



The identity turn in science education research: a critical review of methodologies in a consolidating field

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Abstract

This manuscript reflects on the affordances and limitations of methodological approaches commonly adopted by science education researchers examining learner identities. Our aims are to unpack the relative strengths and weaknesses of such approaches and note their respective prevalence. In so doing, we identify and critique studies which we consider exemplify the different approaches and, in turn, note the direction of fruitful developments and the nature of key challenges. From our review of the field, we suggest that three discrete methodological approaches can be identified: macro-studies within a psychological tradition; macro-studies within a sociological tradition; and micro-studies within an interpretive tradition. Our review comprised a critical analysis of papers included in the Web of Science databases published between 1998 and 2018. A total of 198 papers examining aspects of learner identity relating to science were identified. Of these, the majority (146) were categorised as micro-studies within an interpretive tradition. We discuss the implications of methodological choices for the advancement of understanding and further note ambiguities in the field particularly in relation to the ways in which learner identity research is conceived. We also raise questions for the field relating to the ways in which findings may be scaled, and how the field might develop to allow stronger theoretical and conceptual coherence.

Keywords Science identities · Learner identities · Review · Methodological approaches · Science education

Science education research is witnessing a growing interest in issues regarding the interplay between agency and structure in young people's educational choices, achievements, and aspirations, including how different social categories (such as gender and ethnicity) intersect with students' experiences of the science disciplines. A notion that is used as a theoretical construct in researching this interplay, but also increasingly to denote the field of research, is that of 'science identities' (see, for example, Avraamidou 2019). The construct of science identities has been particularly valuable for exploring inequalities in science participation, examining why and how it is more difficult for some people to see

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science as being ‘for me’, in relation to both formal (e.g. Calabrese Barton and Tan 2009) and informal (e.g. Carlone et al. 2015) learning context.

The field of science identities is, as Lucy Avraamidou (2019) notes, broad and growing rapidly. An illustration of this growth can be found in the instance of the European Science Education Research Association (ESERA) ‘Special Interest Group (SIG) on Science Identities’ which, although only established in 2017, is already one of the organisation’s largest special interest groups. Two recent ESERA conferences have also had keynote speeches focused on science identity work (Louise Archer in 2013, Angela Calabrese Barton and Emily Dawson in 2017) and several edited volumes have been published: Avraamidou (2016); Allison Gonsalves and Anna Danielsson (2020); and Louise Archer and Henriette Holmegaard (forthcoming).

In an early review of science identities research, Marie-Claire Shanahan (2009) noticed that most studies up until that point had predominantly focused their gaze on the individual, with less attention being paid to social structures. Shanahan concluded that this had to do with the dominance of communities of practice (Lave and Wenger 1991) as a theoretical perspective within this research, a perspective that does recognise the importance of social structures, but mostly in terms of how they affect the individual. Hence, methodologically, this research was dominated by small-scale, qualitative studies. She suggested that science identities work would benefit from broadened methodological approaches, such as including the use of mixed methods. Yew-Jin Lee’s (2012) review of identity-based research in science education, meanwhile, found a more varied theoretical landscape to that identified by Shanahan. While community of practice perspectives were still prevalent, other traditions, such as discursive stances and activity theory, were identified. However, and similar to Shanahan, Lee concluded that there had been ‘frustratingly little in terms of “hard data” from longitudinal or large-scale studies to guide change’ (p. 42), stressing the (over) reliance on sociocultural perspectives, interpretative paradigms and small-scale qualitative studies.

Almost ten years on since Lee’s review, we argue that a new discussion pertaining to methodologies in the field of science identities research is needed. As science identity researchers and teachers who regularly participate in national and international science education conferences, use science identity scholarship in our teaching and in discussions with policy and practice, we have observed that scholarship within the realm of ‘science identities’ utilises several different theoretical perspectives and analytical approaches. The breadth of perspectives is also evident in the description of the ESERA ‘Special Interest Group on Science Identities’: the field draws ‘on different research frameworks as for example post-structuralist theories, feminist theories, narrative psychology and Bourdieu’ (ESERA 2022). Yet, as well as the breadth, we have also noted the dominance of a small number of approaches. For example, a handful of key articles (among them Carlone and Johnson 2007 and Brickhouse et al. 2000) are very frequently cited and have thus guided many subsequent small-scale qualitative studies focusing on the identity formation of a few students. The dominance of one approach raises the question of the field possibly becoming inward-looking and ignoring approaches that do not fit into what seems to have become somewhat of the methodological norm. We have also observed the difficulties that educators and policy-makers experience in making sense of how best to digest and apply the science identity research into their work, often citing the challenge of applying insight from a detailed, contextual case study to their own particular practice or, more broadly, to a wider policy.

These reflections motivated us to consider the ways in which identity issues in the science education field are theorised and, in turn, affect the design of research approaches and the nature of the insights that can be generated. Thus, the aim of the present paper is not to provide a review of the empirical findings pertaining to science identities, but rather, to critically consider the methodological approaches used in the field, question what insights these different approaches generate and what insights might be missed, and reflect on how current scholarship can inform policy and practice. In addition, while our interest in reviewing the field of science identities work was in part incited by an observation that some texts in the field are very frequently cited, we do not extend the review to an analysis of citations.

With a view to unpack both the affordances and limitations of different methodological choices in the field of learner identities in science, and identify potential ways forward for this increasingly influential line of research, our research questions are as follows:

- What are the methodological approaches that can be identified within studies focused on learner identities in science?
- What are the relative strengths and weaknesses of these approaches?
- What is the relative prevalence of different methodological approaches?

We also reflect on the following:

- What are the implications of current methodological choices for practice?
- What are the challenges and potential opportunities for the field of science identity research?

Materials and methods

To investigate the type and prevalence of methodological approaches currently utilised in the science learner identity research, we reviewed bodies of literature held in the Web of Science database published between 1998 and 2018. By investigating the prevalence of different methodological approaches (including concomitant theoretical traditions), we seek to critically consider what insights these approaches offer and what the field might be missing. We do not aim to synthesise empirical findings, but some empirical findings will be showcased in order to illustrate strengths and weaknesses of various methodological approaches identified. The four co-authors have all conducted research on identity as related to the teaching and learning of science, mostly from qualitative perspectives. The first three authors are situated within science education research, the fourth author within child and youth studies, with a background in sociology of education. Authors one and four have predominantly focused on higher education, whereas authors two and three have predominantly focused on K-12 (primary and secondary school) and informal science education.

