated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14.* Scientific knowledge can be proven.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. The evaluation of scientific knowledge varies with changes in situations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

| 16. The accuracy of current scientific knowledge is beyond question. | 1 | 2 | 3 | 4 | 5 |
| 17.* Currently accepted scientific knowledge will be modified in the future. | 1 | 2 | 3 | 4 | 5 |
| 18. Scientific knowledge is influenced by cultural and social attitudes. | 1 | 2 | 3 | 4 | 5 |
| 19. Scientific knowledge is free of human perspectives. | 1 | 2 | 3 | 4 | 5 |
| 20. Scientific knowledge is influenced by myths. | 1 | 2 | 3 | 4 | 5 |
Your Views About What Should Occur In School Science

Please indicate how often, in your opinion, each practice should occur in school science.

### Process of School Science Inquiry

<table>
<thead>
<tr>
<th>Practice</th>
<th>Almost Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. In science classes, investigations should enable students to explore their own ideas.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. In science classes, students should work collaboratively.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23. In science classes, students should discuss ideas with others.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24. In science classes, students should think creatively.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>25. In science classes, students should explore different methods of investigation.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26. Students should view science as a problem-solving exercise.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Certainty of School Science Knowledge

<table>
<thead>
<tr>
<th>Practice</th>
<th>Almost Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>32. In school science, students should be critical of accepted theories.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>33. In school science, students should view scientific knowledge as tentative.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>34. In school science, student understanding should be influenced by their existing knowledge.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>35. In school science, students should examine the history of accepted scientific knowledge.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36. In school science, students should learn that more than one theory can account for a given set of data.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Additional Items

- In school science, inquiry learning should start with observation. (27)
- In school classes, students should apply the scientific method. (28)
- Students should enjoy themselves during science experiments. (29)
- Students should be taught that there is a distinction between theory and observation. (30)
- In school classes, students should consider ethical issues related to scientific investigation. (31)
- In school science, students should be taught that accepted scientific knowledge will be modified in the future. (38)
- In school science, students should examine how society influences what counts as scientific knowledge. (39)
- In school science, students should consider social issues related to accepted scientific knowledge. (40)
- In school science, students should be taught that scientific knowledge is objective and therefore free of human values. (41)

*Items omitted during analysis
Underlined items reflect a more objectivist view and were therefore scored in reverse.