



Science Self-Efficacy in the Primary Classroom: Using Mixed Methods to Investigate Sources of Self-Efficacy

Jane Webb-Williams¹ 

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Abstract Self-efficacy has been shown to influence student engagement, effort and performance as well as course selection and future career choice. Extending our knowledge regarding the development of self-efficacy has important implications for educators and for those concerned about the international uptake of science careers. Previous research has identified four sources that may contribute towards self-efficacy: mastery experiences, vicarious experiences, verbal persuasion and physiological/affective states. Very little research has been conducted within the school environment that looks at the formation of these sources and yet early school experiences have been posited to be a key factor in girls' lack of engagement in post compulsory science education. This paper investigates children's self-efficacy beliefs in science and reports on findings from mixed method research conducted with 182 children aged between 10 and 12 years. Classroom data were collected through focus groups, individual interviews and surveys. Findings revealed that although girls and boys held similar levels of academic performance in science, many girls underestimated their capability. The four sources of self-efficacy identified by Bandura (1997) plus self-regulation as an additional source, were evident in the children's descriptions, with boys being more influenced by mastery experience and girls by a combination of vicarious experience and physiological/affective states. Girl's appraisal of information appeared to operate through a heuristic process whereby girls disregarded salient information such as teacher feedback in favour of reliance on social comparison. Contextual factors were identified. Implications for science teachers are discussed.

Keywords Self-efficacy · Sources of self-efficacy · Science · Primary school · Social comparison

✉ Jane Webb-Williams
jane.webb-williams@unisa.edu.au

¹ Division of Education, Arts and Social Sciences, G1-38 School of Education, University of South Australia, Magill Campus, GPO Box 2471, Adelaide, SA 5001, Australia

Introduction

This paper investigates school students' self-efficacy beliefs and the sources of these beliefs with the aim of providing insights into student engagement in school science. Previous research has shown self-efficacy to be strongly related to academic achievement, course selection and career choice (Bandura 1997). It stands to reason, therefore, that if we can understand what influences the development of self-efficacy, then we can utilise this knowledge to promote and encourage engagement and participation in science. This would be of particular value to those working with girls who fail to continue with science beyond compulsory education despite high academic achievement in science.

Girls' high educational achievement is seen internationally across a range of subjects and is better than boys' in 70% of the countries participating in the OECD Programme for International Student Assessment (PISA) (Stoet and Geary 2015). The PISA measures achievement in mathematics, reading and scientific literacy in 15-year-olds around the world and has become the international yardstick for evaluating educational success. In the UK, the release of PISA data and annual examination results are often accompanied with intense media coverage, which highlights the disparities that exist between boys and girls and creates a 'moral panic' over the gender divide (Smith 2003; Wilkins 2012). The focus tends to shine on the apparent failure of the education system to adequately educate boys (Epstein et al., 1998; Francis and Skelton 2005), overshadowing the achievements made by girls (Francis 2000). Arguments often centre on the dominance of females within the workforce, and schools are criticised for their feminine culture which fosters beliefs, norms and values that override the concept of masculinity to the detriment of boys' academic attainment (Carrington and McPhee 2008; Francis and Skelton 2005). Countering this, the discourse has turned to girls' success as being symbolic of equality and progress (Ringrose 2007). This success, however, is not seen when one looks beyond the narrow focus of academic attainment and examines the gender disparities that exist in the sciences.

In school science, girls tend to have lower participation rates than boys (Gorard and See 2009), avoid further study and careers in science (Sahin et al., 2015; Hill et al., 2010; Nimmesgern 2016) and hold more negative attitudes to science than boys (Sjöberg and Schreiner 2010). That said, the pattern is not consistent across the different areas of science. In the UK, although post compulsory education sees girls tending to study biological sciences more than boys (Ofsted 2015), there is a particular concern about the under-representation of girls studying physics beyond the age of 16 years as "on average, only 20% of physics A-level students are female and this number has not changed for the past 30 years." (Institute of Physics 2016 p. 8). Indeed, despite similar or better school performance by girls, some science subjects are male dominated and seen as 'boy subjects' (Blickenstaff 2005; Ong et al. 2011; Hill et al. 2010). Thus, the reasons for the lack of girls in science are not due to lack of academic ability but socio-cultural factors (Hill et al. 2010) including parental expectations (Weinburgh 1995) and socio-economic status (Perry et al. 2012). Moreover, although a large body of work has found sex to be a significant variable related to attitudes to science, it is not the only factor (Tytler and Osborne 2012). Blickenstaff (2005) found nine explanations within the literature, including girls' poor attitude towards science, the absence of female scientists/engineers as role models, irrelevance of science curricula to girls, the pedagogy of science classes favouring male students and cultural pressure on girls to conform to traditional gender roles. Many of these ideas overlap and interact and finding a single cause is unlikely (Blickenstaff 2005). Educational experiences prior to late adolescence have been posited to hold the key to further understanding (Perry et al. 2012). The hypothesis in this line of research

is that classroom experiences may influence stereotypes and sex roles, which in turn influence attitudes and beliefs, leading to girls' avoidance of science.

In the UK, there is a concern regarding the lack of high-quality science education (RSC 2016). In general, two models of science teaching operate in primary schools in the UK (Wellcome Trust 2013). The 'class model' is where class teachers teach science, and the 'science teacher model' is where specialist science teachers teach science. The former is by far the most prevalent in the UK with 95% of schools using this model as opposed to 5% employing the latter model. The concern is that class teachers lack the specialist knowledge and confidence to teach science, which can make a significant difference to young student's attainment, engagement and beliefs in science. Beliefs about one's own capability to complete tasks and achieve goals (self-efficacy) could hold important information about student engagement in, or avoidance of, science. As DeWitt and Archer (2015) conclude, "it would seem key to target factors that influence students' ability to imagine a future for themselves in science, and begin to do so early" (p.2187). It is hoped that furthering our understanding of self-efficacy formation may provide crucial information that will enable teachers to tailor their support and instruction to enhance student's future take-up of science.