Inspired by Elizabeth Rushton and Michael Reiss (2021), we employed a four-stage process to identify relevant papers and carry out the analysis:

1. Discussion of review strategy and design of review parameters
2. Identification of literature, using inclusion and exclusion criteria
3. Extraction of key information from the literature
4. Analysis of methodological approaches in the included studies

Review strategy and review parameters

1. We agreed to focus on learner identities. Since studies of teacher identity make up a field of their own and also have been reviewed relatively recently (Avraamidou 2014; Rushton and Reiss 2021), we chose to delineate our review to learner identities, but with a broad definition of ‘learner’ (thus including studies conducted in formal school settings, but also in informal or professional settings, and comprising all ages).
2. We agreed to focus on methodological approaches rather than empirical findings.
3. We discussed different routes to identify the literature: In order to capture articles published in a variety of different sub-fields of education, we chose to employ the multi-disciplinary Web of Science Core Collection, comprising of six different databases. Using one website rather than a collection of different routes to identify literature makes the search easier to repeat at a later stage, in order to capture subsequent trends in the field. However, we accept that this does not give a comprehensive overview of the field. Further, we note that our review is limited to papers published in English—the language that the four authors have in common.
4. We clarified keywords and search processes, which acknowledge that identity may be used differently in different research traditions. We did not want to assume a particular use of the identity, but rather to capture the breadth and variety of the field. Hence, the starting point was a literature search for the keywords “identity/subjectivity”, thereby allowing the various authors’ uses of the word to guide our search, rather than being limited by a specific definition.
5. We agreed the following keywords to be used in the database searches: identity, subjectivity, science, STEM, biology, chemistry, geology, physics. The search strings we used are presented in Table 1. Here, it should be noted that in delineating the search to studies including the terms identity/identities or subjectivity/subjectivities, we are likely to have excluded studies investigating similar phenomena but using different terms (such as self-perception).
6. We agreed on a timeframe for the review. While studies of identity are relatively recent in science education, we decided not to have a set starting point in time for the review,

Table 1 Strings used in the Web of Science search, utilising Boolean AND and OR operators

Main string	Additional strings
identit* OR subjectivit*	AND science AND STEM AND biology AND chemistry AND physics AND geology

but rather to let the field delineate itself. As such, we used keyword combinations concerning identity/subjectivity and science (including sub-disciplines of science) within the field of “Education and educational research” (as defined by Web of Science), published from 1900 to 2018. The first papers we found were published in 1998, thereby delineating the field to a twenty-year period.

Identification of literature

1. We conducted a search of Web of Science for literature published in international, peer-reviewed journals in science education (in total 14 journals) and general education (in total 11 journals), listed in Table 2.
2. We used a Boolean search using the search strings in Table 1 as follows. This rendered 591 papers. These papers were entered into an Excel document, listing title, authors, publication year and journal.

Extraction of key information from the literature

1. Titles and abstracts, and when necessary full-texts, of the 591 papers were then scrutinised to find papers that concerned science identities research and specifically learner identity. Through this review, we developed the following inclusion criteria:
 1. Identity/subjectivity as a concept used in the study (excluding studies where identity was only part of the literature review or in the reference list).
 2. Learner identity as the focus of the research (excluding studies of teacher identity).
 3. Science as the focus of the research (excluding studies of, e.g. computer science and social science).
 4. An empirical study (excluding review papers and theoretical papers without any empirical components).

Table 2 Journals included in the Web of Science search

Thematic area	Journals
Science education	Chemistry education research and practice; Cultural studies in science education; International journal of science and mathematics education; International journal of science education; International journal of science education part B; International journal of STEM education; Journal of research in science teaching; Journal of science education and technology; Journal of science teacher education; Physical review physics education research; Physical review special topics physics education research; Research in science education; Science education; Studies in science education
General education	American educational research journal; British educational research journal; British journal of sociology of education; Gender and education; Higher education; Higher education research development; Journal of curriculum studies; Journal of the learning sciences; Studies in higher education; Teaching and teacher education; Teaching in higher education

2. This round of elimination resulted in 198 papers, which were then examined in detail, to extract key information. The Excel document including the 198 papers was refined to also include country, method (including number of participants), age of participants, context (formal, informal, professional) and conceptualisation of identity (see Appendix 1).

Analysis of methodological approaches

In a first round of analysis, we categorised the papers according to the identity frameworks presented in *The SAGE Handbook of Identities* (Wetherell and Mohanty 2010). These are psychoanalytic perspectives, social psychology perspectives, anthropological perspectives, interactional perspectives, performative perspectives, post-colonial perspectives, and post-positivist accounts of identity. However, given that the handbook takes a very broad perspective on identity studies used in the humanities and social sciences, we found that several of the presented theoretical frameworks were not used within science education research (and that others, which we would perceive to exist in the multi-disciplinary area of science education, were not present). Consequently, we decided instead to take a grounded approach to the categorisation of studies into methodological approaches. Thus, based on a thematic analysis of the full papers, we firstly made a broad distinction between studies with micro- and macro-analytical focuses and then iteratively organised the studies into the following themes.

- (A) Macro-studies within a psychological tradition (e.g. Andersen and Ward 2014);
- (B) Macro-studies within a sociological tradition (e.g. DeWitt, Archer and Osborne 2014);
- (C) Micro-studies within an interpretive tradition:
 - (C1) Non-interventionist studies (e.g. Holmegaard, Madsen and Ulriksen 2014);
 - (C2) Interventionist studies (e.g. Calabrese Barton and Tan 2009).

The construction of these themes was mainly carried out by Authors 1 and 2, who drew on their extensive experience of science education research. However, to assist us in the process of agreeing which papers should be placed in which theme, we constructed detailed descriptions of each theme (including commonly used methods, conceptualisation of identity, and strengths and weaknesses with a particular approach). As more papers were added, the descriptions of the themes were adjusted and sharpened. For each theme, we first selected illustrative studies that we were able to place firmly into the particular themes; we provide an overview of these studies in the early parts of the Results sections. Next, we chose two papers for each theme that we thought exemplified perspectives that extend thinking in a fruitful methodological direction. These case study papers are chosen to represent scholarship across national contexts, educational levels and settings. They are also chosen to represent somewhat more unusual methodological approaches within each theme, thereby drawing attention to some less cited works.

In conducting the analysis, we allowed for studies to be placed into two themes (in order to capture the methodological complexity of, for example, mixed-method studies); we later reviewed these studies to establish whether they were a better fit within one of the themes than the other(s) and categorised them accordingly. Clearly, our categorisation process and paper selections may not do full justice to the nuance and unique value of individual papers, however, we argue that our approach captures the current tone of the wider field.

