

*Journal of Trainee Teacher Education Research***Seeing themselves in Science: Exploring Year 1 Pupils'
Perceptions of Scientists and Science Self-Efficacy****Hannah Asha Toseland**

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Abstract

Closing the gender and race gap in science, technology, engineering, and mathematics (STEM) fields is paramount for fostering inclusivity and equity in education. Early childhood experiences significantly shape attitudes towards STEM subjects, making it imperative to understand their formation and implications. I propose a mixed methods study to explore Year 1 pupils' perceptions of scientists and their science self-efficacy. After quantitative analysis using the Draw-A-Scientist-Checklist (DAST-C) and science self-efficacy questionnaire, six students, from diverse backgrounds, will be interviewed. This research seeks to uncover nuanced insights into the formation of STEM attitudes in young children. Additionally, I introduce a refined version of the Draw-A-Scientist Test (DAST) to explore the influence of racial identity. By shedding light on these crucial aspects, this study aims to inform educational practices and interventions that promote inclusivity, addressing STEM disparities from an early age.

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Seeing themselves in Science: Exploring Year 1 Pupils' Perceptions of Scientists and Science Self-Efficacy

Hanna Asha Toseland

Introduction

The underrepresentation of women, and specifically Black women, in science-education and related careers is irrefutable (Steele, Reisz, Williams & Kawakami, 2007). Why are there fewer women than men in STEM education and careers? How does this gender and race disparity start, and how is it perpetuated? Historically, the cause has been attributed to the inherent 'lesser' STEM aptitude of marginalised groups, such as women and Black people. Conversely, there is a large body of research that indicates the causes of this underrepresentation are social factors, namely discrimination, pervasive gender and race stereotypes, and social and economic barriers to education. This study proposes to focus on the origin of these stereotypes, with a close examination of whether these are present in the mind of young children. To examine this phenomenon, I have made adaptations to the existing DAST (Chambers, 1983) to provide greater clarity as to students' perceptions of stereotypical scientists. To the best of my knowledge, these modifications represent a novel proposition, previously unexplored in the literature.

Existing research suggests that the gender gap in science starts in early childhood, corresponding with the formation of gender and race stereotypes (Charlesworth & Banaji, 2019). Indeed, children become increasingly aware of their gender between three and five years of age. This awareness coincides with the development of gender stereotypes, which become well-established by five years old and firmly entrenched by seven (Martin & Ruble, 2004). For instance, in early primary school, girls perceive men as excelling in mathematics compared to both women and men, rather than demonstrating a preference for mathematics themselves (Steele, 2003). Consequently, school subjects are conceptualised as 'masculine' and 'feminine' from a young age, and these conceptualisations closely map onto male- and female- dominated careers in adulthood (Cheryan, Master & Meltzoff, 2015).

The issue of underrepresentation of women in science-related careers is more pronounced when examining the data of Black women in STEM. It is crucial to disaggregate the experiences of White girls and Black girls within STEM fields; otherwise, the experiences of White girls' risk being

generalized as representative of all girls, thus marginalizing, and silencing the essential experiences of Black girls. Collins, Joseph, and Ford (2020) compellingly argue that these challenges stem from the intersectional dynamics of racial and gender discrimination. Specifically, Black girls confront the compounding effects of gender and racial stereotypes, which serve as formidable barriers to their success in STEM unless actively confronted and dismantled in educational settings. Notably, disparities in positive STEM experiences emerge as early as primary school, exacerbating over time and widening the educational gap. Eccles (2007) contends that our current curriculum perpetuates gender and race stereotypes of scientists, contributing to the marginalisation of White and Black girls in STEM. Further, there are systemic issues such as a lack of practical mastery experiences (Bandura, 1977) and a lack of relatable STEM role models for girls. These factors, coupled with a culture that fosters the exclusion and attrition of systemically marginalised groups from STEM exacerbate the issue of underrepresentation (Johnson, 2020). Studies in which Black women were asked to reflect on their school science experiences highlighted that Black girls were consciously internalising the stereotype of scientists from as young as four-years old (Morton, 2022). Taken together, this research indicates that young Black girls not only feel a disconnect with scientists due to race and gender stereotypes, but that the curriculum reinforces this and encourages their attrition from science courses before they reach higher education. Collectively, this body of research underscores the importance of establishing a robust STEM identity for Black girls in school. Indeed, when individuals perceive something as 'like them' or part of their identity, they are motivated, engaged, and resilient in its pursuit (Haslam, Power & Turner, 2000).

