Chapter 42
Children's Attitudes to Primary Science

Karen Kerr and Colette Murphy

Attitudes toward science are often studied in an attempt to ascertain the possible reasons behind a decline in the number of students choosing to study science in secondary school and/or at tertiary level. However, there are several debated issues within the realm of attitudes toward science including: the diversity and interpretations of subcategories and the terms used to denote them, the link between attitudes and what children actually do (behavior), and what is meant by science. In this chapter we consider the relationship between the sub-categories and terms used in relation to attitudes toward science. Many of the subcategories and terms used in the literature delineate the emotional (such as a belief about science), cognitive (which includes motivation) and action-tendency (behavioral intent or manifested interest) components of attitudes. Through discussion of these three components we emphasize that when conducting attitudinal research, it is important to include questionnaire items/questions which actually consider action tendency.

This chapter also discusses some of the main concerns over measuring attitudes. The instruments that have traditionally been used to consider attitudes toward science are diverse in nature. However, with reference to primary children's attitudes, we demonstrate the importance of incorporating a mixture of quantitative and qualitative instruments. For example, Judith Ramsden (1998) suggested that a range of techniques must be used; we provide further details on the suggestions made by Cheryl Blalock et al. (2008).

We look to the future and consider new directions in attitudinal research work relating to children. Current research in this area by the authors involves the establishment of Children's Research Advisory Groups (CRAGs), following work carried out by Laura Lundy and Lesley McEvoy (2007, 2008). Children in these groups

K. Kerr (✉) • C. Murphy
School of Education, Queen's University Belfast,
Belfast, BT7 1HL, Northern Ireland
e-mail: kkerr02@qub.ac.uk; c.a.murphy@qub.ac.uk

B.J. Fraser et al. (eds.), *Second International Handbook of Science Education*,
Springer International Handbooks of Education 24, DOI 10.1007/978-1-4020-9041-7_42,

informed the processes, interpretations, and outcomes of the research. In our research, children informed the design of questionnaire instruments and interview schedules, as well as giving their interpretations on findings and what they considered to be the outcomes of the work (Murphy et al. 2010).

Relevant literature in relation to primary children's attitudes to science is discussed. The literature considered reflects two major aspects of school science: children's attitudes to the science topics taught, and their interest in and enjoyment of science lessons. The majority of studies discuss primary children's attitudes in relation to age and gender. Overall, this literature suggests that, at primary level, there is a decline in positive attitudes toward science with age. However, this decline is less apparent when children are involved in practical, investigative science activities (Murphy et al. 2004). With regard to interest in and enjoyment of science, a gender difference with respect to physical science is less obvious in more recent studies. A difference between findings with respect to gender in older studies compared with more recent studies emphasizes the importance of a cautious approach when discussing and comparing results from recent studies with those from older studies.

What Are Attitudes to Science?

Major recent reviews in this area, for example, by Ramsden (1998) and Simon (2000), begin by discussing confusion in terms. Even over 30 years ago this was an issue, as discussed by Gardner (1975). Indeed, Jonathon Osborne et al. (2003, p. 1053) began their recent and substantial review of the attitudes literature by suggesting that 30 years of research into attitudes toward science has been "bedeviled by a lack of clarity into the concept under investigation." The most pertinent distinction mentioned in almost every recent review relates to the broad categories outlined by Gardner (1975): scientific attitudes and attitudes toward science. In Table 42.1, we have outlined the references made to both types of attitudes as well as how authors have described aspects of scientific attitudes or attitudes to science.

The scientific attitudes outlined in Table 42.1 relate to the way scientists should think or the qualities they should have. For example, as attempts are made to increase the number of future scientists, students can be encouraged to question and look for answers to questions such as why the liver is the only organ than can grow back or the supposed impact of global warming on our weather. In doing so, teachers may encourage a questioning approach (Education Policies Commission 1962). Very often, scientific attitudes are defined within attitudinal studies to emphasize that they will not be studied because of their dissimilarity with the affective nature of attitudes toward science. Nevertheless, scientific attitudes have their place in science classrooms.

There are several debated issues within the realm of attitudes toward science including: the diversity and interpretations of subcategories and the terms used to denote them (as shown in Table 42.1 and Fig. 42.1), the link between attitudes and what children actually do (behavior), and what is meant by science.

Table 42.1 A summary of references to scientific attitudes and attitudes toward science

Attitude type	Description of the attitude	Reference
Scientific attitudes	Acceptance of scientific enquiry as a way of thought, Adoption of scientific attitudes	L.E. Klopfer (1971)
	"Styles of thinking which scientists are presumed to display" (e.g., open-mindedness, honesty, skepticism)	Gardner (1975, p. 2)
	"Students' approach to thinking about science"	Tom Haladyna and Joan Shaughnessy (1982, pp. 548–549)
	"Scientific attributes"	Thomas Koballa and Frank Crawley (1985, p. 223)
	Longing to know and understand: A questioning approach to all statements; a search for data and their meaning; a demand for verification; a respect for logic; and a consideration of premises and consequences	Education Policies Commission (1962, as cited in Osborne et al. 2002, p. 1054)
Attitudes toward science	React favorably or unfavorably to a definite object (e.g., science or scientists)	Gardner (1975)
	"General or enduring positive feeling about science"	Koballa and Crawley (1985, p. 223)
	"Attitudes or feelings toward science refer to a person's positive or negative response to the enterprise of science…whether a person likes or dislikes science"	Ronald Simpson, Thomas Koballa, Steve Oliver and Frank Crawley (1994, p. 213)
	Perception of the science teacher, Anxiety toward science, Value of science, Self-esteem at science, Motivation toward science, Enjoyment of science, Attitudes of peers and friends toward science, Attitudes of parents toward science, Nature of the classroom environment, Achievement in science, Fear of failure on course	Simon (2000, p. 105) and Osborne et al. (2002, p. 1054)