Results

There has been a notable growth in the field of science identities research over the recent years. For example, looking at the papers we identified for this review, 10 papers were published in the five-year period between 2000 and 2004, while 113 papers were published between 2014 and 2018. Furthermore, in the period up to 2010, fewer than ten papers on science identity were published annually. The number of papers nearly tripled in the next decade with, for instance, 25 papers being published in 2016 alone. While we acknowledge that the growth is in part aligned with an increase in the numbers of academic papers overall (e.g. Van Noorden 2014), we suggest that an increase in the field of science identities is nonetheless remarkable. Of the 198 English-language papers we considered, two thirds ($n=131$; 66%) were from US-based scholars, followed by the UK ($n=25$; 13%) and the rest of Europe ($n=19$; 10%).

Science identities research has used a wide range of qualitative and quantitative data collection methods. However, the field appears to be dominated by qualitative studies utilising observations and interview methods (see Appendix 1 for details of methods used). 55% of the empirical studies we identified for this review used these methods, often employing more than one qualitative method, such as for instance the work of Cory Buxton (2005), Heidi Carlone, Catherine Scott and Cassi Lowder (2014), and Michael Middleton, Juliann Dupuis and Judy Tang (2013). 17% of the empirical studies used quantitative methods, such as surveys (e.g. Robnett et al. 2018), and further 9% used mixed methods, i.e. combining quantitative and qualitative data collection methods (e.g. Gorard and See 2011). See Table 3 for an overview of the data collection methods used in the studies included in the review.

Next, we present a more detailed qualitative overview of the four identified methodological approaches.

For each theme, we begin by describing key characteristics of the approach (illustrated by examples of studies), then discuss key strengths of the methodological approach and its limitations. Finally, we focus in greater depth on two papers categorised as belonging to the theme, but selected to highlight more unusual, or unique approaches to studying science identities that we consider interesting and potentially fruitful with regards to extending thinking underpinning the field. These two papers are juxtapositioned in order to draw attention to the nuances in the methodological approaches.

Theme A: macro-studies within a psychological tradition

The studies included in this theme conceptualise identity as a trait of an individual, something that is individually enacted and largely self-constructed. As such, the wider social setting is taken less into account, and the individual becomes the unit of analysis. It needs to be noted, however, that a conceptualisation of identity as sense of self or self-perception does not imply that identity is something completely internal or innate, rather, as Margaret Wetherell (2010) explains, what emerges from contemporary scholarship is:

‘a more complex notion of the ways in [sic] identity slots might *pre-exist* the individual, so that minds, psychologies and senses of self are formed in dialogue and in conflict with what is ready-made and handed down.’ (pp. 8, 9)

From a methodological point of view, the theme is dominated by large-scale quantitative studies that seek to establish patterns across a large number of individuals. The

Table 3 Number of studies utilising different data collection methods

Primary data collection method	Number of studies
Observation-based studies (incl. ethnography, video-recordings, also when complemented with, e.g. interviews)	66
Interview (incl. focus groups)	43
Quantitative studies (survey, evaluations)	34
Mixed method (qualitative and quantitative)	18
Interventions and quasi-experimental studies	25
Other methods (e.g. drawings, auto-ethnography)	14

quantitative approaches take the form of surveys (Seyranian et al. 2018), analysis of secondary data (such as PISA-tests, Jack, Lin and Yore 2014) or quasi-experimental studies (Marchand and Taasobshirazi 2013). There are also some studies where large-scale quantitative data are complemented by qualitative data, such as Kuay-keng Yang et al.'s (2015) mixed method study combining questionnaires and interviews. □

A total of 36 studies (from the total sample of 198) were categorised as belonging to this theme. Many studies within the theme are grounded in social psychology theories of self-efficacy (Bandura 1977) and expectancy value (Eccles 2009). An example of the former is Vashti Sawtelle, Eric Brewe and Laird Kramer (2012), who explore the relationship between self-efficacy and retention in higher education introductory physics from a gender perspective, taking the view that 'self-efficacy is one of the primary dimensions of students' overall science identity' (p. 1096). They find that predicting the probability of passing introductory physics courses relies on different sources of self-efficacy for women and men. An example of the latter theoretical framing is Barbara Means et al. (2016), which is a quasi-experimental study testing whether attending a STEM-focused high-school increases students' readiness for postsecondary STEM studies (in terms of, for example, involvement in STEM extracurricular activities and their interest in science careers), discussed further below.

The studies in this theme seek to make universal and generalisable claims, albeit sometimes limited to a select population. However, the value of large-scale studies using comprehensive models to study phenomena such as stereotype threat (Marchand and Taasobshirazi 2013) or the STEM-pipeline (Means et al. 2017) is arguably limited in that they are unable to take contextual differences into account. A strength with the approach is the construction of validated methods (such as surveys) that are repeatable. As such, it is possible to scale studies to new contexts and/or larger groups. An example of this is the study by Ruurd Taconis and Ursula Kessels (2009), who repeat a study of self-to-prototype matching in a different national context. The large-scale nature of such studies also makes it possible to make statistical generalisations from their results, a strength when communicating findings to, for example, policy-makers. Another strength is that research designs which test a hypothesis create clear-cut and easily communicable results. For example, Means et al. (2016) used student surveys and the state's longitudinal student data system to compare students from 12 inclusive STEM high schools (ISHS) and 16 non-STEM comparison high schools with similar student populations, with regard to STEM attainment, interest, and aspirations. ISHS are schools offering enhanced STEM courses and experiences for students who have been traditionally underrepresented in STEM fields and accept students on the basis of interest rather than competitive examination. Means et al. (2016) found

that attending an ISHS school increases the likelihood that a student will take chemistry and calculus or pre-calculus while in secondary school and that attendance also enhances a student's identity as a person who does science and mathematics. 'Science identity' in the study is operationalised as 'one's identity as a person who does science' but while the concept is used rather extensively in the study, it is not explicitly defined. We found a similar under-conceptualisation of science identity in other studies within this theme (and other themes, see below), which we considered to be a notable limitation. Other limitations within this theme include paying little attention to context and a risk of reproducing stereotypical notions of groups of individuals.

Below, we select two studies that highlight some of the characteristics of Theme A.

Case studies theme A: psychologically oriented studies designed for accumulating knowledge

As noted above, common theoretical foundations within Theme A are the social psychology theories of self-efficacy (Bandura 1977) and expectancy value (Eccles 2009). However, for our two case studies, we have chosen to focus on studies that utilise other theoretical foundations, in order to highlight other possible approaches: self-to-prototype matching (Taconis and Kessels, 2009) and academic intrinsic motivation (Gottfried et al. 2016).