Rationale

To close the gender and race gap in STEM, it is important to examine the perspectives of children during early childhood, the critical stage at which undermining stereotypes often emerge. The evidence suggests that gender and race gaps in STEM are not driven by ability but by socio-cultural factors (Collins, Joseph & Ford, 2020). However, researchers have reported that people who are most affected by the challenges of intersectionality are often misrepresented or even excluded from educational research on their own lived experience (Steele et al., 2007). In these instances, research can have a harmful role in deepening the systematic silencing and oppression of Black girls. It is therefore an imperative to amplify the voices of marginalised students in research so they can receive an equitable and inspiring education that not only closes the achievement gap but fosters an educational environment free from oppression for every student (Blackwell, 2010).

To elevate the voices of young Black girls, and girls more generally, this study will specifically focus on their perspectives in the qualitative section. This action is taken to delve deeper into the responses of female participants, who may feel marginalised in STEM. Thus, I will elucidate any overarching themes and trends in these responses while also drawing out the nuances of students' lived experiences in a more holistic approach than either method alone. Additionally, I am adapting the Draw-A-Scientist test (Chambers, 1983) in an innovative way with the aim of enhancing its validity and overcoming methodological limitations. In this project, I aim to comprehensively explore the following three research questions (RQs):

RQ1: How do Year 1 pupils conceptualise scientists?

RQ2: How do Year 1 pupils rate their science self-efficacy?

RQ3: Do Year 1 pupils see scientists as physically 'like' or 'unlike' them?

Literature Review

This section will critically review the current research on pupil perspectives of scientists, how these perspectives relate to science self-efficacy as well as the importance of exploring pupil perspectives.

What does a scientist look like?

Since Mead and Mertraux's (1957) seminal work in which 35,000 high school pupils in the United States were surveyed on their perspectives of scientists, there has been a growing body of research dedicated to understanding this phenomenon. The stereotypical image of a scientist as a White male has been consistently reproduced by pupils and teachers alike across various cultural contexts (Ferguson & Lezotte, 2020; Finson, 2003). This image is significant as pupils' stereotypical perceptions of scientists are influential in their attitudes towards STEM subjects and careers (Painter, Jones, Tretter & Kubasko, 2006). Similarly, individuals require relatable and motivational role models to identify with in their career aspirations. Thus, examining when these perceptions form and what drives them is crucial to understand the gender and race gap in STEM fields.

To assess whether this image of a scientist is present in the minds of young children, and when this stereotype emerges, Chambers (1983) developed the Draw-A-Scientist Test (DAST). This test involves asking children to draw a picture of a scientist and describe their drawing. The drawings are

then analysed, coded, and compared to the stereotypic image from Mead and Mertraux's (1957) study. Chambers (1983) administered the test to 4807 children, aged five- to eleven-years-old, over an eleven-year period. Interestingly, only 28 of these children drew female scientists – all of whom were girls themselves. This and subsequent studies using the DAST indicate that drawings by White and Black girls show they perceive scientists as 'unlike me' (Silver, 1992).

The importance of self-efficacy in school

Self-efficacy (SE) refers to the individuals' beliefs in their capacity to effectively accomplish a task (Bandura, 1997). It is a powerful determinant of effort, resilience, and problem-solving. In the classroom, SE undergoes a continual process of evaluation and validation, making it an imperative for educators to foster and sustain high levels of SE in all pupils. It is also domain specific so it can differ by academic subject. Bandura identifies four key factors influencing SE levels: mastery experiences, vicarious experiences, social persuasion, and physiological reactions. In this context, mastery experiences delineate the link between experiences and attainment, in which children are given the opportunity to learn, hone domain specific skills and subsequently succeed in a task. By contrast, vicarious experiences denote learning through the observation of others. Hence, a viable approach to improving SE is through facilitating vicarious experiences from relatable role models. For instance, seeing peers with the same gender or race as you can increase your belief that you can succeed (Bandura, 1977). Significantly, vicarious experiences in which girls see women or girls succeeding in a task are more powerful for SE than mastery experiences (Rittmeyer & Beier, 2008). By integrating the work of people from underrepresented groups in the curriculum, teachers can influence student SE beliefs by providing relatable and motivation aspirations. The third factor contributing to SE is social persuasion, which refers to the influence of others' feedback and support. It follows that positive feedback and support improve SE while all negative reduces SE. Interestingly, only positive feedback perceived as genuine and from a trusted individual can improve SE (Joët, Usher & Bressoux, 2011). This is salient as all negative feedback impacts students, particularly those with lower SE to begin with, whereas positive feedback and support is only impactful when from a trusted individual. Finally, negative physiological reactions to specific tasks, such as increased anxiety, can reduce SE and undermine resilience whereas positive physiological reactions have the reverse effect.