Subcategories and Terms

Ramsden (1998) suggested that the use of terms is a complex issue and that terms are often used interchangeably and their meanings often overlap. For example, the subcategories outlined in Fig. 42.1 include the terms feelings, perceptions, motivation, and enjoyment under the umbrella of attitudes. Ramsden (1998) included the terms interest, views, images, beliefs, and values. Based on her discussion of these terms, Ramsden (1998) concluded that attitudes are not unidimensional and include three components: cognitive, emotional, and action-tendency related in the following way:

> … attitudes…[are]…a state of readiness or predisposition to respond in a certain manner when confronted with certain stimuli … attitudes are reinforced by beliefs (the cognitive

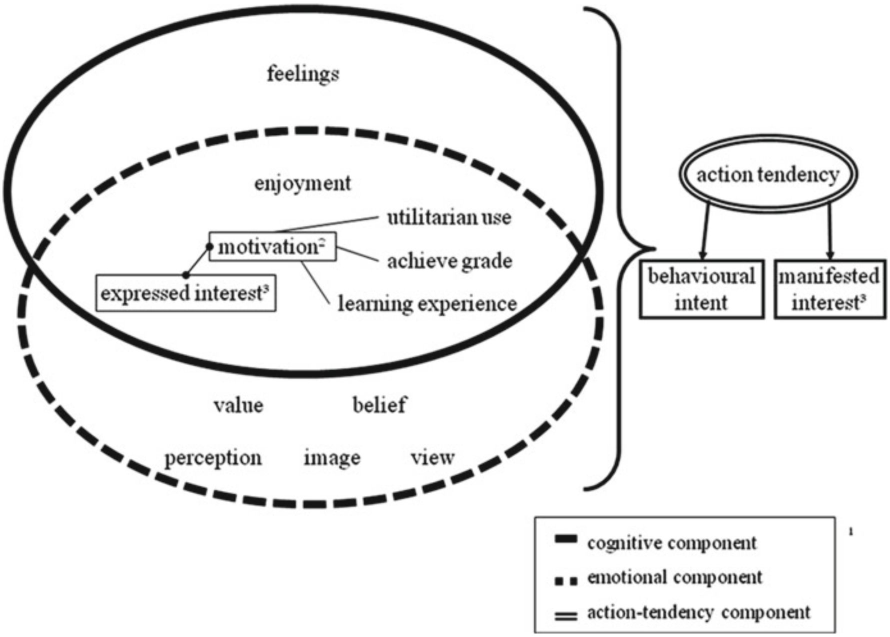

Fig. 42.1 A diagrammatical representation of the main relationships given by Ramsden (1998) and other researchers in relation to the terms used for attitudes

[1] The three attitudinal components outlined by Oppenheim (1992, p. 74)
[2] Strands of motivation outlined by Ramsden (1998, p. 128). The connection with interest was suggested by Gardner (1985)
[3] William Wall (1968) differentiated between expressed interest (like vs. dislike) and manifested interest (evidenced by hobbies)

> component), often attract string feelings (the emotional component) which may lead to particular behavioural intents (the action-tendency component). [Oppenheim 1992, p. 74, as cited in Ramsden (1998, p. 128)]

Figure 42.1 is based on this definition and we have diagrammatically represented some of the main relationships presented by Ramsden (1998) and other researchers in relation to the terms used for attitudes. The solid ring represents the cognitive components mentioned in some studies (e.g., Ramsden 1998). The dashed ring shows the words used to talk about and describe the emotional components of attitudes toward science, such as a perception of science that a child may have. The double-lined ring represents action tendency which can happen as a result of the cognitive and/or emotional components. For example, an action tendency can be children's involvement in science revision classes (manifested interest) because they are motivated by needing to achieve a higher grade for a university course (achieve grade – cognitive and emotional component).

The concept of "motivation" is also multidimensional. Gardner (1985) argued that motivation is related to declared interest. In other words, it is a measure of how willing children are to take part in certain actions in which they have expressed interest.

However, Ramsden (1998) pointed out that motivation can arise from other sources: utilitarian use (for a career), to achieve a grade or students can be motivated by a learning experience. Many secondary school children may be motivated by career choice or driven by the need to achieve a grade (in order to be accepted for a career). For example, students might take physics with the sole purpose of increasing their chances of acceptance to a medical course. However, the utilitarian and career components of motivation might not apply as strongly at primary level, except perhaps in countries where children's selection for secondary level education is based on high-stakes testing. The link with declared/expressed interest (Gardner 1985) should also be viewed with caution because children may like and be interested in an aspect of science that they have not specifically declared within a given study. For example, a child may be really interested in topics or different instructional procedures that have not been included in a research instrument.

Attitudes and Behavior

Children might express a preference for an element of science (expressed interest) or feeling about science (cognitive and emotional components), but they might not exhibit related behavior (Osborne et al. 2003). Children's behavior may be affected by other elements such as the attitudes of peers (Osborne et al. 2003). For example, children may not participate in a given science activity because they may not consider it to be "cool." The possibility that attitudes and behavior may be affected by other variables has led researchers to focus on behavior as opposed to whether or not children are interested in particular topics/activities (Osborne et al. 2003). Many researchers have reconsidered Icek Ajzen and Martin Fishbein's (1980) theory of reasoned action which differentiates between attitudes toward an object (science) and attitudes toward actions to be carried out on that object (activities, learning about topics). Ajzen and Fishbein (1980) claimed that finding out about attitudes toward actions is a better predictor of behavior than finding out about attitudes toward science itself. For example, children could be asked if they would like to learn more about given topics (an action) as opposed to being asked if they like it (an object). The behavior element is presented in Fig. 42.1 as the "action-tendency" component, how children intend to behave. Manifested interests (e.g., hobbies) are also considered part of the action-tendency component in Fig. 42.1. It is at this point that we will consider the issues around what is thought of as science in the context of attitudinal research.