The studies by Taconis and Kessels (2009) and Adele Gottfried et al. (2016) both concern the issue of understanding students' entry into science careers, motivated by the difficulty to attract students to such careers. In the study conducted by Taconis and Kessel (2009), the issue is approached by testing whether a perceived mismatch between the typical representation of the science culture and students' self-image is linked to not choosing to major in science. Gottfried et al. (2016) investigated the role of parental stimulation of children's curiosity for facilitating their entry into science. Both studies utilise surveys developed in earlier studies, either repeating an earlier study (Taconis and Kessel) or combining several different, validated surveys (Gottfried et al.) to capture a complex phenomenon.

Taconis and Kessel (2009) utilise a questionnaire, answered by 54 Dutch students, which measures students' perceptions of typical peers favouring different school subjects and students' self-image. In their study, they seek to investigate compatibility of the science prototype to the students' self-identity, which they argue is an important factor influencing whether students wish to specialise in science. In doing so, they repeat an earlier study by Bettina Hannover and Ursula Kessels (2004) that found that German secondary school students' liking of school subjects was stronger the more similar their description of 'the prototypical peer favouring a particular subject was to their own self-image' (p. 1118). The conceptual starting point of the paper is that interest in and decision to specialise in science is connected to the enculturation into the specific culture of science, using self-to-prototype matching theory to construct a hypothesis that educational choice can be predicted by the perceived distance between self-identity and prototypes. In line with their expectation, Taconis and Kessels found that students' academic choices were dependent on their perception of similarity between themselves and their prototype of a science-liking peer.

The data for the study by Gottfried et al. come from an ongoing long-term investigation in the USA where 130 children are followed from infancy into early adulthood. This study draws on data collected from when the children were eight years old until the last year of high school, through the use of multiple different surveys. Parental stimulation of

curiosity at eight years was measured using questions which, for example, explored the impact of exposing children to new experiences and encouraging asking questions. Intrinsic motivation was measured at ages 9, 10, and 13 years, and achievement at ages 9, 10, and 11 years. In the last year of high school, participants' career interest and skill across different domains were measured. Conceptually, the study is grounded in an assumption that curiosity is a foundation of individuals' science pursuit. The study further draws on the first author's previous work regarding academic intrinsic motivation, where they demonstrated its significance for student achievement. In order to explore the relationship between parents' stimulation of curiosity, intrinsic motivation, science accomplishment, and science career interest and skill, the authors engage in complex statistical and conceptual modelling. They conclude that 'The theoretical connectedness between parents' stimulation of children's curiosity and their academic intrinsic motivation and academic achievement received empirical support.' (p. 1986).

Methodologically, the studies may, at first, seem quite different; Taconis and Kessels conducted a relatively small-scale quantitative study, utilising one data set, whereas Gottfried et al. utilised a complex, longitudinal data set. However, a similarity (and a strength) of both studies is that they very explicitly state the assumptions they build on and formulate hypotheses to be tested, the latter providing a clear-cut and easily communicable result. A weakness is that such a research design limits the scope of the study to already relatively well-explored phenomena and that negative results are unlikely to be published. Both studies use the term *identity* repeatedly; Taconis and Kessels are interested in the meeting between science culture and identity, and Gottfried et al. discuss how parents' stimulation of children's curiosity may be of importance for children to develop a science identity. However, we note that neither of the studies is a study of identity per se. Rather, they investigate one (or several) aspect that may be conceptualised as components of science identity. Further, the authors use the term *identity* in almost an everyday understanding of the word. Arguably, a more explicit positioning concerning identity would have made it easier for these studies to contribute to the broader literature on science identity.

Theme B: Macro-studies within a sociological tradition

This theme conceptualises identity as something that is socially produced and, as such, shaped by social structures. Wetherell (2010) explains that identity studies have, for a long time, been linked not only to identity as a sense of self, but also linked with group membership. She continues:

For contemporary researchers interested in the representational fields which accompany social classifications and their histories, the study of identity and social location becomes an investigation of the creations of values and distinction, specifying the worth as well as the normative content of possible identities linked to social categories (p. 10).

Methodologically, the most common approach within the theme is large-scale quantitative studies, which seek to establish patterns across large numbers of individuals, often in relation to social categories (such as social class or gender). Examples of such large-scale studies are the ASPIRES projects, which track young people's science and career aspirations, from age 10–19, using surveys and interviews (e.g. Archer et al. 2012a). While quantitative research designs are most frequent within Theme B, there are also studies utilising large-scale collection of qualitative data, such as interviews (Thiry and Laursen 2011).

A total of 15 studies (from the total sample of 198) were categorised as belonging to this theme. One recurring theoretical basis within this approach is Pierre Bourdieu's theory of practice which, while it does not engage with identity per se, does offer important theoretical tools for understanding the reproduction of social inequalities in society. In particular, by engaging with the interplay between agency and structure, his work provides powerful ways of conceptualising how the individual is socially constituted, that is how identity is shaped by social structures. Examples of studies with a theoretical basis in Bourdieu's work are Jennifer DeWitt, Louise Archer and Ada Mau (2016) and Louise Archer et al. (2017). Further, it is also common for studies within Theme B to draw on theories concerning different social categories and their intersections, such as gender theory and intersectionality (Rainey et al. 2018). It can also be noted that there are studies that draw on theoretical developments within the field of science identities, such as Louise Archer et al. (2015), who combine Bourdieu's theory of practice with Heidi Carlone and Angela Johnson's (2007) conceptualisation of identity as performance and recognition.

A benefit of adopting a macro-approach in the sociological tradition is that research studies are able to provide broad overviews, sometimes even on a national scale (by employing representative samples). An example is Maria Vetleseter Bøe (2012), who investigated the relevant importance of different issues for Norwegian students' choice of upper secondary school programme, through a survey of 1,628 students. Bøe (2012) found that students choose science both for identity reasons (such as, interests and self-realisation) and for strategic utility reasons. Further, because of their large-scale character, macro-sociological studies can provide powerful ways to gain sight of structural inequalities and, thereby, provide a strong base for social justice work. An example of this is how the concept of 'science capital' (Archer et al. 2015) was conceived to explain the variation in participation in science: some young people possess knowledge of science and positive attitude towards it, have contacts with people who work in science, and engage in science-related activities in their free time. As a result, they are more likely to consider science as future study or employment. Other students, correlating with those who did not see themselves in a science-related future, had less of these forms of (dominantly valued) science-related capital.