Self-Efficacy

Two decades of research has suggested that self-assessments of capability (self-efficacy) help to determine our thoughts, feelings, motivations and behaviours (Bandura 1997). Self-efficacy is, therefore, instrumental to the goals we pursue and the choices we make. Educational studies have demonstrated that self-efficacy beliefs are highly correlated with academic achievement through their influence on persistence, effort, motivation and choice (Pajares and Schunk 2001; Mackay and Parkinson 2010; Schunk 1981). This means that if you believe you have the capabilities to succeed in a task or successfully achieve a goal then you will be more likely to try harder and less likely to give up, which ultimately leads to increased performance and achievement. The important aspect of this theory is that it is about ones' perceptions of one's own capability and not about actual capability. Bandura (1997) suggests that there is an important difference between having the necessary metacognitive skills and using them effectively. Students must have "both the 'will' and the 'skill' to be successful in classrooms" (Pintrich and De Groot 1990 p. 38).

Within educational research, studies of self-efficacy have been conducted across many domains, including science, mathematics, reading and writing (Butz and Usher 2015; Joët et al. 2011; Britner and Pajares 2006; Schunk 2003). However, over the last two decades, there has been scarce research in the UK educational context and limited research with younger students (Usher and Pajares 2008). The majority of studies conducted in USA with high school or college students.

Of relevance to the current paper are studies that have explored the issue of choice in activities, careers and further education (Lent and Hackett 1987; Abele and Spurk 2009; Fenning and May 2013). Much research has shown that expectations for success and the value that is attached to success have powerful influence on motivation and choice (Wigfield and Eccles 2000). Self-efficacy is an expectancy belief because it is measured before the task is performed and is conceptually similar to 'expectancies for success' within expectancy-value theory (Wigfield et al. 2015). Thus, students make decisions according to their self-efficacy beliefs and choose educational pathways and careers in areas in which they deem themselves to have the capacity to succeed. Students who exhibit low self-efficacy beliefs for science would therefore be less likely to choose careers within science. Indeed, girls are less likely to aspire to science careers than boys (Archer et al. 2013), and PISA 2012 results show gender gaps in drive, motivation and self-

beliefs, with girls reporting lower self-belief in their abilities (OECD 2014). This highlights the importance of developing a good sense of self-efficacy. Whilst external environmental and societal influences on self-efficacy (such as parents and family) have been extensively studied, and school experiences have been suggested to be a key factor in the development of beliefs, limited research has yet to be conducted within the school environment that looks at the sources of self-efficacy.

Sources of Self-Efficacy

Bandura (1997) identified four sources that contribute towards the formation of self-efficacy: mastery experiences, vicarious experiences, verbal persuasion and physiological/affective states. Mastery experience refers to an individual's past performance and for Bandura (1997), this is the most influential source. Past performances are interpreted as successes or failures, and these perceptions then influence future performance on similar activities. Thus, success in the past leads to success in the future. Vicarious experience is an indirect information source regarding the skills, strategies, behaviours and beliefs of others, as opposed to direct experience where information is obtained through one's own mastery of a particular task, skill or domain. Vicarious experience, therefore, provides opportunities to alter self-perceptions through observing, assessing, comparing and modelling other people (Bandura 1997; Usher and Pajares 2008). Verbal persuasion can help or hinder the development of self-efficacy, although Bandura (1997) argues that this form of influence is weaker than mastery experience and vicarious experience. Individuals often depend on other people, such as their family and friends, to provide evaluative verbal feedback and appraisals about their performance. The final self-efficacy source suggested by Bandura (1997) is concerned with the way individuals interpret their self-efficacy beliefs on the basis of their physiological and affective states such as stress, anxiety, fatigue and mood.

Little is known about how the information from these sources contribute towards the formation of self-efficacy, but it is agreed that cognitive processing of the sources is needed for changes in self-efficacy to occur (Bandura 1997; Chen and Usher 2013). Klassen and Usher (2010) posit that the appraisal of source information involves “an interpretative process in which an individual sifts through a multitude of often-contradictory stimuli and selectively chooses and weighs selected factors” (p. 3). These processes are thought to involve rules concerning availability of information, relative weighting, interaction of sources and strength of sources (Bandura 1997). Although the research is limited, a small number of studies have focused on these ‘rules’ or ‘heuristics’, that is, short cut rule-of-thumb strategies used to make decisions in an effort to minimise cognitive processing of excessive amounts of information. For example, Hepler and Feltz (2012) link self-efficacy and heuristics in sport and in mathematics, and Bernacki et al. (2015) found that appraisal of self-efficacy for 9th grade students in the USA employed “different heuristics based on the utility of information about their performance” (p. 114). Usher and Pajares (2008) suggest that “qualitative studies could help in this important line of research because they have the potential to describe the heuristic techniques students use” (p. 784).

Bandura (1997) theorised that the most influential source of self-efficacy was mastery experience. Although much research is consistent with this proposition, some research has provided evidence of the power of the other sources. For example, Phan and Locke (2016) found that social persuasion was the most influential source in their study of Vietnamese EFL university teachers. Furthermore, some researchers have found evidence to suggest that additional sources

of self-efficacy may exist in addition to those proposed by Bandura (Palmer; 2006; Usher 2009; Butz and Usher 2015). One reason for these different findings could be the influence of contextual and cultural factors on self-efficacy. In a recent study, Ahn et al. (2016) found differences in the sources of self-efficacy for adolescents from Korea, USA and the Philippines. Investigating the self-efficacy beliefs of 16–18-year-olds studying chemistry, Cheung (2015, p. 114) stated that “research is particularly needed to examine the differential effects of various sources because they may operate differently in different contexts and result in different effects”. Thus, despite the plethora of self-efficacy studies, limited research has focused on how self-efficacy develops in context. Recent studies (e.g. Chen and Usher 2013; Butz and Usher 2015; Phan and Ngu 2016) are a step in right direction, but further research is needed. Current calls within the field are focused on better understanding of the sources of self-efficacy.

Gender Differences in Self-Efficacy

Gender differences in the sources of self-efficacy have been investigated, and results tend to vary by the domain of the study (Butz and Usher 2015). In science, Britner and Pajares (2006) found that middle school American girls (grades 5 to 8) held stronger self-efficacy beliefs than boys. In the domain of maths, Joët et al. (2011) reported that boys in France had more mastery experiences, received more positive social messages and felt less anxious than girls. The opposite trend was found for writing, with girls having higher levels of mastery experience and lower levels of anxiety (Pajares et al. 2007). Furthermore, some studies have found that girls use higher levels of vicarious experience and social persuasion than boys, and utilise more self-regulatory strategies in maths (Cleary and Chen 2009). Research, therefore, provides strong evidence that gender differences exist in the formation of self-efficacy, yet patterns are inconsistent.