Science self-efficacy

Given that SE is inherently domain-specific, it is vital that, in the present study, it is measured in relation to science. Science self-efficacy centres on pupils' belief in their capacity to succeed in scientific courses or tasks (Britner & Pajares, 2006). Like academic SE, it is a powerful for the promotion of motivation, resilience, and attainment in science as well as the cultivating ambition for STEM careers. The research indicates that science self-efficacy begins to drop in primary school pupils, with a more pronounced drop in girls than boys (Rice et al., 2013). Therefore, one avenue to improving interest and confidence in science is through providing ample mastery and vicarious experiences, coupled with social persuasion that affirming students' capabilities in science and eliciting positive physiological reactions.

Scrutinizing science self-efficacy levels in young children offers insight into their attitudes towards STEM subjects and the degree to which they find them motivating. As science self-efficacy predicts engagement in STEM courses and careers, it is important to analyse pupils' science self-efficacy beliefs to discern the onset and mechanisms underlying the gap in interest and attainment in STEM disciplines during early childhood. Thus, investigating the levels of science self-efficacy among Year 1 participants will shed light on when and how this gender and race divergence in STEM engagement emerges.

Exploring science self-efficacy in young children

While there is a rich body of research examining science self-efficacy in high school students, there is a dearth of research examining these beliefs in younger children. This is due in part to the ongoing debate in the literature on whether children are developmentally mature enough for objective self-assessment (Davis-Keen & Sandler, 2001). Among the limited studies exploring science self-efficacy with young children, those employing age-appropriate methodologies have demonstrated the significant correlation between high SE and academic attainment and engagement. For instance, in Wilson and Tranin's (2007) study with 198 Year 1 pupils, those with higher SE in English performed better, were more motivated and more resilient than those with lower SE. The researchers critiqued previous studies for employing less domain-specific language and less developmentally sensitive measures with young children as they contended that this meant they could not accurately ascertain what students felt about certain subjects. Indeed, using specific and accessible language is important for accurately capturing the perspectives of younger children. Wilson and Tranin (2007) created the

Early Literacy Motivation Survey with these limitations in mind and were able the researchers to capture detailed and specific insights from Year 1 students assessing their own SE. The success of their research indicates it is possible for children to self-assess their SE. Marsh, Craven and Debus (1991) had similar success in Year 1 students' self-assessment of their academic achievement, but not with reception age children. Taken together, these studies suggest self-assessment is possible and appropriate with accessible measures. To redress the lack of research on SSE in Year 1 students and with the lessons of age-appropriate measurement in mind, I have created a detailed, accessible, and specific measure of science self-efficacy inspired by Wilson and Tranin's (2007) work (see Appendix 1). Consequently, my research endeavours to bridge this gap by examining science self-efficacy beliefs as assessed by Year 1 pupils.

Researching pupil perspectives

Conducting research with children is paramount to understanding how to improve the education system for their benefit. In the UK, there is a growing recognition of the significance of pupil perspectives in the legislative process. However, this acknowledgement in law does not always translate into the formation of educational policies. As Devine (2003) contends, school often operates in an adult-centric manner, where pupils' voices are not heard.

Historically, research has predominantly viewed children through the lens of adults, assuming that adults provide richer information and possess a superior ability to articulate children's experiences. Consequently, children have often been treated as passive subjects rather than active participants in research endeavours. This approach is problematic as it introduces biases, interpretations, and cognitive distortions that may obscure the authentic voices of children.

A common criticism of research involving children is its tendency to tokenize their engagement, often using their perspectives in superficial ways, such as incorporating a charming quote for study titles. However, as Sorin (2003) suggests, children are the foremost experts on their own experiences, possessing voices that can offer profound insights, often richer than those acting on their behalf.

Therefore, it is incumbent upon researchers to listen to and empower the voices of children who may otherwise go unheard (MacNaughton & Smith, 2005). One effective method of amplifying these voices is by conducting research that directly investigates the perspectives of these pupils. Consequently, there has been a notable surge in educational research with children in recent years,

accompanied by advancements in research methodologies aimed at accurately capturing the wealth of insights pupil perspectives offer.