A further strength of adopting this methodological approach is that studies have potential to provide substantial data sets that allow for multiple different types of analyses, from which it is possible to make both statistical and analytical generalizations. The SPIRES studies (Archer et al. 2012b) are a good example of this; the rich and large-scale mixed-methods data sets from the project allows both for different methodological approaches and for different levels of specification in the analyses such that some hone in on gender, ethnicity, or the cultural characteristics of a certain science discipline.

The large-scale nature of the Theme B approach does, however, mean that studies are costly and labour-intensive. Many of the limitations of this theme aligns with those we discussed above for Theme A. Due to the focus on structures, studies employing a macro-sociological approach will inevitably miss local differences and thus not see potential advantages or disadvantages afforded in context. In missing the nuance, the significance of an individual's actions or particular situations, which do not fit into the standardized picture, can be lost. There is also a danger that studies reproduce inequalities, by reinforcing the importance of certain social categories, such as gender or social class.

Below, we select two studies categorised under Theme B and which both approach identity as a sociological construct.

Case studies theme B: mixed-method studies as an entryway to science identities

In her review of 2009, Shanahan advocated for an increased use of mixed-methods studies for understanding the role of identity in science learning. For our exemplars, we have chosen studies that employ different kinds of mixed-method designs in order to investigate how identity is socially produced. In addition, the two case studies have in common the fact that they analytically isolate one factor related to science identity: the focus of Marie-Claire Shanahan and Martina Nieswandt (2011) is on social structures of school science, whereas Katherine Rainey et al. (2018) focus on students' sense of belonging and how this is related to students' decisions to major and remain in STEM.

In a study carried out in Canada, Shanahan and Nieswandt (2011) seek to identify social structures that are specific to school science. Theoretically, the study is positioned within Personality and Social Structure Perspective (PSSP) (Côté and Levine 2002), a meta-theoretical framework that recognises three different levels of analysis (social structure, interaction and personality). The research design consists of an explorative qualitative phase where students' perceptions of the science student are investigated using interviews, and a confirmatory quantitative phase where a survey is used to examine whether the expectations found in the first phase are associated with the science student role rather than a more generalized student role. They found four groups of expectations that differentiated the science student from other expectations at school (intelligence, scientific actions and attributes, scientific skills, and good behaviour). Rainey et al. (2018) also utilised a mix-method approach, but in their case, they collected large-scale qualitative data (201 interviews with US college seniors, who either majored in STEM or started but dropped a STEM major) that were analysed both qualitatively and quantitatively. The analysis considers the intersections of race and gender with students' sense of belonging. They found that students who remain STEM majors report a greater sense of belonging and that students from under-represented groups are less likely to feel that they belong.

For Shanahan and Nieswandt (2011) and Rainey et al. (2018), identity is a key construct and, in a broad sense, both sets of authors approach it within a sociological tradition. Shanahan and Nieswandt (2011) present a complex theoretical build that allows for a nuanced consideration of the relationship between individual and structure and operationalise identity processes as being played out on the different levels of personality, interaction, and social structure. In their study, the focus is on social structures of relevance to the science classroom and herein lies both the methodological strength and weakness of the work: it develops a complex and coherent theoretical framework, but by utilising only one aspect of the framework in the actual analysis, it also renders large parts of the framework somewhat redundant. Rainey et al. (2018) use identity in two different, but related ways: race and gender are described as 'axes of identity' and they also consider 'science identity' (that is, science as part of someone's identity as a person) as one aspect of 'belonging'. In Rainey et al. (2018), the looser use of the concept of identity gives rise to less precision in the analysis, but this is at least partly compensated for by the clarity in the presentation of the empirical results.

Theme C: micro-studies in an interpretive tradition

The studies included in this theme approach identity as something that is individually enacted, albeit in relation to wider social structures. Whether positioned within a more

anthropological or a more linguistic tradition, studies in this theme approach identity as something that is fluid, contested, and always in process, thereby representing a shift in how identity is understood. Wetherell (2010) summarises this shift as follows:

The focus was no longer on single individuals or social groups constituting themselves 'as themselves' through time but on the multiplicity of identity possibilities in any particular situation or context. It became clear that identity positions appeared in fragments, not manifested as entire characters, and changed according to context (p. 15).

Methodologically, the theme is characterised by small-scale qualitative studies, involving detailed examinations of one or a small group of students' identity work. Some of the studies investigate a situation/context as it is, others study the implementation of curricular designs. As such, it is possible to distinguish two sub-themes, where one type of study intervenes, and the other type does not. However, it is not possible to make an absolute distinction between the interventionist and non-interventionist studies as what is to be considered an intervention in one context is deemed everyday practice in another. An example of a non-interventionist study is Nancy Brickhouse and Jennifer Potter (2001) who describe the identity formation of two young women of colour in relation to both their participation and marginalisation in various STEM contexts. Like many studies which adopt a micro-perspective, Brickhouse and Potter (2001) take an ethnographic approach and combine several different means of data collection. Thus, they collected empirical data consisting of classroom observations, interviews, field notes and journals in their three-year longitudinal study. Other studies utilise interviews (Brown 2006) and video-recordings (Reveles and Brown 2008). While most studies predominantly rely on researcher-generated data, there are also studies utilising data generated by the research subjects. For example, Phoebe Jackson and Gale Seiler (2013) make use of reflective journals and online forums, complemented by interviews.

The intervention studies seek to instigate change and sometimes also evaluate the outcome of an intervention. Many of the interventions are explicitly designed to strengthen students' identification with science, for example, through authentic science experiences (Chapman and Feldman 2017) or apprenticeships (Richmond and Kurth 1999). They often seek to bridge students' experiences and cultural knowledge with school science. An example of this is Angela Calabrese Barton and Edna Tan (2009) who investigated students' funds of knowledge in order to build on these in the design of a unit on food and nutrition for students in a low-income urban middle school. There are also studies that utilise findings from macro-studies to design interventions, such as Robynne Lock and Zahra Hazari (2016) who, drawing on a national survey of college students, designed a teaching case study. In an initial survey study, Hazari et al. (2013) had tested commonly proposed suggestions to positively impact female students' choice of a physical science career and found that the only factor that had a positive effect was explicit discussion of women's under-representation in physics. In their subsequent study, Lock and Hazari (2016) designed and implemented lessons discussing women's under-representation in physics with the aim of facilitating female students' physics identity development.