What Is Science?

Charles Barman et al. (1997) considered fifth grade children's perceptions about scientists, science in school and science out of school. Barman et al. (1997) used the Draw-A-Scientist Test (DAST), originally developed by David Chambers (1983), and found that the majority of children drew white males who worked in some sort of laboratory. With regard to doing science in school, Barman et al. (1997) found that 56% of children drew themselves reading a science book or taking notes. Out-of-school science was characterized as an extension of school science by 60% of children (e.g., repeating school activities). These findings indicate that children think of science in different ways and reinforce the need for studies to differentiate between out-of-school science and in-school science (Osborne et al. 2003) with a focus on the latter (Ramsden 1998).

Ramsden (1998) also mentioned the issue of using science as an umbrella term to include biology, chemistry, physics, and possibly other areas. It is important to note that the impact of such a demarcation may not have the same effect on the expressed attitudes of primary school children compared with secondary school children. This is because many primary-aged children are unlikely to be aware of the different areas of science but a decline in positive attitudes toward physical science is well cited in literature relating to secondary school children (Bennett 2001; Haussler and Hoffman 2000). Nevertheless, a spread of topics/activities relating to the three major aspects (biological, chemical, and physical science) of science should be incorporated. Firstly, to address the possibility that children may already show signs of dislike toward a certain area of science at primary level. Secondly, including a range of topics from different science areas is representative of the current curricula.

For the most part, primary science is considered as school science because the majority of questions are related to in-school science. Ramsden (1998, p. 128) suggested we must collect data on a variety of aspects in order to look at "underlying trends and patterns," and claimed that such an approach is necessary because we can only deduce attitudes from words and actions because they "cannot be measured directly." Perhaps methodological issues surrounding attitudinal studies have arisen from a general assumption that attitudinal instruments actually measure attitudes, coupled with the confusion that comes with the diversity of instruments (Osborne et al. 2003) that claim to measure different aspects of science. The following section considers the much debated methodological issues relating to studies of children's attitudes to science.

Measuring Attitudes

Many of the issues surrounding the measurement of attitudes to science are analyzed, explored, and argued about in well-known reviews of the literature, spanning four decades – from a very early study by Gardner (1975), to later studies by Ramsden (1998) and Osborne et al. (2003), to a recent study by Blalock et al. (2008). Osborne et al. (2003) pointed out that the diversity of methods used in attitudes studies has led to the recognition of difficulties in measuring attitudes toward science, which is demonstrated in the extensive list of techniques and instruments (with examples) outlined by Gardner (1975) and Osborne et al. (2003). Both studies (Gardner 1975; Osborne 2003) mention the list of techniques and instruments outlined below. The examples given in both studies have been collapsed into this list:

- Summated rating scales – Likert scales, yes/no, agree/disagree, approve/disapprove (number of points on the scale vary)
- Semantic differential scales – use of bipolar adjectives (good/bad, interesting/dull) and participants are asked to indicate on a scale between these
- Interest inventories – participants tick what they find interesting from a given list
- Preference ranking – rank subjects in order of preference
- Enrollment data – number of students who take A-level sciences/proceed with aspects of science at third level
- Qualitative methodologies (Gardner referred to these as clinical and anthropological observations) – interviews, classroom observations

In addition to these, Gardner (1975) also specified the following instruments:

- Differential (Thurstone) scales – tick statements that best match beliefs; a mixture of positive and negative statements are included
- Rating scales – mainly external raters (teachers) asked to rate students along a numerical scale
- Projective techniques – word association, interpretation of drawings, sentence completion

We have given an overview of the methodologies used in studies which consider primary aged children in Table 42.2. In an attempt to group similar studies we have separated Table 42.2 into three sections. Comparative studies were those carried out in order to compare different samples. For example, one comparative study considered the attitudes of children from different countries (Murphy et al. 2006) and another compared children at different stages in an education system (Tymms 1997). Intervention studies considered aspects of children's attitudes before and after an intervention. Many of the studies in the *Other Studies* section in Table 42.2 considered different aspects of children's attitudes at a given time. It is evident from Table 42.2 that the majority of studies with primary children in recent years incorporated a mixture of questionnaire and interview-based questions.

In Fig. 42.2, we have graphically represented the methods used and variables considered in the primary studies outlined in Table 42.2. Counting the actual instruments/techniques/methods (Fig. 42.2) used to consider primary children's attitudes in well-cited studies showed that not all of the instruments outlined above by Gardner (1975) and Osborne et al. (2003) have been considered appropriate nor are regularly used with children of this age.