Amplifying the voices of marginalised groups

Younger children have been historically marginalised in self-reporting education research, in part due to entrenched beliefs about their developmental and cognitive capacities to articulate coherent self-narratives, engage in self-reflection and self-assessment. This oversight has been perpetuated by researchers prioritising participant cooperation with existing measures, rather than adapting measures to suit the most age-appropriate participants for said research (Christensen & James, 2017). Regrettably, this trend is mirrored in the attitudes of policymakers, further exacerbating the marginalization of this demographic.

While age and maturity are undoubtably significant factors to consider when designing an appropriate study for children, these factors should not lead to the exclusion or dampening of the voices of children. After all, children are the foremost experts of their own experience. Indeed, the United Nations Convention on the Rights of the Child (UNCRC, 1989) underscores the importance of incorporating children's voices in policy-making efforts.

In responding to these challenges, this project seeks to amplify the voices of a group of an often-overlooked cohort of participants younger children from diverse backgrounds, particularly focusing on the experience of young Black girls. By spotlighting the complexity and richness of their perspectives and experience, this study strives to contribute to a more holistic understanding of pupil perspectives of scientists. Ultimately, I aim to inform more inclusive and effective educational practices that honour the diversity and complexity of children's experiences.

Drawing for research and the DAST

Methodologies incorporating drawings astutely provide insight into the mind of the young child (Eldén, 2013). They are especially useful for work with younger children as they are playful and thus can sustain pupil's attention for longer and do not rely on language proficiency so are suitable for participants from diverse backgrounds (Literat, 2013). The DAST was initially adapted from Goodenough's (1926) Draw-A-Man Test which sought to measure intelligence through drawing in young children. By contrast, the DAST focuses on the mean number of predetermined stereotypical

indicators in students' drawings to elucidate to what degree students' hold the stereotypic image of a scientist. In the present study, the DAST has been selected as it is easy to administer and is accessible for young children.

Rather than Chambers' (1983, p.257) instruction to "Draw a picture of a scientist", the present research will use an instruction like Fung's (2002, p.200) "How does a scientist appear to you? Try to draw one in the rectangular box below. (If you like, you may draw two)". This instruction has been shown to be valid with primary and secondary school participants. To make the language simpler for younger children, in the present study pupils will be asked to 'Draw what a scientist looks like to you. If you like you may draw more than one'. Existing research suggests that individuals may be inclined to draw a less stereotypical image of a scientist if they draw more than one (Fung, 2002) and thus this will be an option available to the participants.

The Draw-A-Scientist-Test Checklist (DAST-C)

To enhance the assessment of DAST results, Finson, Beaver, and Cramond (1995) developed the Draw-A-Scientist Checklist (DAST-C). A distinct advantage of using the DAST and DAST-C in conjunction is that quantitative data can be derived from the drawings and thus be subject to comparative data analysis. This is useful in comparing data from larger samples which can then be analysed alongside subsequent research using similar methodology. If the findings are replicated, they can therefore be considered more robust and generalisable, in turn, contributing to a more detailed and persuasive account of pupil perspectives. In addition, the DAST-C takes assessment further than the seven stereotypical characteristics highlighted in Chambers (1983) original research, incorporating other stereotypical attributes, such as gender, that have been prominent in subsequent research. In 2003, Finson tested the validity of the DAST-C for use with diverse samples. He found that there were no significant differences in the perception of scientists on the DAST-C from Caucasian, African American, and Native American samples. Hence, it is an appropriate measure to use in the present study to assess pupils' drawings. In this study, I will be adapting the DAST further in novel ways with the aim of combating existing limitations and thereby improving its effectiveness.

Methodology

Participants

Diverse sampling methods will be used throughout this project. To recruit participants for the quantitative part of the study, I will use the convenience sample of a Year 1 (aged 5-7) class, from my recent placement school, to recruit participants for the DAST, and science self-efficacy questionnaire. While convenience sampling is recognised for its cost-effectiveness, speed, and flexibility, it is not without its limitations. Because it samples an easily accessible cohort, it cannot be assumed that it is generalisable to a larger population. However, as this is a pilot investigation into pupil perspectives of scientists, using my new version of the DAST. It is appropriate for this project because it will provide initial insights before conducting larger-scale research.

To gain informed consent, letters will be given out to the families of the pupils, explaining the details of the study, and asking for consent for children to partake in the study. When studies have been conducted with children in the 5-6 age range researchers often recruits neurotypical participants (Pekdoğan & Bozgün, 2019). However, this study has adapted the quantitative measures involved so they can be accessed by neurotypical and neurodiverse participants. Again, this choice has been made with a view to exploring how neurodiverse participants access the study with a view to conducting a more comprehensive project in the future.