In total, 146 studies out of 198 were categorised as belonging to Theme C, suggesting it to be the most prevalent methodological approach in the field of science learner identities. Theoretically, studies adopting this approach draw on practice theory, often building on the work of Dorothy Holland and colleagues (2001) or the work of Jean Lave and Etienne Wenger (1991). Joseph Polman and Diane Miller (2010) position their study in a line of scholarship that considers 'how identities are dialogically negotiated within cultural

contexts through interactions between individuals as they carry out actions and position one another in relation to cultural norms'. Sometimes, such theoretical starting points are also used in combination with post-structuralist notions of identity as performative (Butler 1993). An example of this is Carlone et al. (2015), who discuss diverse high school youths' engagement in a herpetology summer enrichment program through the lens of identity boundary work which in turn helped the researchers to gain a nuanced understanding of cultural norms, practices and tools. There is also a related, theoretical strand in this wider category drawing on, for example, James Paul Gee (2005), that approaches identity as a discursive practice (e.g. Brown 2006).

One strength of the ethnographically inspired methodologies prevalent within theme C is that they provide very detailed and context-sensitive findings, which enables analytical generalisation. By conducting small-scale studies of a very limited number of subjects, studies which adopt this approach are able to provide in-depth understandings of students' choices, experiences, and aspirations. As such, it is possible to highlight the experiences of individual students and provide nuanced interpretations of the large-scale patterns. For example, Spela Godec (2018), through purposeful sampling of informants, was able to identify discursive strategies that helped working-class girls to identify with science (such as, reframing "science people" as caring and nurturing). A strength of the interventionist studies is that they offer ways to afford change that are founded in research, often drawing on ethnographically inspired studies. For example, in the study by Carlone et al. (2015), the analytical focus was developed organically during an enrichment program, allowing the researchers to work in a context-sensitive way. Their initial, broadly explorative ethnographic approach was later focused onto norms, practices, and tools that encouraged identity boundary work and, finally, a number of 'insights' about how to engage diverse and/or fearful learners in future environmental science initiatives were developed.

Sometimes, researchers also seek to make abstractions from the case studies to develop more broadly applicable models, i.e. analytical generalisation. An example of this is the study by Heidi Carlone, Julie Haun-Frank and Angela Webb (2011), which examined case studies of two carefully chosen classrooms and analysed the normative scientific identity in each classroom, thereafter developing a number of principles for accessible and equitable practice of sharing scientific ideas. A weakness of the methodology in Theme C, however, is the small-scale nature of these studies, and that outcomes provide little or no insights into the distribution of a phenomenon (i.e. statistical generalisation). Further, since findings are often very context-specific, they might not translate easily from one context to another. The interventionist studies are also often normative in the sense that they strive to promote, for example, specific ways of engaging with science (such as the importance of connecting science topics to a school's local context). This can potentially be a weakness, in that such studies are most likely to be picked up by teachers, researchers and stakeholders who already share a similar agenda.

Below, we first present two examples of non-interventionist studies within Theme C and then two interventionist studies.

Case studies theme C1: Interpretive studies with original theoretical vantage points

A common theoretical inspiration among studies in Theme C is practice theory, and methodologically many studies conduct analyses of individual students' identity work. Here, we have chosen to showcase two studies that take unusual theoretical or methodological approaches. Joanna Kidman, Eleanor Abrams and Hiria McRae (2011) is an interview

study with secondary school Maori students that draws on the work of Basil Bernstein, while Jenny Arnold (2012) uses video-recordings and video-stimulated interviews to investigate the classroom discourse in an Australian secondary school science classroom.

The purpose of Kidman, Abrams and McRae (2011) is ‘to identify the ways in which children from diverse indigenous communities position themselves as learners in relation to science curricula’. However, in contrast to many other studies in Theme C, Kidman, Abrams and McRae (2011) utilise a theoretical framing that brings issues of power as connected to knowledge to the fore. Drawing on Bernstein (2000), they argue that the recontextualisation of science knowledge to school science needs to be understood as an ideological process, and that the interconnection of power and knowledge be carefully analysed. In particular, they highlight that while many interventions have been concerned with the cultural micro-level interaction in the classroom, this ‘often comes at the expense of a close analysis of the classification of knowledge within the curriculum itself’ (p. 204). That is, interventions seeking to address the disengagement of indigenous students have sometimes resulted in tokenistic activities ‘celebrating’ ethnic diversity (such as food fairs), rather than politicising knowledge–power relations within the science curriculum. Thus, Kidman, Abrams and McRae make an interesting methodological contribution in relation to studies in Theme C, by highlighting how micro-level interactions in the classroom are connected to more over-arching power relations.

The core interest of Arnold’s (2012) study is how students make meaning in secondary school science: the study is strongly framed using identity research and seeks to understand how students position themselves as participants in science. Identity is not used as an analytical approach (or even studied as an empirical phenomenon), instead, the paper utilises positioning theory (Harré and van Langenhove, 1999) to approach questions of high relevance to identity research. In particular, the detailed discourse analysis makes a methodological contribution to the field. At a first glance, both papers look like yet another small-scale case study, analysing how a particular group of students or a student relate to science. However, the unusual theoretical and methodological approaches make the studies stand out. That said, the potential of the theoretical framing in Kidman, Abrams and McRae (2011) is not really carried through the study as a whole. The young research participants obviously find it difficult to talk about science in an interview situation, giving rise to a not particularly nuanced empirical dataset and an analysis that largely focuses on the students’ stereotyping of scientists as white men. Nonetheless, we would argue that with a ‘thicker’, nuance-filled empirical dataset, their theoretical framing is very promising in terms of highlighting issues of power. In Arnold (2012), the empirical data are rich and allow for a detailed discourse analysis, but the reader is left with a sense of inconclusiveness in terms of interpretation and implications of the analysis. The theoretical framework is very well-suited in terms of providing a detailed account of the classroom events, but could have been complemented with a theory that would have provided a stronger interpretative stance—such as the Bernsteinian approach used by Kidman, Abrams and McRae (2011).

Case studies theme C2: utilising identity perspectives to design curricular interventions

The studies by Katie van Horne and Phillip Bell (2017) and Junjun Chen and Bronwen Cowie (2013) develop and analyse curricular units based on identity theory, and in doing so combine a teaching intervention with an ethnographically inspired study. van Horne and

Bell (2017) is situated in a US secondary school setting and concerned with a genetics unit about infectious disease, that included working on a computational model of infectious disease spread. The unit was designed with the explicit aim of developing science identities, working from an assumption that stabilised identities result from numerous events that occur over time and space. The authors develop a complex model of ‘disciplinary identification’ drawing on ecological, sociocultural and social practice theory perspectives on learning. The design of the genetics course drew analytically on the concept of celebrated identity positions (i.e. student performances that are valorised in the science classroom), and sought to promote identity work that challenges typical identity work of school science by, for example, leveraging youths’ existing identities. The design principles are built around different identity resources (material, ideational and relational) from Na’ilah Nasir and Jamal Cooks (2009). The empirical data consisted of student work and online posts, lesson plans, class performance data for the students, video-recordings and fieldnotes. The findings are presented in the form of case studies of two students that illustrate the identity work taking place during the designed unit.