In the classroom environment, one cannot discount the potential impact of teaching practices on gendered differences in self-efficacy, yet studies examining this link are rare. Research suggests that teachers give more attention and more assessment feedback to boys than to girls (Eccles and Blumenfeld 1985; Wilkinson and Marrett 1985; Sadker and Sadker 1994), and that feedback comments tend to focus on ideas and understanding for boys and presentation for girls (Spear 1987; Eccles and Blumenfeld 1985; Sadker and Sadker 1994). Boys tend to dominate classroom discussion (Sadker and Zittleman 2009) and, despite girls have been found to exhibit superior performance, the gender discourse within the classroom reinforces the ‘boys are better’ stereotype (Reay 2001). Moreover, there are concerns that approaches to boys’ ‘laddish’ behaviour (Jackson, 2002) can affect pupil achievement (Jackson, 2010). Gender disparity is also apparent in classroom collaboration practices, and this line of research suggests that group work may be more beneficial for boys than girls (Coates 2004), depending on class size and the gender composition of the group (Crawford and MacLeod 1990; Webb 1984; Hunter et al. 2005). In view of this research, one may propose that differential treatment of boys and girls within the classroom may influence the development of self-efficacy. However, the nature and potential extent of this influence is yet to be fully assessed.

Measurement of Self-Efficacy

The measurement of self-efficacy continues to be an issue in the field. A decade ago, self-efficacy researchers warned of the ‘plague’ of mismeasurement (Pajares 1997) and contended that

educational research had overlooked the issues of specificity, correspondence and wording, resulting in the use of invalid atheoretical measures. Determination of the optimal level of specificity for the self-efficacy measure is vital in order to capture the fact that self-efficacy is domain and task-specific, context-dependent and is measured before the task is performed (Zimmerman 1995; Usher and Pajares 2008). Self-efficacy beliefs are therefore an indication of one's expectations of performance and measures need to be worded in terms of what an individual 'can do'. Measures also need to be tailored to the domain and be specific to the task or goal being assessed. Bandura (2006) created a set of guidelines for the construction of self-efficacy scales in which details, such as context validity and response scale, are provided. Nevertheless, "measurement problems continue to pose the single greatest threat to growth in the influence of self-efficacy research in educational settings" (Klassen and Usher 2010, p. 29).

Quantitative and Qualitative Approaches

Self-efficacy researchers tend to make use of Likert scale self-report questionnaires to measure self-efficacy beliefs. Participants respond to each item according to a rating scale. Individuals rate their responses to questions such as "How well can you... learn science?" with descriptors at different points, for example, 1 (not well at all), 3 (not too well), 5 (pretty well) and 7 (very well). In this way, the level, strength and generality of self-efficacy can be ascertained. Self-efficacy level refers to the different levels of tasks, strength to the degree of certainty to perform a task and generality refers to transfer of self-efficacy across activities. Rating scales have many advantages; they can be group-administered enabling researchers to access a large sample; they also allow participants the opportunity of a differentiated response. Cohen, Manion and Morrison (2011, p. 253) maintain that rating scales "afford the researcher the freedom to fuse measurement with opinion, quantity and quality". That said, rating scales also have clear limitations. They usually rely on recall from memory of past tasks and are subjective in that the value one person assigns to a particular point on the scale may differ from another's person interpretation of the same point. There is also a tendency to avoid the scale extremes (thus, effectively shrinking the scale), and participants may not respond honestly.

Despite the limitations, the majority of self-efficacy research has employed self-reports in large-scale data collection studies (Tschannen-Moran and Woolfolk Hoy 2001; Klassen and Usher 2010). Klassen and Usher (2010) identified that over 90% of research conducted between 2000 and 2009 was quantitative. Researchers have primarily used quantitative measures to investigate the sources of self-efficacy, with most studies being conducted in the USA within the field of mathematics (Usher and Pajares 2009). Rarely have qualitative approaches been employed in self-efficacy research. However, the problem is that reliance on quantitative approaches restricts our understanding of self-efficacy. Scales provide a numerical level of student's self-efficacy, but they provide no understanding of the meaning of self-efficacy for the individual child, no understanding about the contextual influences, no understanding about the perceived source or interpretation of that source and no understanding about where students need help by teachers. As Usher and Pajares (2009, p. 100) suggest, "a qualitative lens might permit researchers to illuminate the blind spots inherent in solely quantitative approaches". They are amongst a growing number of researchers (Zeldin and Pajares 2000; Usher 2009; Klassen and Usher 2010; Chen and Usher 2013) who proclaim the benefits of qualitative and mixed methods self-efficacy research.

More recent self-efficacy research has started to include qualitative approaches, yet there remains a gap in the field. Butz and Usher (2015) examined the sources of student's self-efficacy in maths

and reading using a free text written response format, in which students described what makes them ‘more confident’. As the authors suggest, the word ‘more’ may have elicited false positive responses and they warn other researchers to be cautious of the wording utilised. Thinking about what makes you more confident is fundamentally different from thinking about what makes you confident at your currently perceived level. Moreover, although the free text response method used in Butz and Usher’s (2015) study covered a large sample size (2511), those students with low literacy levels or young or reluctant writers, may have been disadvantaged. Usher (2009, p. 278) contends that “an interview approach offers a phenomenological lens through which the development of efficacy beliefs can be viewed and enables researchers to examine the different conditions under which students process and appraise their experiences at particular junctures in their schooling”. The trade off with such an approach is the smaller sample size and the lower generalisability of findings.

Aims of the Study

Given the research discussed above, the current study aimed to:

- (1) ascertain the science self-efficacy beliefs and academic performance of students aged 10–12 years using conventional quantitative self-report and attainment measures,
- (2) explore qualitatively, through individual and focus group interviews, the sources of student’s self-efficacy beliefs
- (3) determine if there are gender differences in relation to the first two aims.