For the qualitative part of the study, six participants will be selected via purposive sampling to ensure that students with diverse demographics are selected. This form of sampling is appropriate for this project as I require detailed responses from participants who can be marginalised in STEM, namely Black girls.

Given that this project adopts a case study approach in a single school, it is important to highlight its limited generalisability. However, it is valuable in providing in-depth analysis on a smaller scale with a view to providing insights for future research. Any future research should increase the sample size, diversify the schools recruited, and interviewing more participants to provide more robust answers to the research questions.

Summary of research design

All participants will first complete my new version of the DAST, and then results will be coded and explored by the researcher as outlined in the Data Analysis section. Subsequently, six participants will be purposively sampled based on their characteristics and interviewed using a semi-structured interview schedule. Finally, all participants will complete the Likert scale science self-efficacy questionnaire I have created, using Bandura's (2006) guidelines. In this questionnaire, students need to 'circle the answer they agree with' about 'how well they can answer questions on' the Year 1 science curriculum. Children will self-assess and select their response from 'I can do that very well' to 'I cannot do that well at all'.

The DAST, its limitations, and my new version of it

The challenge of interpretation

While the results from the DAST and DAST-C are broadly consistent with interview accounts of pupil perspectives of scientists, there are some limitations of note. These limitations are discussed considering the version of the DAST I propose to make for this project.

While statistical analysis is useful for identifying relationships in the data, quantitative research can only tell us what we are seeing and not explain why we are seeing it. Additionally, results from the DAST and DAST-C cannot provide the level of insight that is afforded in an interview (Finson, Beaver & Cramond, 1995). Hence, the two are projective methods from which the researcher can interpret data rather than attribute cause. As a result, these measures are open to interpretative bias.

This bias can be seen in researchers' coding of gender ambiguous drawings as male or female. Losh, Wilke and Pop (2008) critique the use of drawing methodology with young children due to their less developed fine motor skills and the impact this has on their ability to portray accurate representations through drawing. In the literature, girls have consistently drawn more female scientists. Losh et al. (2008) study (p.776) noted that girls typically drew more obviously gendered scientists, owing to their "greater graphic abilities". On the other hand, boys, particularly those in the first grade, drew many more gender ambiguous scientists. This led the authors to query the validity of prior research which found highly gendered scientists from even very young children. Thus, the authors have questioned whether the coders had to decide if it was a male or female scientist. Interestingly, even

in research with pre-service teachers, with far greater graphic abilities, using the modified DAST (mDAST), the authors noted that they would not have recognised the gender of the scientist in many drawings had there not been a checkbox item which made participants state the gender in their drawing (Reinisch et al., 2017). As a result, the present study will add an indeterminate gender option to the DAST-C to allow for coding of ambiguous gender scientists – as recommended by Losh et al. (2008).

Using interviews for greater insight

Considering these limitations, the present study will include a semi-structured interview with a subset of the children to discuss their drawings and rationale behind them. As Mitchell (2006) highlights, research methods using drawing should not be used as a substitute for pupil voice; they are a starting point for further reflection. Additionally, the interviews will help overcome the challenge of mis- and over-interpretation of the DAST, as pupils can explore the more obscure or subtle aspects of the drawings with the researcher. This is especially important because of the imaginative style of the drawings of younger children (Literat, 2013). In turn, this will help ensure that the pupil's perceptions are accurately recorded and analysed.

Removing white as the default

From a critical race theory perspective, the stereotypic image of the White male scientist may not result from racial bias in children but rather limitations of the original DAST measure in interpreting race. In Wills' (2022) review of 28 DAST studies based in the United States, it was shown that while researchers claimed most, if not all, participants drew White male scientists, few researchers elaborated on how they discerned they were white. Further, in their analysis of DAST tasks Losh et al. (2008, p.778) explained that “for statistical analysis, the colour of the figure was scored 1 if the figure was brown, tan, or yellow and 0 otherwise; virtually all zeroes were uncoloured, thus making the figure the background colour of the page (i.e., ‘White’)”. Similarly, while Milford and Tipett (2013) had initially adopted the DAST-C (Finson, Beaver & Cramond, 1995) to analyse their DAST tasks, they had to delete the ethnicity coding from their checklist and results as they could not accurately interpret the ethnicity of scientists. This is a critical limitation of the DAST measure because it assumes that children intended their drawings to be white when they had not coloured them

in. Indeed, this represents a crucial interpretative bias that could be reduced through methodological changes.