Traditionally, the majority of studies which consider primary school children's attitudes to science incorporate the use of Likert scales, open questions/interviews, subject preference, and semantic differential scales (Fig. 42.2). Ramsden (1998) suggested that interview methods must be included as a means of cross-checking written and verbal responses. Osborne et al. (2003, p. 1059) also suggested that open questions give more "insight into the origins of attitudes to school science." Karen Kerr (2008) also pointed out that children can talk about science

Table 42.2 A list of studies which consider primary children's attitudes to science

Study	Countries	Age band	Sample size	Aspects of attitudes	Methodology	Variables
Comparative studies						
Tymms (1997)	UK	10–11	5,000, 1,740	Self-concept in science (5,000 children)	5-point Likert scale	Overall sample school
				Achievement in science (1,740 children)	Multiple-choice test	
Catherine Woodward and Nicholas Woodward (1998a)	Wales	10–11	120 pupils in 3 years	Ranking of science Preferred and least preferred topics	Preference ranking	Gender
Chris Dawson (2000)	Australia	12–13	1980: 753 1997: 203	Topic preference Activity preference	Likert scale	Gender Sample years
Murphy and Beggs (2001)	Northern Ireland, England	8–11	979 (N.I.) 653 (Eng)	Topics: Enjoyment, importance, perceived ability Like best/not like/hardest thing	Semantic differential Likert scale Open questions	Age Gender Countries
Murphy et al. (2006) and Murphy and Beggs (2003)	Northern Ireland, Oman	8–11	979 (N.I.)	Topics: Enjoyment, importance, perceived ability	Semantic differential	Age, gender, ability
			944 (Oman)	Science in/out of/later in school	Likert scale Open Questions	Overall sample countries
Intervention studies						
Tina Jarvis and Tony Pell (2002)	England	10–11	655	Science enthusiasm and social context Space and getting the job done	Likert scales	Gender, age overall sample intervention
Murphy et al. (2004)	Northern Ireland	8–11	1,286	Topics: Enjoyment, importance, perceived ability	Semantic differential	Gender, age, overall sample intervention

				Something you remember from lessons	Likert scale	
					Open questions	
Jarvis and Pell (2005)	England	10–11	300	See factors outlined above (2002)	Likert scale	Overall sample intervention
				Information on attention, activities, independence, conversations	Observation of the visit	
				Recall, likes/dislikes, role, what they learned, become an astronaut?	Open questions	
Jenny Mant, Helen Wilson, and David Coates (2007)	England	10–11	Not specified	Achievement in national assessment test: % of level 5	% achieving level 5	Overall sample intervention
				Perceptions of the lessons	Focus groups	
				Perceptions of the lessons Perceptions of the impact of the lessons on their learning		
Other studies						
R. A. Hadden and A. H. Johnstone (1982)	Scotland	10–12	1,000+	Attitudes to studying science	Semantic differential with Likert	Overall sample
				Early perceptions of science	scale, structured discussions, free response	
M. B. Ormerod and Charles Wood (1983)	England	10–11	330	Attitudes to space and nature study	Likert scale, sentence completion	Gender, compare methods
				General attitudes	Projective tests	
Margaret Collins (1993)	England	5–6	35	Beliefs and boys'/girls' preferences, their science and scientists' work	Choose from a list	Gender

(continued)

Table 42.2 (continued)

Study	Countries	Age band	Sample size	Aspects of attitudes	Methodology	Variables
				Preferences for science work	Drawings with speech bubbles	Overall sample
				Activity preferences – boys and girls	Make a chart	
Barman et al. (1997)	USA	10–11	117	Perceptions: Scientists and in-school science	Drawings with explanations	Overall sample
				Using science out of school	Open questions	
Lynn Newton and Douglas Newton (1998)	England	4–12	1,000	Perceptions of scientists and science	Chamber's Draw-A-Scientist Test	Age, gender
Woodward and Woodward (1998b)	Wales	10–11	120 in 1991, 1993 & 1995	Subject preferences and prospective preferences. Subjects in which high	Select one subject Likert scale	Overall sample Gender
Thomas Andre et al. (1999)	USA	5–12	337	Self-competence Subject liking Gender and jobs	Likert scales	Age, gender
John Johnston et al. (1999)	Northern Ireland	10–11	1571	Learning disposition Enjoyment of science, parental influence, perceived difficulty, science as a boys' subject	Classroom observations	Gender
				Self-esteem and locus of control orientation Experiences of learning science and gender	5-point scale Open-ended statements 4-point Likert scale "yes" or "no" focus groups	School sector School size Class size
Andrew Pollard and Patricia Triggs (2000)	UK	5–11	54 in each year group	Attitudes to the curriculum	Most-liked and least-liked subjects	Age, gender Overall sample

Elizabeth Jurd (2001)	England	9–11	535	Activities, econdary school, Science at home, Usefulness	Likert scales Focus-group Interviews	Gender Overall sample
Tony Pell and Tina Jarvis (2001)	England	5–11	978	Independent investigator, Difficult subject, Enthusiasm, Social context	Likert scale	Age, gender Overall sample
Murphy and Beggs (2002)	Northern Ireland	8–11	979	Topics. Enjoyment, Importance, Perceived ability Enjoy/do not enjoy Hard and easy science	Semantic differential Likert scale Open questions	Age, gender
Christine Chin and G Kayalvizhi (2005)	Singapore	10–11	39	How I feel about doing investigations Investigation reflections	Likert scale Open questions Planning sheets	Overall sample Ability, gender