This study, therefore, builds on previous research, such as that of Britner and Pajares (2006), who investigated science self-efficacy beliefs of middle school students in the USA, and extends this research to a UK context. Moreover, by employing qualitative methods previously not used in self-efficacy research, the current study aims to provide rich descriptions of school student’s thoughts and feelings about their own science self-efficacy beliefs, thereby furthering our understanding of the different sources of self-efficacy, their interpretation and relative importance.

Methodology

Design

Qualitative and quantitative data were collected together in a parallel mixed model design (Creswell and Plano Clark 2011). The main aim of this approach was to gather quantitative measures of self-efficacy together with qualitative data of student’s understandings and explanations of the formation of those self-beliefs.

Participants

One hundred eighty-two students aged between 10 and 12 years (mean age 11.4 years; 84 girls, 98 boys) participated in the study. Students attended two large public junior schools in the UK educating students aged between 7 and 12 years. Fifty-seven students attended school A (roll size 304), and 125 students attended school B (roll size 537). No relationship existed between the researcher and the participating schools. Class teachers taught science in both schools with

support by specialist science leaders who had a specific science degree. In school B, class teachers had also undertaken science-specific professional development within the past 2 years. Schools were matched on academic results, location and religious denomination. In addition, data published by the Office for Standards in Education, Children's Services and Skills (Ofsted) was used to match schools according to the proportion of students identified as having special educational needs and the proportion of students entitled to free school meals. The latter was used as a proxy for socio-economic status (Gorard 2012). All students completed a science performance test and three self-efficacy scales (described below). Stratified random sampling was used to select students for interview according to gender (boys, girls), science performance (high, medium, low) and self-efficacy level (high, medium, low). Qualitative data were collected 1 to 2 weeks after the science test and self-efficacy scales by way of focus groups, conducted with 36 pupils split into groups of 6 students (3 boys, 3 girls) and individual interviews with 16 pupils (8 boys, 8 girls). The researcher conducted all interviews and administered all tests. The study was conducted in compliance with the British Educational Research Associations Ethical Guidelines and appropriate ethical approvals and consents were obtained.

Academic Performance

A performance test in science was administered to all students. This test was developed using test items from past standardised National Curriculum tests in science (Key Stage 2, levels 3 to 5, Science SATs A and B) developed in England by the Department for Education and Employment (DfEE) and the Qualifications Curriculum Authority (QCA). In the past, it was mandatory for all 10 to 11-year-old students in year 6 in England to sit National Curriculum Tests in science. Since 2009, only students who are randomly selected are legally obliged to complete the tests, yet many schools continue to administer them to assess science performance. In their original format, the tests require 45 min for completion. A shortened version was developed for use in this study to reduce completion time to 20 min. Items were selected to ensure a balance of question difficulty, and all sections of the National Curriculum programme of study were represented in the shortened science test. Topics included materials and their properties (reversible and irreversible changes, separating mixtures of materials), physical processes (earth, sun and moon, electricity), life processes and living things (green plants, keeping healthy) and scientific enquiry: investigate skills (considering evidence, planning).

Self-Efficacy Questionnaires

Science self-efficacy was measured via a questionnaire designed in accordance with Bandura's (2006) *Guide for constructing self-efficacy scales*. Three scales were constructed using a 7-point Likert response scale combined with verbal descriptors. In accordance with Bandura's recommendations, all questions were phrased in terms of *can* (e.g. "How well can you ...") except for the general science attainment measure which was, in addition, phrased in terms of confidence (e.g. "How confident are you that you can ..."). Table 1 provides an example of the response format. This response scale was chosen because it has been used in much of the past self-efficacy research, in particular the study by Britner and Pajares (2006) on sources of science self-efficacy to which this paper relates.

Self-Efficacy for General Science Attainment This general attainment scale was based on the National Curriculum Levels in science, e.g. "How confident are you that you can get a

Table 1 Example of response scale

How well can you answer questions about green plants?

1	2	3	4	5	6	7
Not well at all		Not too well		Pretty well		Very well

level 5 in science?” National Curriculum levels are a UK Government grading system consisting of eight bands used to measure a child’s progress against other pupils of the same age, across the country. National Curriculum attainment levels are awarded to each child on the basis of their National Curriculum Tests.

Domain-Specific Self-Efficacy for Science This scale measured self-efficacy for a number of core topics in the science curriculum, e.g. “How well can you answer questions about keeping healthy?”

Task-Specific Self-Efficacy for Science This scale included items specific to scientific enquiry, e.g. “How well can you write a conclusion for an investigation?” Task information presented as a stimulus to this scale was taken from a National Curriculum Test relevant to the scientific enquiry programme of study and involved students measuring shadows at different times of the day in the playground and recording the length of the shadow in a table.

Piloting

Pilot testing of the scales and the science performance measure was conducted with 52 students aged 10 and 11 years (24 girls, 28 boys) who were not involved in the main study. The science test was highly reliable with Cronbach’s alpha coefficient of 0.78 and correlated well with prediction by teachers of their student’s test scores $r = 0.76$ ($P < 0.01$). High reliabilities for each of the domains within the science test were obtained: materials and their properties (0.69), physical processes (0.68), life processes and living things (0.89) and scientific enquiry (0.75). All self-efficacy scales were highly reliable with coefficients over 0.81. Minor modifications were made to the administration procedure as a result of the pilot study.

Interviews and Focus Group Discussions

All focus group discussions and interviews were conducted by the researcher on school premises during school hours. Interviews lasted no longer than 20 min, and all responses were audio taped. Interviews and focus group discussions were semi-structured and were guided by the student’s responses. This ensured that students could freely explore, discuss and describe issues, observations and self-reflections as they desired. All interviews included some ‘get to know you’ questions in order to build rapport between the researcher and participants. Students were reminded of the confidential nature of the interviews so that they could speak freely without the worry that teachers would reprimand them or contradict them. This was important because the interviews were conducted on school grounds and thus students may

have assumed researcher/teacher collaboration. The questions below give an indication of the questions asked:

- What do you think about doing science at school?
- How confident are you at science?
- What makes you feel this confident?
- Describe a normal science lesson.
- What things influence the way you think about yourself in science lessons?
- What things influence the way you think about your school work and confidence in science lessons?
- Looking at the questionnaire you completed, why did you mark yourself at this point?
- Thinking about the science test you just did, what do you predict your score to be?