To mitigate these potential biases, I will implement several modifications to the DAST. Firstly, the present study will utilise a range of brightly coloured paper for the DAST task so that white is not the default colour of paper, nor the assumed default skin colour of the scientist. Blue and pink paper will not be used as these colours may prime participants to draw certain sexes (Pomerleau, Bolduc, Malcuit & Cossette, 1990). Additionally, participants will have access to a range of colouring pencils, including skin tone colours, allowing them to select colours if they wish to attribute a specific skin tone to their drawn scientist. Rather than using ethnicity coding as in the DAST-C (Finson, 2002), the data analysis will code for what colour pencil they have used, if any, to colour in their figure. In this way, it is hoped that interpreter bias will not influence the coding as the researchers are not asked to draw conclusions about ethnicity. Further, to ensure accurate interpretation of pupil's responses, researchers will inquire about the skin colour after participants have completed the DAST. This will occur after to prevent priming and ascertain if pupils naturally attribute race to scientists as a key aspect of their representation. By incorporating these adaptations to the DAST in this project, I seek to investigate whether these modifications improve the task's ability to accurately capture children's perceptions of the skin colour of scientists.

Measuring self-efficacy

While the definition of SE has remained relatively stable since its conception, how to best measure it has been a source of contention. Pajares, Hartley & Valiante (2001) highlighted the issue of mismeasurement of SE, reporting that researchers were constructing measures that were not specific enough to tap SE. Specificity is crucial in measuring SE because it is domain and task specific. Because of the need for specificity, there is no one approach that is suitable for all SE measures. However, to improve measures of SE, Bandura (2006) produced a set of guidelines for the construction of valid measures of SE:

Content validity: items must reflect an individual's ability to do something, not their intention of doing it. Therefore, they should be phrased as 'can do' rather than 'will do'.

Domain specific: examines an individuals' perceived efficacy to do something specific to the subject area.

Levels of difficulty: impediments and challenge should be factored into the items to discern the level of difficulty at which the individual believes they can achieve.

Use a response scale: efficacy beliefs vary based on task and challenge so the items should be sensitive to variation within a domain.

Questionnaire measuring science self-efficacy

With Bandura's (2006) guidelines in mind, the present study has created an accessible science self-efficacy measure specific to the current Year 1 science curriculum in the UK. Accordingly, questionnaire items are phrased in line with what children think they 'can do' to reflect their assessment of their own capability rather than what they 'will do' which implies intentionality. Despite research demonstrating that scales with a 0-100 response format is more sensitive and therefore useful for data analysis than a five-interval scale (Pajares, Hartley & Valiante, 2001), research on questionnaires for young children indicate that fewer choice options are important for preventing confusion.

"It is likely that these children do not recognize these refined differences between the response options and get confused by the unrecognized differences between the options. This can cause a satisficing strategy with these kinds of questions,"

(Borgers & Hox, 2000, p.17).

Therefore, a five-interval Likert scale has been created for the current study (see Appendix 1). Each interval has been clearly labelled to help clarify the difference between each discrete response. The research shows that visual aids are useful for all children (Scott, 2008), but Widgit Symbols© are especially recognised for their utility in research with children with neurodiverse children (Gevarter, et al., 2014). The present study has used symbol-based writing software (SymWriter© and Widgit Symbols©) to make the questionnaire accessible to neurodivergent pupils and pupils with English as an additional language.

Semi-structured interview

The current study has selected a semi-structured interview design so that the researcher and participant are able to co-construct an account of how the child perceive scientists. The current research will use Kirk's (2007) principles to guide the interview. Accordingly, questions used will be open-ended to encourage longer and more detailed responses from the participants and closed

questions will be avoided. Further, the researcher will avoid interrupting the child and allow for longer pauses to allow the child's response to come naturally to a close and enable thinking time.

A pilot interview will be conducted prior to the study to check for the suitability of the current interview schedule as research shows pilot interviews increase the reliability and validity of the research (Majid et al., 2017). After the pilot interview, researchers can reflect on whether the questions were suitable or appropriate for that age group, and hence improve the quality of the actual research data. Additionally, it will be important to reflect on the individual child before conducting an interview as chronological age does not always reflect the child's developmental stage (Krotter-Grühn, Kornadt & Stephan, 2016). Thus, to collect reliable data, it will be important to adapt the interview schedule to suit the individual needs of the child. Further, throughout the actual interview it may be appropriate to provide alternative explanations to clarify the meanings of words or questions. Indeed, an advantage of using a semi-structured interview approach is that these are more flexible and thus conducive to the kinds of vital adaptations in conducting research with children.