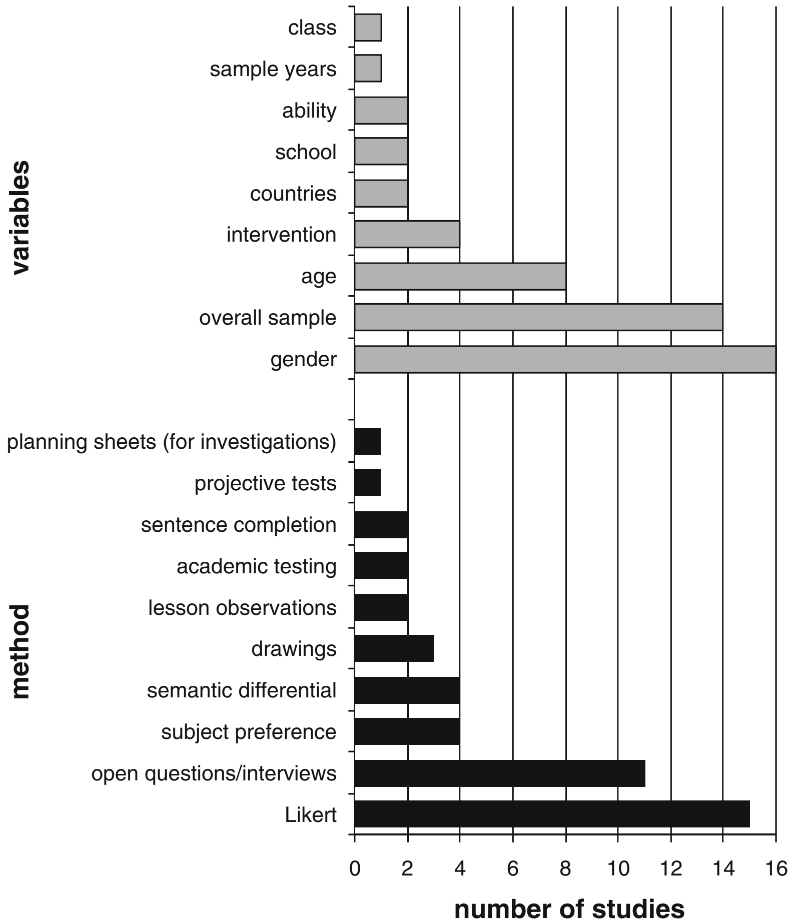

Fig. 42.2 Bar graphs to show the methods used in well-cited primary science studies and the variables considered

in unexpected ways when they are given the opportunity to talk about any aspect of science using a variety of methods (drawing, writing or talking). For example, children may dislike activities that adults assume they would enjoy, such as painting and playing with sand and water.

Only two primary studies compared children according to their academic ability (Fig. 42.2). Most studies which consider children's ability tend to incorporate secondary/university level pupils. This is perhaps due to the fact that students' performance at secondary/university levels is measured and can have an impact on their later lives/career decisions and motivation to achieve (Fig. 42.1).

With regard to variables, the majority of studies report their findings in relation to gender, overall sample, and age (Table 42.2). Traditionally, there has been an emphasis on the impact of gender on children's attitudes toward science. Perhaps the main reason for an emphasis on gender lies in the well-documented finding that "sex is probably the most significant variable related to attitudes to science" (Gardner 1975, p. 32). This view was generally supported by Milton Ormerod and Derek Duckworth (1975) and in Renato Schibeci's (1984) extensive review of literature. In their meta-analyses of literature, Becker (1989) and Molly Weinburgh (1995) also concurred with the view that gender has a large effect on attitudes to science in comparison with other variables. Nevertheless, Schibeci (1984) highlighted other primary level studies in which little or no gender effect was recorded: for example, studies conducted by Ayers and Price (1975) and Mohamed Selim and Robert Shrigley (1983). Haladyna and Shaughnessy (1982) carried out a large meta-analytic study of quantitative instruments and concluded that the difference between boys and girls was consistently small and varied between studies and grade levels. Gardner (1975, p. 29) argued that "teacher and pupil variables may exert more powerful effects upon attitudes than curricula and instructional materials." Although these studies are dated, the traditional emphasis on gender has continued in more recent attitudinal studies. Twelve of the 22 primary studies outlined in Table 42.2 have been conducted on or after the year 2000. Of these 12 studies, 10 have considered the impact of gender on children's attitudes toward science. All of the studies which considered gender reported that there were gender effects and in the majority of studies these effects were significant (e.g., Dawson 2000; Murphy and Beggs 2001). An earlier emphasis on gender as a significant variable (Gardner 1975) coupled with significant results since, has also contributed to the consideration of gender in attitudinal studies.

The final column in Table 42.2 demonstrates that in many primary studies there are only a few variables reported. It is also clear from Table 42.2 that the number and age of participants vary greatly. Not only has there been a well-documented focus on secondary school attitudes to science but many of the primary school studies that have been carried out (17 out of 22) focus on children in upper primary school. In Fig. 42.3, we have graphically represented the studies outlined in Table 42.2 in terms of the age and number of students. For example, only one study included children in every year of primary school with a sample size greater than 1,000 (Fig. 42.3).

The importance of a large sample size when carrying out a quantitative study cannot be underestimated. Many research texts suggest appropriate sample sizes for quantitative/questionnaire-based studies. Louis Cohen et al. (2000) suggested that research involving questionnaires should have no fewer than 100 cases in each major subgroup and 20–50 in each minor subgroup. Although not all of the primary studies shown in Fig. 42.3 were quantitative, it is interesting to note that 12 out of 22 studies had more than 500 participants. The largest and most extensive studies on specific aspects of children's attitudes to school science were carried out by Murphy and Beggs (2003, 2004) and Pell and Jarvis (2001). Of these, Pell and Jarvis (2001, p. 859) also advocated the importance of including younger children's attitudes as they found that "quite young pupils can provide worthwhile indicators of how they view science." As a result of including young children in every age group, as opposed to selected age groups, Pell and Jarvis (2001) graphically presented a year-on-year deterioration.