Students were asked about their confidence level in science at the beginning of the interview/focus group discussions to afford them time to focus on the construct prior to reflecting on any influential factors. Following the recommendations of Bandura (2006), the everyday term *confidence* was used as a proxy for the term *self-efficacy*, which was likely to be unfamiliar to students.

Science Test and Self-Efficacy Measurement Procedure

The self-efficacy questionnaires and science test were administered in the classroom during a scheduled 60-min science session. To familiarise students with the Likert rating scale, the researcher presented practice items on a white board and students were encouraged to ask questions to clarify anything they did not understand. The students were informed that the questionnaires were not a test and that there were no right or wrong answers. There were no time limits for answering the self-efficacy items. Next, the students read the scientific experiment task information and, at their own pace, completed the task-specific self-efficacy questions. Finally, all students completed a science test (time limit of 20 min).

Analytical Approach

The study involved quantitative analysis of the science test and self-efficacy scales and qualitative analysis of the interviews and focus group discussions. The science test was marked according to the relevant marking scheme. On the rare occasion where an answer was ambiguous, a second marker (a teacher) independently assessed the entire test paper. Any remaining discrepancies were discussed and jointly agreed. Scores for the self-efficacy measures were taken directly from the pupil questionnaires and entered into SPSS.

Transcriptions of audio tapes and field notes were analysed using Atlas.ti software to identify themes and look for patterns (Miles and Huberman 1994). Coding for sources of self-efficacy was guided by both deductive and inductive reasoning with social cognitive theory (Bandura 1986) providing guidance. Contextual factors emerged from the data. To generate an initial draft of the coding scheme, an independent coder blind examined the responses of a small random sample of data and proposed themes and codes. The two coders (one was the researcher) then agreed and modified codes. The coding scheme was used to independently code a small number of interviews. Interrater reliability achieved 93%. The final coding scheme was then used to code the remaining transcripts. Student's narratives and responses were combined with frequency counts of main themes to retain the rich description of the student's experiences.

Findings

Considering the quantitative findings first, all three self-efficacy scales showed good internal reliabilities, as indicated in Table 2.

The analysis of the mean scores showed that girls had lower self-efficacy beliefs than boys on all three scales (see Table 3); however, this was not statistically significant.

The analysis of the scores on the science performance test showed that the mean score was 12.99 (standard deviation 3.96). The mean score for girls was 12.81, and boys scored 13.14. The analysis by gender showed no significant difference between girls and boys. The linear relationship between science performance and self-efficacy allowed for Pearson product moment correlations to be calculated. All three self-efficacy scales were positively correlated with performance on the science test (see Table 4). High performance was associated with high self-efficacy and low performance associated with low self-efficacy. The self-efficacy measures were positively correlated with performance and reached statistical significance at the 0.01 level. The correlations for the boys are considered strong (0.54 to 0.63), and the girls are considered modest (0.44 to 0.54).

Table 5 provides an overview of the themes that emerged from the qualitative analysis of the sources of self-efficacy. The table provides analysis of the frequency of occurrence by source by gender. For example, for the themes coded as mastery, 39% of those were from girls and 61% were from boys. A ‘source profile’ for boys and girls is also provided in Table 5 which shows the proportion of all sources by gender. For example, for girls, 31% of their source information was coded as mastery, 4% as social persuasion, 41% as vicarious experience, 15% as physiological/affective states and 9% as self-regulation.

Sources of Self-Efficacy

Mastery experiences Bandura (1997) contends that mastery experience is the most powerful of all the sources of self-efficacy. In the current study, mastery experience was found to be an important source of self-efficacy but not the most influential source for all the participants. The larger number of boys’ responses coded as mastery experience than girls’ highlights the importance of personal performance accomplishments as a source of self-efficacy for boys.

I just know I will be able to do it, I can tell by looking at my work myself. Before, I used to not really know what I was doing but for the last few months I seem to have got the hang of some of the concepts better than I have in the past and I feel confident. I think to myself yes I have managed to get better at that and now I can do well in the future. (boy, 11 years, high ability)

You see I did something like this before and I can remember doing well which makes me confident that I can do well again this time. (boy, 11 years, low ability)

Table 2 Self-efficacy scale reliabilities: Cronbach’s alpha

Self-efficacy scale	<i>N</i> items	Range	Cronbach’s alpha <i>n</i> = 182
General science attainment	3	18 (min 3; max 21)	0.81
Domain specific	8	37 (19 min; 56 max)	0.88
Task-specific	8	43 (min 13; max 56)	0.83

Table 3 Mean and standard deviations: self-efficacy scores

Self-efficacy scale	Overall Mean (SD)	Boys (<i>n</i> = 98) Mean (SD)	Girls (<i>n</i> = 84) Mean (SD)	<i>p</i> value
General science attainment	15.71 (4.40)	16.70 (3.83)	15.45 (4.35)	0.059
Domain specific	39.55 (7.59)	40.12 (7.84)	39.06 (7.24)	0.122
Task-specific	39.93 (7.88)	40.74 (7.82)	39.40 (7.63)	0.084

Boys' discussion tended to feature greater reference than girls' to independence and being successful in the future without having to ask others. This was indicative of boys' preference for mastery of their own experiences rather than relying on other people or sources. For boys, experiencing success or failure themselves (as opposed to observing others) was crucial for their sense of self-efficacy. In contrast, the girls were socially focused and rarely referred to independent assessments. Asking students to describe their confidence level in science and to predict their science test performance revealed gender differences. Boys' perceptions of past performance were in line with their actual performance whereas girls tended to underestimate their performance and hold misperceptions.

I know I can't do it, it's like I know that I will do badly and I am certain, I am 100% certain I will make loads of mistakes and do a rubbish job on my work. So I don't feel confident in science because I know I will do badly. (girl, 10 years, medium ability)

Students referred to experiences in the classroom that made them feel confident in science, but these descriptions did not always involve mastery. Failures and unsuccessful best efforts influenced student's self-beliefs, and this appeared to have a greater influence on self-efficacy than success. Some students mentioned overcoming challenges and expending significant effort. As one girl put it "I had to do drastic things to learn the new stuff". These instances were significant and appeared to have a strong influence on student's self-efficacy.