Data Analysis

Thematic Analysis

This study will use theoretical thematic analysis to explore pupils' perspectives on what a scientist looks like, and to what extent a scientist is 'like' them. It will follow Braun and Clarke's (2006) guide to conducting thematic analysis. The DAST responses will be analysed in context with interview responses. In the interviews, participants will be asked to elaborate on their drawings to provide greater detail.

Transcription

Transcription is an innately interpretative process and thus open to the bias of the transcriber (Jaffe, 2007). To limit this bias, audio recordings will initially be transcribed according to the principles of denaturalised verbatim in which everything is included, such as repetitions and grammatical errors (Bucholtz, 2000). While some researchers argue that naturalised verbatim, in which the transcriber adapts oral responses to mimic more closely those of written responses, or what they construe as the intention of participant, it is likely that the participants in the current study, due to their age, will make

grammatical errors and it is important to accurately represent their views. Additionally, as participants from diverse backgrounds are frequently misrepresented in qualitative research it is imperative to limit the effects of interpretive bias as much as possible.

Coding

After transcription, initial codes, will be created from interesting aspects of data and data will be organised accordingly. Following this, codes will be generated into overarching themes. Themes encapsulate something important about the data as it pertains to the research question, usually representing a pattern in the responses or meaning in the data (Clarke, Braun & Hayfield, 2015). Themes are not necessarily selected for prevalence, but rather for what insight they provide on the research questions. As the current study is using theoretical, top-down, thematic analysis the analysis will be driven by the research questions, and theory surrounding them, rather than inductively driven by the responses. Once the themes are organised, these will be reviewed to check they astutely capture the relevant coded extracts and the data. Then, themes will be further refined and will be given relevant and clear titles and finally will be discussed in the context of relevant literature.

Quantitative analysis

The quantitative data from the DAST-C and science self-efficacy measure will be coded and examined using SPSS. As the DAST-C will be completed by the researcher, there should not be any incomplete data from the checklist. Participants responses will be collated and analysed using SPSS and presented in tables to show the percentages of students who drew scientists with that characteristic. The analysis will also show the percentage of students of each sub-group, based on gender, race, and any special educational need diagnosis, that depicted a scientist with those characteristics. This is especially important as it will capture the relationships between sub-groups and perceptions of scientists. Similarly, the data from the SE measure (Appendix 1) will be presented in tables and explored in relation to pupils' demographic characteristics. Each category on the Likert scale will be coded numerically, ranging from 1 for very poorly and 6 for very well, and pupils' science self-efficacy overall score will be generated from the mean of their total score on the measure. From this, the mean and standard deviation will be compared across sub-groups, as detailed earlier, to draw conclusions about the relationship between science self-efficacy and sub-group

demographics. Finally, a discussion will explore the relationship between results on the DAST, interview data, and science self-efficacy.

Ethical considerations

A crucial ethical consideration when conducting adult-child research is power dynamics. Christensen (2017) contends that the subordinate nature of children to adults must be considered by the researcher as children tend to find it challenging to say something adults may not like or find acceptable. While it is an oversimplification to assume all power lies with the adult, it is vital to engage the student actively in the research process so that they feel heard, particularly as they may not be used to being asked their views (Moore, McArthur & Noble-Carr, 2008). The latter is especially important when considering the views of minority or marginalised children. For instance, the perspectives of Black and Asian Global Majority (BAGM) students may be minimised in qualitative analysis when they are a smaller subsection of participants or if BAGM participants are reluctant or nervous in studies with white researchers (Barn, Sinclair & Ferdinand, 1997). Similarly, students with special educational needs and disabilities (SEND) are largely ignored in research unless the research aims pertain to their respective SEND (Armstrong, 2003). To accommodate students from SEND or BAGM backgrounds, and for the possibility for increased power discrepancies between researchers and these informants, spending more time with these students to make them feel more comfortable or help their communication is paramount for their inclusion (Clark, 2005). As the present study seeks to explore all pupil perspectives, it is imperative that time and efforts are directed at making these students feel more comfortable and able to voice their perspectives.