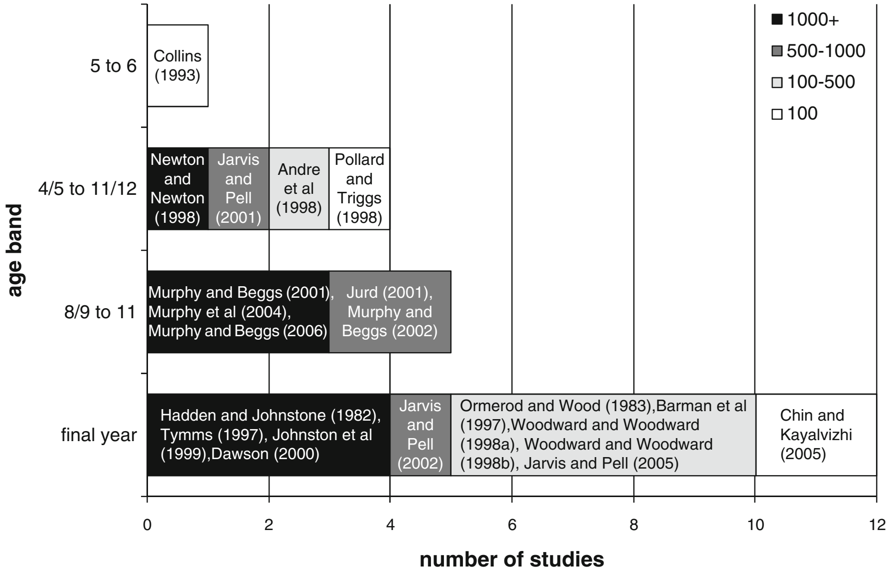

Fig. 42.3 A bar graph showing the number and age of participants involved in primary science attitude studies. The reference for each study has also been included

As well as a deterioration with age, Pell and Jarvis (2001, p. 860) pointed out that their other findings (e.g., in relation to gender) were in line with those of other studies, suggesting that "the instrument has value over a wide population."

Suggestions made by reviewers for improving attitudinal work offer an efficient summary of the issues raised with regard to measuring attitudes. Some of the main suggestions for conducting reliable and valid studies have been outlined succinctly by Ramsden (1998). A recent review of science attitude instruments with a focus on validity has been published by Blalock et al. (2008) who used a process of database searching and reference identification of peer-reviewed articles. Although Blalock et al. (2008) acknowledge that they only considered published, psychometric data they do outline tangible and important suggestions for conducting reliable studies. Their suggestions are based on the premise that it is better to refine, improve upon, and reuse the most promising instruments that are already in existence and carry out additional procedures (Blalock 2008). We have listed the suggestions outlined by Ramsden (1998) and Blalock (2008) in Table 42.3.

We would argue, however, that there could be another crucial element to attitudinal research with children which has, to date, been overlooked: the assumption of common understanding between the researcher and the researched, especially when the latter comprises children. To this end, our current work involves the establishment of children's research advisory groups (CRAGs) to inform all aspects of the research process (Murphy et al. 2010). The methodology was designed to ensure that the research process was compliant with international children's rights standards on

Table 42.3 An outline of the suggestions made in previous literature reviews to address reliability and validity in attitudinal research

Author(s)	Suggestion
Ramsden (1998)	Because issues of reliability and validity must be addressed, a range of techniques must be used. Interviews are highly desirable to validate instruments and provide the means for cross-checking with written and verbal responses. Collection should be repeated a few weeks later (because attitudes are unstable and changeable). Checks with both pupils and teachers would also aid validation.
Blalock et al. (2008)	Be more aware of the strengths and weaknesses of an instrument Reliability and validity evidence should be collected and reported. Compare with previous results to estimate generalizability Collect more data Deal with missing data and potential response bias Submit data to dimensionality analysis (e.g., explanatory and confirmatory factor analysis). As a result of such analysis, if no items or subscales form sensible structures for capturing science attitudes, that area would need to be reexamined. In agreement with Osborne et al. (2002), there must be a clear distinction between out-of-school science and in-school science because the latter is a better predictor of behavior.

children's participation (Laura Lundy 2007). The project's Children's Research Advisory Committee (CRAG) were be involved actively in the design and delivery of an online survey and in the analysis and dissemination of the results. The survey facilitated participating children not only in expressing their views but also in forming views through reading and analysis of a range of perspectives (Murphy et al. 2010).

Attitudes to Science

Ramsden (1998, p. 128) argued that attitudes cannot be "measured directly" but "inferred from words and actions," because attitudes are abstract concepts. Indeed, attitudes are not concrete, for example, because they can change or be changed. If children become involved with an activity that excites and enthuses them (such as growing their own vegetables), it may well have an impact on their attitude toward a topic (plants) on a given day or during a given lesson. However, this may be short-lived and they may feel differently if the next lesson focuses on an aspect that they do not like. Ramsden (1998) went further to suggest that any attempt at measurement must consider different aspects of attitudes and that we must look for underlying trends and patterns. However, the issues that ensue as a result of the diversity of attitudinal instruments, variables considered, and number and age of participants (Osborne et al. 2003) are intensified by confusion over the actual aspect of attitudes

- out of school science/social context
- perceived ability/difficulty

referred to in 6 studies

- topics
- perceptions of in-school science

referred to in 5 studies

- enjoyment
- activities
- experiences of learning science
- studying science later in school
- subject level preferences
- importance/usefulness

referred to in 4 studies

Fig. 42.4 The most common attitudinal aspects referred to in studies of primary science

under consideration (e.g., science content, science delivery, school science vs. societal science). Very often, the aspect under consideration is not defined or the title given to a factor is confusing. Analysis of Table 42.2 brought to light 29 named aspects that are considered within 22 primary studies. The most common aspects referred to are shown in Fig. 42.4.