Chen and Cowie (2013) focused on a butterfly unit in a New Zealand primary classroom. The teaching unit was designed to allow students to understand and develop an identity as a citizen scientist. Identity is, following Jay Lemke (2000), understood as encompassing how students understand who they are and who they might be as well as how others think about them. The empirical data consisted of video and audio recordings of lessons, field notes, teaching materials and student work, and were collected to provide a rich description of classroom events. These data were complemented with student interviews, directly after the teaching unit and six months later. One conclusion proposed by Chen and Cowie (2013) is that:

The focus on students being and becoming citizen scientists meant the students experienced that they could make a difference as ‘scientists’ through ‘being there’ experiences in the school grounds, around their homes, at camp and by posting data on a national website. In this way, students came to see and experience themselves in science as making a contribution. (p. 2173).

While van Horne and Bell (2017) and Chen and Cowie (2013) are very similar in terms of the basic design of the studies and also broadly take a similar theoretical approach to identity, they are very different in terms of theoretical complexity. van Horne and Bell (2017) builds a highly complex model of disciplinary identification, in order to conceptualise how identities stabilise and destabilise over time and across contexts, that then is operationalised into a number of design principles. Chen and Cowie (2013) more or less operate with an everyday understanding of identity. As such, the studies are almost to be found on the extremes of how identity can be theorised, but the interesting thing is that both approaches work really well. In the case of Chen and Cowie (2013), the theoretical simplicity is compensated for with a very precise notion of what identity the unit aims for the students to develop. As such, identity is less of a theoretical/analytical construct and more of a way to express an empirical learning goal. Thereby, the study shows that a concept of identity (and an idea of what identity you would like your students to develop) can be useful as a design principle, even without all the theoretical bells and whistles. van Horne and Bell (2017) integrate the teaching design and the theoretical framework in an excellent manner, but, in their analysis of the empirical data, the consideration of power relations that ought to be integral to the notion of ‘celebrated identity positions’ is not followed through fully. Both students that are chosen as case studies had a strong affiliation with science and/or technology before the intervention, and the consideration of how to

support disciplinary interests and identities for students who do not already have a strong affiliation with STEM is limited.

Taken together, the two studies show the usefulness of identity in constructing design principles, and that both more and less elaborate theoretical approaches to identity can be fruitful, as long as the aim of a teaching unit is clearly defined.

Summary of Results

In the analysis of the papers, we identified three main research traditions: psychological macro-studies (Theme A), sociological macro-studies (Theme B), and interpretive micro-studies (Theme C). Overall, interpretive micro-studies arguably currently dominate the science identities field, with 146 of the analysed 198 papers being categorised as such. Psychological macro-studies amount to 36 studies and sociological macro-studies to 15 studies. Consequently, this field is still dominated by small-scale, qualitative case studies, in accordance with what has been found in previous reviews. The relative strengths and limitations of the three themes are summarised in Table 4 as follows.

Discussion

In the main body of this paper, we have categorised research studies into three methodological approaches and have discussed the affordances and limitations of each. The current patterns within scholarship have particular implications for educational research, and also for educational policy and practice. We highlight three such implications below.

Methodological homogeneity and blank spots

During the past twenty years or so, the field of science education research has seen an increased interest in issues of identity, with influential papers (e.g. Brickhouse et al. 2000) cited in the hundreds. But, while the field of science identities research has grown considerably since Shanahan's review in 2009, our analysis suggests that the majority of studies are still small-scale qualitative ones, drawing on anthropological perspectives of identity (e.g. Holland et al. 2001). As we have demonstrated, research predominantly involves case studies documenting the identity formation of a few individuals, and provide detailed accounts of how those individuals are positioning themselves, and being positioned by others, relative to science. Empirically, research is dominated by traditional data generation methods (interviews, ethnographic observations, surveys), although recently, technological developments have afforded new tools for data collection, for example the use of video-diaries and the use of social media (Höttecke and Allchin 2020). In generating detailed case studies, few experimental or quasi-experimental studies are conducted, with only one or two notable exceptions (Marchand and Taasobshirazi 2013). This preference contrasts starkly with the majority of research in science education writ large, which includes a larger proportion of quantitative studies and draws on a wider range of methodological approaches. Science identities work can thus be regarded as relatively homogeneous, though the lack of studies using detailed micro-analysis of interactions (inspired by, e.g. conversation analysis or discourse psychology) is somewhat surprising (an example of an exception is Brown 2004).

Table 4 Strengths and limitations of themes A, B and C

	Number of studies	Strengths	Limitations
Theme A: Macro-studies within a psychological tradition	36 of 198	<p>Statistical generalizable results</p> <p>Use of validated instruments allows scaling to new contexts and populations</p> <p>Hypothesis testing generates clear-cut results</p> <p>Easily communicable results, e.g. to policy-makers</p>	<p>Not possible to take contextual nuances into account</p> <p>Identity is often not clearly defined, but explored via proxy concepts such as self-efficacy</p> <p>May reproduce stereotypical notions of groups of individuals</p>
Theme B: Macro-studies within a sociological tradition	15 of 198	<p>Statistical and analytical generalizable results</p> <p>Identification of structural inequalities</p> <p>Rich data that allows for multiple different types of analysis</p>	<p>Costly and labour-intensive</p> <p>Individuals who do not fit into the over-arching patterns identified may be invisible</p> <p>May reproduce inequalities, by reinforcing the importance of social categories</p>
Theme C: Micro-studies in an interpretive tradition	146 of 198	<p>Analytical generalizable results</p> <p>Detailed and context sensitive findings</p> <p>Interventionist studies offer ways to afford change</p>	<p>Results do not allow for statistical generalizations</p> <p>Dominated by a few theoretical perspectives</p> <p>Interventionist studies are normative and are most likely to be picked up by teachers, researchers and stakeholders who already share a similar agenda</p>

The benefit of a methodologically homogeneous approach is that an established structure and framework is readily available for the design of subsequent studies. However, homogeneity can also be a disadvantage: if work remains too funneled towards ethnographic and anthropological studies (in the tradition of scholars such as Dorothy Holland and Jean Lave), there is a danger that researchers will not see the affordances offered by other approaches. The distinction between blank and blind spots in research (Wagner 1993) can help us think about this issue. A blank spot is an area of research where we have enough knowledge to form the questions, but not yet the answers, whereas blind spots are 'areas in which existing theories, methods, and perceptions actually keep us from seeing phenomena as clearly as we might' (p. 16). In the context of science identities research, it is useful to consider blank and blind spots across the wider field (i.e. all three identified approaches) and with particular respect to the dominant approach of micro-studies within an interpretive tradition (Theme C). As we have argued, the preponderance of case studies has tended to make the field blind to other approaches. In highlighting a number of lesser cited papers and methodological outliers, we hope to have reduced the number of blind spots besetting the field. For example, we have drawn attention to papers that represent unusual approaches for the field in terms of research paradigm (hypothesis testing (Taconis and Kessels 2009)); research design (quasi-experimental study (Means et al. 2016); mixed method study (Rainey et al. 2018)); analytical framework (discourse analysis (Arnold 2012)) and theoretical approach (Bernstein's research on power relations in education (Kidman, Abrams and McRae 2011)).