Social persuasion Social persuasion provided additional self-efficacy information, but it was not a major source. Some students described events where family or friends provided encouragement with regard to their science capability. However, in some cases, students dismissed the encouragement as being overly positive and described the person delivering the feedback as being kind. This perceived false praise was ineffective and some students found it annoying.

My friends tell me that I can do well in science. (boy, age 10, medium ability)

The way I look at it is that they [friends] tell me that I am good but they are nice and I know they are just saying it. (girl, age 10, low ability)

Table 4 Relationship: self-efficacy and science performance

Self-efficacy scale	Boys (<i>n</i> = 98)	Girls (<i>n</i> = 84)
General science attainment	0.63**	0.54**
Domain specific	0.59**	0.48**
Task-specific	0.54**	0.44**

**Pearson correlation with science performance significant to the 0.01 level

Table 5 Source of self-efficacy themes and sub-themes identified from the qualitative analysis

Theme	Frequency of occurrence by source by gender		Proportion of all sources by gender		Sub-themes
	Girls (%)	Boys (%)	Girls (%)	Boys (%)	
Mastery experience	39	61	31	55	Content of own work Comparison of own past performance Learning
Social persuasion	56	44	4	4	Self-self-talk/self-modelling Social-teacher Social-family Social-friends
Vicarious experience	71	29	41	19	Social comparison Adults Classmates
Physiological/affective states	69	31	15	8	Positive Negative Mixture/balance emotions
Self-regulation	42	58	9	14	Self-talk Metacognition Independence/autonomy Time management/organisation Expectations

She [Mum] keeps telling me that I am OK at science and that it will be OK but I know it is not and that I am dumb at it ... I would prefer it if she stopped. (girl age 11, medium ability)

Teacher feedback, whether verbal, written or non-verbal, featured in all student's discussions. There were gender differences in the interpretation of feedback from science teachers and the extent to which it was used in student's judgments of their science performance. Girls appeared to be particularly sensitive to non-verbal cues such as facial expression, eye contact and hand gestures—many of which may be irrelevant to the task/activity—and use them to form judgments of their own capability and performance. Whilst gestures and body language can improve comprehension and clarify verbal ambiguity, they sometimes convey incongruent information or can be misinterpreted. In contrast, boys seemed less attentive to such cues or dismissed them in favour of verbal or written teacher feedback.

Interestingly, many girls tended to ignore written and verbal teacher feedback in favour of comparison with friends:

His [the teacher's] writing makes no sense to me, I get it more when I look at my friends. (girl, age 11, high ability)

When seeking explanations for this finding, it is important to look at the nature of science classes in the schools studied. When asked to describe their science lessons, many students discussed receiving feedback from science teachers *after* the task was completed. This ranged from 1 day to 3 weeks. The lack of timely teacher feedback meant girls felt ignored by their teachers, yet when feedback was eventually provided, they ignored it.

My teacher works with the lower groups most of the time so she doesn't really see me, if she does write stuff on my book then I probably don't read it cause I know what she is goin' say cause I know mine is the same as Emily's. (girl, age 11, high ability)

Vicarious experiences Vicarious experience was a powerful source of self-efficacy for the girls in the study, with the majority of girls' conversations featuring comparison as opposed to boys, who made no reference or only fleeting reference to others in this way. Girls' were using social comparison to judge themselves against others as a way to examine the accuracy of their self-beliefs and performance. These judgments were more frequently accompanied with feelings or emotional reaction than the boys'. The quotes below are typical of the girls' responses:

I look at my friends and mostly it is the same as hers so I feel good about that. (girl, age 10, high ability)

I am near to the top of the class and so I am very confident at science. (boy, age 10, high ability)

We sort of look at each other's or talk about it together, sort of like sharing it but not like copying. I mean we don't copy, like we wouldn't do that. But it is good to share things, it makes me feel good and like being the same. Some people really seem to get into it but like I don't really get it because we all just don't understand it that well and so it is like crazy how into it they are. It is like I know I am not the best at it or anything and actually I probably suck at it a bit but like I am the same as my friends so that is sort of makes it OK I suppose. (girl, age 11, low ability)

I don't really see the teacher, if it is the same as Sarah's I know it's OK. (girl, age 11, medium ability)

Girls particularly relied upon social comparison to judge their performance and assess the quality of their school. Boys did refer to others in the classroom such as "I sit next to a boy who is really good at science"; however, girls construed this information as indications of their own performance whilst boys made different interpretations. As one girl put it:

if I look her work and it is worse than mine then it sounds bad to say but I sort of feel better about my own work and it gives me greater confidence. (girl, age 10, high ability)

Descriptions of science lessons highlighted the abundance of social comparative information available to students within their science classes. Class discussions, observations of classmates work, discussions with classmates about grade and teacher feedback were amongst the sources mentioned. Many students also spoke of fleeting glances at other classmates' work, body language and just 'knowing'.

they [friends] tell me what scores they get and sometimes I can see a bit of their work.

You know you can get to know who is good and who is bad. I hear the teacher say well done and things to them. (girl, age 11, high ability)

Physiological/affective states In analysing student's responses, it was evident that emotion (positive and negative), stress and pressure were a source of student's self-efficacy, particularly when in tandem with other sources. Feelings of anxiety and self-doubt were evident, particularly when students compared themselves with some classmates:

It makes me feel sad that I can't be like the others. (girl, age 10, low ability)

However, positive emotions were also reported:

I love it cos everyone in the group is the same as me which makes me feel happy. (girl, age 11, medium ability)

Students experienced a range of emotions as a result of interpretation of information from the other sources of self-efficacy. For example, when discussing mastery experience, students talked of feeling happy, content, proud, embarrassed or upset about their past performances. As one girl put it “It makes me feel sad sometimes and I don't feel confident in science”. Student's conversations also referred to the stress of exams and the pressure of parents and teachers to perform well. Students described being worried about their science achievement and were fearful of failing or being awarded low marks. Excessive worrying about performance can create such a high state of arousal that the stress levels can result in poor performance (Bandura 1997).