The aspects are listed here using the exact wording from the primary studies mentioned in Table 42.2. The crossover between these aspects is obvious and emphasizes the need for specificity when comparing studies and their findings. For example, “enjoyment” is often referred to with respect to the “activities” children take part in and their “perceptions of in-school science” might well be what they think about the “topics” they cover in school. Perhaps the most effective way to study attitudes to science is to consider (and clearly outline) as many aspects as possible and thoroughly consider underlying patterns and trends (Ramsden 1998). The following sections will briefly outline two of the main aspects mentioned in the literature: attitudes to science topics, and interest in and enjoyment of school science. We selected these two areas because they are mentioned most frequently in the (primary science) literature and will therefore offer the greatest opportunity for other researchers to compare their own work in this area.

Children’s Attitudes to Science Topics

The majority of studies which consider primary children’s attitudes to science topics discuss their data with respect to age and gender. Andre et al. (1999) compared children’s attitudes toward science with their attitudes toward other subjects and reported that older children (9–11 year old) were significantly more positive than younger children (5–8 year old) about life science and physical science. However, many studies relating to science topics at primary level document a decline in positive attitudes toward science content (topics). With specific reference to Northern Ireland, Murphy and Beggs (2002) reported that all 16 topics in their study (a mixture of biological, chemical, and physical) were liked more by 8/9 year olds than 10/11 year olds. In fact, 10/11 year olds were significantly less positive than 8/9 year olds about 12 topics: healthy living, animals, plants, life cycles, materials, water cycle, environment, recycling, forces, energy, sound, and light (Murphy and Beggs 2002). Murphy and her colleagues also conducted comparative studies with their Northern Irish sample and children in England (Murphy and Beggs 2001) and Oman (Murphy et al. 2006). The topics under consideration were part of the primary science curriculum in all three countries. Older children in England were also significantly less positive about eight topics when compared with their 8/9-year-old counterparts (Murphy and Beggs 2001). Overall, children in England were the least positive (Murphy and Beggs 2001). However, in Oman, older children were more positive about nine topics (Murphy et al. 2006). It would, therefore, appear that the decline in positive attitudes with age toward primary science topics is more obvious in England and Northern Ireland. This trend is concerning, given that the attitudes of students in England were compared with another country in the UK (Northern Ireland) and another country outside of the UK, on another continent (Oman). Murphy and Beggs (2001) suggested that the differences between the attitudes of children in Northern Ireland and England could be attributed, at least in part, to the assessment systems. At the time, in England and Northern Ireland, children were tested during the final year of primary school. Although children were tested in science in both countries, in England the assessment was more extensive: children had to complete more lengthy tests, mostly involving factual recall, and consequently, were involved a lot more repetitive revision compared with children in Northern Ireland. In Oman, on the other hand, there were no high-stakes testing in the final year of primary school, which could be a factor contributing to the smaller decline in positive attitudes to science in primary school as children get older.

It would appear that attitudes toward science topics decline significantly with age in Northern Ireland. However, Murphy et al. (2004) found that the decline was less significant when children were involved in more experimental science. Murphy et al. (2004) compared the attitudes of children who were involved with more experimental science activities (through lessons where their teachers cotaught with science-specialist student teachers) and those who were not. Younger children who were not involved in the intervention were significantly more positive about 12 topics when compared with older children. However, younger children who were involved in the intervention were significantly more positive about just three topics (Murphy et al. 2004). This is an important finding with respect to children's attitudes to science content (topics) and how they can be affected by how science is taught. Murphy et al. (2004) also found that there were fewer gender differences between boys and girls who were involved in the intervention. They speculated that in addition to the focus on investigative science, the fact that more than 90% of the specialist-science student teachers were female could have had some effect on improving female children's attitudes to the physical science topics.

Woodward and Woodward (1998a) considered 10/11-year-old children's preferred science topics and discussed their results with respect to gender. They found that the same topics were liked the most by boys and girls (space and planets, animals and plants). Interestingly, the topics with less appeal were also the same for boys and girls (magnets, weather, and sound). However, Woodward and Woodward (1998a) found that girls showed a higher preference for some topics (keeping healthy) when compared with boys and a lower preference for other topics (electricity). Murphy and Beggs (2002) also found that girls were significantly more positive about the topic "healthy living" and boys were significantly more positive about electricity. Although boys and girls might have a stronger preference for certain science topics, the issue of whether girls or boys are more positive overall is contested. Numerous studies report that, overall, girls are more positive about science topics. For example, Murphy and Beggs (2003) and Kerr (2008) all reported that girls were more positive about science topics. On the other hand, Dawson (2000) compared the attitudes of boys and girls in 1980 and 1997 and found that the overall mean (for topics) was higher for boys than girls. However, closer inspection of Dawson's findings reveals a positive shift in the spread of girls' positive attitudes toward science topics between the two sample years. In 1997, girls liked more physical science topics than in 1980 (Dawson 2000). In 1983, Ormerod and Wood also concluded that girls liked nature study more than boys, who preferred physical science. It would appear that all studies have attempted to bring to light subtle differences in the actual topics preferred by boys and girls (keeping healthy, electricity). Therefore, in order to draw comparisons with other research relating to gender and topics, specific findings toward individual topics was discussed. There is a difference between results from more recent samples (e.g., Dawson 1997; Murphy and Beggs 2003) and results from samples in the 1980s (Dawson 1980; Ormerod and Wood 1983). Namely, a gender difference with respect to physical science is less obvious. Therefore, this emphasizes the importance of a cautious approach when discussing and comparing results from current studies with those from older studies.