For informed consent to be valid, children need to be told the research aims, how long it will take, who will be able to access the results, if there will be feedback, and if confidentiality is guaranteed or not (Gallagher, Haywood, Jones & Milne, 2010). Additionally, children need to access and understand the language. Notably, access can mean different things depending on the child and thus the needs of the children should be discussed with the class teacher prior to the study. In the present study, a video of the researcher explaining the study will be made accessible to pupils, whose families have consented on their behalf, prior to the study so that pupils can familiarise themselves with both the research aims and the researcher themselves. This decision was made in line with existing research; Punch (2002) contends this is important as it is important for younger children to observe adults before the research is conducted so that children feel prepared and comfortable to communicate

and confide in them. Children, like adults, also need the option to withdraw consent at any time so that they can actively choose to participate in the research (MacNaughton & Smith, 2005) thus this right to withdraw will be emphasised to them before each task and in the interview schedule. In addition, in the present study, the researcher will emphasise the potential benefits of the project such as develop a greater understanding of how to make all students feel included and confident in science.

Implications for future research

The findings of this research carry significant implications for future education research and policy. Firstly, by prioritizing and amplifying the voices of younger children, especially young Black girls, this study contributes to an emerging body of literature highlighting the importance of including the perspectives of marginalised groups in educational research. These insights hold the potential to inform policymakers, empowering them to enact reforms that foster a more effective, inspiring, and inclusive educational system.

Secondly, this study introduces my adapted version of the DAST which aims to eliminate the default skin tone bias present in previous DAST studies. By providing children with a colourful canvas, a spectrum of colouring pencils and subsequently observing how children attribute skin colour to scientists, it is hoped that I will overcome previous methodological limitations. If this is successful, it underscores the need to question and refine existing methodologies such as the DAST and DAST-C to enhance their accuracy and inclusivity.

In summary, this research will not only advance our understanding of children's perspectives but also prompt methodological advancements in research practices. Furthermore, it underscores the potential for policy changes to create a more equitable and enriching educational environments for all children.

Implications for future practice

This project has underscored the importance of regularly engaging pupil voice, recognising children as experts in their own experience. Moving forward, I am committed to integrating pupil voice as part of my teaching and planning process. It is particularly important to minimise the influences of implicit bias and cultural stereotypes through active awareness and anti-racist practices. Through this

understanding, it is my responsibility to provide children with the opportunities to be heard and empowered.

Furthermore, this project has emphasised the significance of diverse role models across the curriculum to shape pupils' perceptions of their potential as limitless. It is of vital importance that all children can see themselves in the science curriculum, so they are able to actualise as inspired, motivated, and resilient learners. As I consider my future planning, it is essential that I incorporate a diverse array of scientists into the curriculum, ensuring representation for all children. Indeed, this research was partly inspired by the Primary Science Teacher's Trust new resource 'A Scientist Just Like Me' which enables children to sort through scientists and find some 'like them' based on their personal characteristics (career, ethnicity, gender, disability, and sexual orientation; Trew, Johal & Eley, 2021). This resource is a prime example of how to dispel antiquated and stereotypical ideas of what a scientist looks like, particularly for use in Key Stage 2. Additionally, I will enrich classroom libraries with high quality reading books featuring scientists from diverse backgrounds such as Andrea Beatey's 'Questioneer' book series and Maria Isabel Sánchez Vegara's 'Little People, Big Dreams'.

Finally, I am committed to creating opportunities for all children to have both mastery experiences and vicarious experiences in science, recognising pivotal role of these experiences in fostering science self-efficacy. The research indicates that these experiences are vital in promoting high science self-efficacy, and as this is determinant of motivation, effort, and resilience. It will be integral that I incorporate these experiences in my science planning.

All children should see themselves in science, but the evidence suggests this is not always the case. As educators, it is our responsibility to nurture and empower all children to have a robust learning identity – identities that embolden them to confront the challenges of contemporary society with unwavering confidence, declaring 'I can do it!'. Through this project, it is my aim to enrich the science curriculum to empower all learners to enjoy, identify with, and feel authentically represented in science.

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Appendix 1

Science Self-Efficacy questionnaire

    Circle the answer that you agree with.					
        How well can you answer questions about plants?	I can do that very well. 	I can do that well. 	I am ok at that. 	I cannot do that well. 	I cannot do that well at all. 
         How well can you answer questions about animals and humans?	I can do that very well. 	I can do that well. 	I am ok at that. 	I cannot do that well. 	I cannot do that well at all. 
        How well can you answer questions about materials?	I can do that very well. 	I can do that well. 	I am ok at that. 	I cannot do that well. 	I cannot do that well at all. 
        How well can you answer questions about seasons?	I can do that very well. 	I can do that well. 	I am ok at that. 	I cannot do that well. 	I cannot do that well at all. 