Self-regulation Zimmerman (2002, p. 65) defines self-regulation as “the self-directive process by which learners transform their mental abilities into academic skills”. The findings of the current study suggest that self-regulation was an additional source of self-efficacy. Students mentioned how aspects of planning, checking and goal-setting increased their feelings of confidence. Some aspects of self-talk which students described appeared to be self-persuasive methods where students were explicitly providing themselves with words of encouragement. Students reported using self-talk to combat negative thoughts when tackling complex or new tasks or skills that they had previously failed to master. Students also described how they would give themselves a ‘pep talk’ to make them try harder or persist, particularly when they thought they might fail. This self-talk or self-modelling appeared to be an effective form of self-regulation and/or self-encouragement for some students. These private silent messages appeared to push students to achieve their own self-imposed goals or were used as a form of self-comfort.

I kind of tell myself - come on, you can do it don't give up. (boy, age 11, high ability)
You see I often try to tell myself that it will be OK but then sometimes it isn't and I don't really know what to do then but I suppose it feels better to do that at the time. (girl age 11, high ability)

These findings resonate with ideas of Vygotsky (1962). Who highlighted the purpose of inner speech for thought and self-direction anwith researchers who suggest a reciprocal relationship between self-regulation and self-efficacy (Bandura 1997; Zimmerman and Schunk 2008, Zimmerman and Bandura 1994). They also resonate with recent research, such as that of Tomas et al. (2016), which stresses the importance of students' regulation of their emotions in a science classroom.

Contextual Factors

Contextual factors identified in this study are briefly discussed below. These factors appeared to influence the interpretation of the sources of self-efficacy.

Teachers Students discussed interactions with teachers in terms of support and learning. Teacher attitude and behaviour featured in many conversations with some teachers perceived as ‘kind’, ‘fair’ and ‘supportive’, whilst others were characterised as ‘unfair’, ‘nasty’ and ‘useless’. Girls tended to mention this more often than boys, and some girls mentioned being ‘disliked’ by their science teacher and being treated differently to others. Teachers who explicitly used comparison such as public grading were viewed negatively. Students described how in these instances they felt silly, embarrassed or incompetent in front of their peers. Teachers perceived as well organised tended to receive positive comments from students. For some students, teachers’ expectations were unachievable whereas for others, teachers set such low expectations, such that students assumed they were ‘dumb’ and likely to fail.

Lesson organisation Lesson organisation was a key feature of nearly all student’s conversations. The group composition (peers) and method of grouping, for example, grouping by ability, was important to students. Feedback and assessment methods were also discussed, with many describing how they receive little feedback from teachers. Getting written feedback after the task is complete was considered too late for some.

Classmates/peer groups Conversations revealed that peers and peer groups played an influential role in student’s lives at school, particularly for girls who often mentioned comparison with others, including with their peer group (in-group) and with other peer groups (out-groups). Emphasis on status, hierarchy and competition was seen to varying degrees. Some girls appeared particularly keen to belong to the ‘popular group’, with a desire to be the same as the others and be accepted. Students were quick to judge their classmates, for example, as one 10-year-old girl put it, “The person I normally sit next to in science is a nerd”.

School ethos The ethos of a school is the fundamental character or spirit of the school culture which informs the beliefs, customs and practices of all those in the school community; teachers, students, parents, leadership. Ethos is not an easily articulated concept and, when describing their school, student’s conversations referred to ‘just knowing’ or ‘feeling’. As one boy put it “I know I am under pressure to get high grades, I feel it everywhere and from everyone at school”.

Outside of school External factors such as family, friends, parents and society in general did feature in some of the student’s discussions, although to a very limited extent. Given the classroom context, this is not surprising.

Discussion

Findings revealed that actual performance in science was similar for girls and boys; however, perceptions of performance differed according to gender. Despite the similar quantitative self-efficacy data for boys and girls showing similar self-efficacy beliefs and relationships with performance (Pearson correlation coefficients for the boys were 0.54 to 0.63 compared to 0.44 to 0.54 for the girls), the qualitative data revealed that girls consistently (and in some cases grossly) underestimated their science performance. The qualitative aspect of this research appears, therefore, to have captured

greater depth than the quantitative scales. These findings resonate with the PISA 2012 results (OECD 2014) and beg the question as to why girls underestimate their science ability and what the implications are for educators. The findings presented here regarding the sources of self-efficacy may help to further our understanding on such questions.

In the current study, the four sources of self-efficacy identified by Bandura (1997), together with self-regulation as a source of self-efficacy, were evident in the student's descriptions. Previous research has shown that increasing self-regulation learning skills increases academic self-efficacy and that students with high self-efficacy are more effective at planning their work, monitoring their progress and setting higher goals (Zimmerman and Bandura 1994). Science has always been a subject where students tend to work together, but in recent years, there has been a shift to increased collaborative group work and increasing amounts of peer-led small group work (Dreyfus 2002; Felder and Brent 2007). It could be that we are seeing self-regulation as a source of self-efficacy because of this shift. Indeed, group work and child-centred direction were salient features of the science classrooms involved in this study. It is possible that self-regulation may not be an influential source of self-efficacy in teacher-directed classrooms.

Analysing the relative strength of the sources of self-efficacy revealed that mastery experience was the most powerful source for boys, but not for girls. Moreover, whilst social persuasion played a minimal role as a source of self-efficacy, vicarious experience and physiological/affective states appeared to combine and act in unison as the strongest source for girls. It is posited that the sources of self-efficacy may vary for different students in different settings and that, in some domains or at certain times, sources will be stronger than others. Indeed, there was evidence to suggest that contextual factors, such as lesson organisation, teachers, classmates and school ethos, were associated with the interpretation of the sources and the power of that source to effect changes in self-efficacy beliefs.