Children's Interest in and Enjoyment of Primary Science

The largest and most extensive studies which included specific reference to children's attitudes to primary science (lessons) were carried out by Murphy and Beggs (2003, 2004, 2006) and Pell and Jarvis (2001). All of these studies call attention to a decline in positive attitudes with age. Pell and Jarvis (2001, p. 859) considered the "science enthusiasm" of children aged 5–11 and showed "graphically the year on year deterioration." Murphy and Beggs (2003) found strong evidence of a significant decline in enjoyment of science between children aged 8/9 and 10/11. In fact, the 8/9-year-old children were significantly more positive about four out of six items related to enjoyment of science: science lessons are fun, I look forward to science lessons, solving science problems is enjoyable, and doing experiments is fun.

It is interesting to note that significantly more 10/11-year-old students thought they do too much writing in science (Murphy and Beggs 2003).

Discussion and comparison of practical, investigative science as opposed to traditional teaching methods (e.g., writing) is often discussed in relation to children's interest in and enjoyment of science. In fact, Murphy and Beggs (2003) also asked children open questions about what they liked and did not like in science. They found that the most common response to what they liked was "experiments," regardless of age, gender, or ability, while "writing" was a typical response in relation to what children did not like. Findings related to children's positive views about practical, investigative, active learning aspects of science are reiterated in numerous other studies. In Australia, Dawson (2000) compared boys and girls activity preferences in 1980 and 1997. Dawson (2000) found that boys and girls in both samples preferred creative and especially active learning activities as opposed to copying and informing. The children in Dawson's (2000) study were children in their last year of primary school. Collins (1993) considered infant school boys' and girls' preferences for science work and obtained similar results. Collins asked 35 children aged 5/6 years old to make a chart of their preferred science work. Boys and girls drew active learning activities such as drawing in science/making models (13 boys, 16 girls), and checking up/finding out more (10 boys, 7 girls).

Several studies have considered children's interest in and enjoyment of science before and after interventions which focus on investigative, practical elements of science. Mant et al. (2007) looked at the effect of increasing conceptual challenge in primary science lessons through use of discussion, experiments, and investigations and encouraging children to think for themselves. They then conducted 16 focus group interviews in the intervention schools. In every interview, children talked about how the lessons were better. Children said this was because there were more experiments and investigations and in 11 interviews children said it was because they spent less time writing. Murphy et al. (2004) compared the attitudes of children who were involved in more practical and investigative science (though the use of coteaching) with children who were not involved in the project. They present more compelling evidence for the effect of practical and investigative work given that children's enjoyment of science was influenced in the longer term. Unlike many studies which consider the effect of an intervention, attitudinal data were not collected until 6 months after the project. Murphy et al. (2004) found that children who were involved in the project were significantly more positive in response to the items: science lessons are fun, solving science problems is enjoyable (at $p < 0.01$), and I look forward to science lessons (at $p < 0.05$). Even though children were completing their questionnaire 6 months after the intervention, many of them talked about their enjoyment of science during the project in the open-response questions (Murphy et al. 2004). The studies by Mant et al. (2007) and Murphy et al. (2004) reported a positive effect on children's learning through use of practical work. Mant et al. (2007) reported that children themselves had a clear sense of doing helping learning. Murphy et al. (2004) stated that children could remember specific aspects of their learning in the open-response section of the questionnaire (which was carried out 6 months after the project). Teachers also talked about children's learning in their research journals (Murphy et al. 2004). It would appear that the message from boys and girls of all ages is a resounding thumbs-up for practical, investigative science.

Conclusion

Apart from the fact that the majority of studies have traditionally focused on older primary children and secondary school children, many issues are brought to the fore when literature about (primary) children's attitudes is considered and debated. These include the importance of clear and succinct delineation of and reference to exactly what is being measured, how it is measured, who is involved, and to what extent reliability and validity are addressed. These issues must be addressed given the huge diversity in attitudinal studies that have already been conducted.

Kerr (2008) also pointed out that young children can voice their likes, dislikes, and concerns from a very young age, and that children often talk about science in unexpected ways. When children are given the opportunity to talk about any aspect of science using a variety of methods (drawing, writing, talking), a wealth of different viewpoints become obvious. For example, although girls appeared more positive about school in the questionnaire items – they more frequently mentioned a dislike of writing in science in their open responses when compared with their male counterparts (Kerr 2008). In other words, it is imperative that we give children the opportunity to express their perspectives of science in a variety of different ways, including those which are more amenable to them.

New directions in attitudinal studies with children are focusing on the importance of including children's input, as an expert group, at each stage of the research process. Recent work carried out by Lundy and McEvoy (2008) has demonstrated very effective methods for researching children's perspectives. They pointed out that the involvement of children was a particular strength during the analysis phase because

> …it provided a children's perspective on other children's views which at times countered an adult interpretation of the views and as such led to a more nuanced understanding of the findings. (p. 33)

The authors of this chapter worked with Lundy and McEvoy to implement such techniques into attitudinal research in primary science (Murphy et al. 2010). We end with a personal communication from Laura Lundy (2008) from work she carried out with children's research advisory groups (CRAGs) which focused on assessment in primary school. The CRAG was asked to rank different feedback comments from teachers in relation to how each reflected the level of the work. The CRAG ranked feedback such as "brilliant" and "fantastic" quite low down on their list. In the ensuing discussion, the children implied that teachers frequently used such terms on work that the children said was not their best and, sometimes, not very good. The term they ranked top was "very good"!

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