As discussed earlier in this paper, not much is known about the appraisal of self-efficacy source information but it has been suggested that it involves rules (or heuristics) and requires cognitive processing to effect changes in self-efficacy. One heuristic technique that appeared to be operating in the current study was that of selective attention whereby only salient sources of information were processed. Girls placed great importance on interpretations according to social comparison information (to the extent that other information was discounted and ignored), in contrast to boys, who did not engage in such cognitive processing and only mentioned social comparison in a passing fashion. In addition, girls interpreted non-verbal cues as having meaning and intention whereas boys did not. This dictated how girls understood and remembered others' actions, how they responded and what they predicted about their future action (Baldwin and Baird 2001). It would appear that once the heuristic path has been created, confirmatory evidence, that is, information that confirms the short cut rule, is selected and weighted more heavily. Selective bias then occurs where students seek out only information that affirms a position that is already held. For example, some students in this study—particularly girls—ignored negative teacher feedback in favour of comparisons with peers that were interpreted positively. Relative weighting of information therefore appears to be determined according to the strength of affirmation. That said, the availability of information also played a role. Many students referred to lack of feedback from science teachers or long wait times for feedback. Feedback information was therefore unavailable when students needed it and they turned to other information sources. Comparison with classmates allowed pupils to gauge the quality of their work immediately. This immediacy was viewed as a real benefit in the fast-paced performance-driven classroom.

It appears then, that if teacher feedback is lacking, or disregarded, or accompanied with negative thoughts or doubts, then misperceptions can occur. In schools, formal assessment of performance provides students with objective information on which to base their self-perceptions. The association between self-assessment and learning and performance is robust, with self-assessment being shown to contribute to student learning (Harlen 2006; Boud 1998; Clark 2012). Thus, students need to identify the standards and criteria that apply to their work and then decide how well they have met them (Boud 1995), which requires the ability to self-reflect (Taras 2010). These findings resonate with assertions that social comparison processes are more likely to occur when it is not possible to base self-evaluations on objective non-social criteria (Festinger 1954). The processes involved in social comparison in the classroom environment are complex as students need to select the information (relating to others and themselves) on which to attend, from an array of sources, interpret the information, analyse the similarities and differences in the information from others compared to their own, draw conclusions (e.g. “overall his science work is better than mine”) and contemplate the implications (e.g. “I am hopeless at science and I need to pay more attention”). It is difficult to gauge accurately others’ achievements using limited information, yet it appears that some students were doing just that. Indeed, the girls in the current study gauged their relative standing amongst classmates on ambiguous information such as gestural cues and students’ self-proclaimed grades. Some students reported that their classmates had intentionally reported incorrect test scores, pretended to get better teacher feedback than they actually did or falsified some aspect of their performance.

Furthermore, in this study, student’s descriptions of their self-efficacy, particularly girls, involved reference to perceptions of their abilities relative to others. Whilst earlier research has identified that comparison with others is an important factor in self-concept and the big-fish-little-pond effect (Marsh 1987), most past research has not specifically linked this to self-efficacy. Self-efficacy responses do not ask individuals to use normative frames of reference as other measures do. Moreover, when making specific self-efficacy judgments, individuals are provided with the criterion on which to make assessments, which does not require a normative frame (Bandura 1986; Bong and Skaalvik 2003). It is possible that the interview method of asking students questions about their ‘confidence’ elicited responses from students that relied on a normative frame. Questions were framed in terms of confidence in science and thus provided a general science self-efficacy perspective. A more task-specific focus may have elicited different responses. Further qualitative self-efficacy research would help to elucidate in what circumstances normative frames of reference for judgments of self-efficacy are made. One possible factor involves girls’ use of interpersonal relationships to construct their identities (Gilligan 1982), which may be particularly salient to the girls in the current study who, at the age of 10–12, are commencing physical and emotional changes related to adolescence. Whatever the case, it is clear that girls’ self-efficacy judgments need closer attention.

Conclusion and Implications

Findings from the current study yielded noteworthy information about the sources of student’s self-efficacy beliefs that could have a number of implications for science teachers. Improving girls’ engagement and uptake of science hinges to some extent on

science the teacher's ability to engage, motivate and interest girls, to dispel gender stereotypes and to provide role models for girls in science. Within the classroom environment, teachers have the power to influence girl's perceptions of science. The findings from this study highlight the vital nature of students' interpretations of their own experiences which, in some instances, may be more important than the actual experiences themselves. Thus, asking students to review their own work and predict their own grades and feedback may help change girls' interpretations of their capabilities in science. Girls tended to underestimate their performance, so making contrasts between their predictions with teacher feedback could challenge these misperceptions. Moreover, the findings of the current study suggest that students—and particularly girls—interpret negatively even the smallest cue that may suggest incongruence in teacher feedback. This means that teachers need to be particularly sensitive to the unintended feedback they may be providing to girls through their gestures and body language. To debunk misperceptions, there needs to be consistent and repeated reinforcement of material or stimuli contrary to students' existing perceptions. Girls therefore need to be encouraged to critically reflect on the information they attend to. Moreover, the potentially faulty system of heuristics based on a lack of objective feedback and minimal, falsified or incorrectly interpreted social comparative information could be challenged by talking to girls and making their perceptions explicit, by challenging the foundations on which the perceptions/misperceptions lie, and by providing explicit, clear and timely feedback. In this way, teachers will be arming students with the necessary skills to make well-informed judgments of performance which should then feed into greater self-efficacy.

Previous research has shown that assessment feedback can enhance learning and student outcomes; however, despite a number of reviews, details about how this contributes to student's learning are still lacking (Hargreaves 2013). If used unwisely, feedback can reinforce the underachievement it sets out to combat. Hattie and Timperley (2007) suggest that teacher feedback can impact on the 'self' and that any consequent emotional responses can affect learning. Coupled with the findings of this study, this suggests that teachers need to reflect on their own teaching practices with regard to assessment feedback and consider their understandings of the relationship between gender and achievement. Additionally, when setting up student groupings within the classroom, think about classroom organisation, teaching style and tasks with an understanding of the impact these have on student's attitudes (Whitelaw et al. 2000). According to the participants in this study, some teachers explicitly used comparison and competition within the classroom. No doubt teachers used this powerful influence in order to encourage student achievement; however, caution needs to be exercised, as this approach can elicit feelings of anxiety and self-doubt and thus impact negatively on self-efficacy.

A strength of the mixed methods approach used in this study is the richness of the data. Capturing student's own descriptions of their self-efficacy using qualitative interviews provided insights beyond those provided by quantitative measures alone. In the current study, girls' perceptions of low capability in science were unfounded; their science performance was the same as boys. Such perceptions could be one reason why girls are not taking up science study and are underrepresented in science careers, regardless of their competence in this field. An increased understanding of the development of self-efficacy across different personal circumstances (culture, gender and socioeconomic status) and different contexts may help to counter this concerning trend.

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