Important blank spots in the field at large include research addressing social categories and identities beyond gender, ethnicity and social class. Research from a greater variety of national contexts (particularly the Global South) may also comprise a blank spot, but here we again note that our review focused on English-language papers only, and as a result inevitably omits many, potentially interesting, publications.

In the development of the field, it is important to find a balance between breadth and depth when approaching blank and blind spots. Identifying blind spots can be highly productive for pushing the boundaries of the field, and allowing hitherto unexplored questions to be approached. Addressing blind spots broadens the field. In contrast, identifying and investigating questions representing blank spots, which involves building on current approaches and theoretical frameworks, makes it possible to build a denser state of knowledge, thus deepening the field.

The issue with (under)conceptualisation of science identity.

The concept of identity is used broadly, both in a variety of academic disciplines and in everyday speech: as Darinka Radovic et al. (2018) have commented, the term can be slippery. It could also be described as somewhat baggy. For example, while identity is often theorised as a *perspective* (see for example, Calabrese Barton and Tan's (2010) use of identity in a framework drawing on Holland et al.'s (2001) notion of figured worlds), it is frequently also used in a looser sense to describe an empirical *phenomenon*. For example, Means et al. (2016) (categorised as Theme A) use 'science identity' quite frequently in the paper, but seem to assume that what it is can be taken for granted, and thus, it is not conceptualised beyond the explanation of being one's 'identity as a person who does science'. Such taken-for-grantedness or under-conceptualisation assumes that identity essentially is a phenomenon that be captured or measured rather than a perspective that, firstly, can be

conceptualised in different ways (as, for example, performative or socially constructed), and, secondly, used to understand events, (for example, inclusionary/exclusionary practices or aspirations) rather than necessarily being the focus of the investigation in itself.

Clearly, the broad range of studies that we have reviewed—from those that adopt identity as a perspective to those that view identity as a phenomenon—have value in that they have made fruitful contributions to scholarship and wider understanding related to the science education of learners. However, to avoid the impossibility of defining identity as being two things at once, we would argue that there is need to put looser articulations to one side. Research needs to move away from the exploratory phase, wherein identity provides a broad perspective for experimental thinking. Too many papers are proposing new theoretical frameworks, and too few are empirically justifying and validating such conceptualisations. There is now a need to fully operationalise perspectives on identity, and be clear and definite with respect to our articulations and applications. Precision and clarity in how ‘identity’ (and related concepts) is operationalized also serve the purpose of not losing the analytical sharpness of the work, avoiding the danger of turning ‘identity’ into nothing more than a ‘buzz word’ suggesting no more than a nod to the importance of equity, diversity, and inclusion.

Consequently, we would advocate for keeping an openness to what ‘identity’ can offer in science education research, but also encourage the inclusion of clear definitions/descriptions of concepts such as identity, structure, agency, and performativity in order for studies to more easily build on one another. Indeed, a joint frame of reference could be located in a conceptual core notion of identity as constituting performance and recognition. This could be further complemented, when necessary, with other theoretical concepts/tools from, for example, sociology or sociolinguistics. By doing so, the field would establish theoretical coherence: studies would utilise the same concepts, thereby aiding the building of cumulative knowledge across studies.

Scaling up and scaling down to inform policy and practice

In conducting this review, we analysed 198 studies and found that the large majority comprised small-scale case studies. Small-scale case studies can provide very detailed examinations of individual teaching and learning situations, not to mention important nuancing of generalisations made in large-scale quantitative studies (Gonsalves 2014) or policy critique (Mendick, Berge and Danielsson 2017). Yet, it is noticeable that even when research-based instructional strategies have proven to be very successful in improving students’ conceptual understanding and their reasoning, the adoption of such strategies more broadly is still low (Fraser et al. 2014). Furthermore, while qualitative accounts may allow readers to apply findings to their own contexts, the onus of transferability still lies with the researcher. To this end, a research design that allows a degree of scaling up from one’s study is essential. Scaling out and applying insights to neighbouring subfields are also important: Maria Vetleseter Bøe, Ellen Karoline Henriksen and Carl Angell (2018) have shown that students are more likely to adopt innovative approaches (in this instance in physics), if they resembled what they were used to from traditional science classrooms. Consequently, we argue that attentiveness to how curriculum and content can be designed in order to adapt to and transform a (local) disciplinary culture is key. We also call for greater consideration being paid to how a local initiative may be developed for a larger group of students and educators, in ways that allow for adaptation to the contingent aspects of a teaching situation (Wickman 2012).

Thus, we would argue that the field of science identities research has a lot to gain from an increased attentiveness to the scaling of findings and the use of conceptual models, as Cynthia Coburn (2003) has advocated. An example of the development of such a conceptual model is the work by Johnson (2020) who, in a detailed, ethnographic study, documented the culture of a physics department and the way it moves between interpersonal, cultural, and structural domains, including how different axes of power intersect with these domains. Johnson's analysis thus balanced the context-sensitive account of a particular setting with how these relate to more over-arching domains. However, here, we note that scaling up is not just about extending findings and models from one teaching and learning context to other contexts of a similar kind, it can also be about using data, analyses, and models to inform policy. Scaling can also include the application of findings and theoretical developments to new (national) contexts. Here, the dominance of US scholars in the field (66% of reviewed papers) presents a challenge to scholars aiming to extend their citation practices. Given that a strength of the small-scale qualitative studies that dominate the field is their sensitivity to situational and contextual circumstances, it can be tempting to predominantly cite authors in similar contexts. Here we would argue that both authors and those who cite have a responsibility in considering what is in fact transferable from a certain study, both in order to avoid routine citations of U.S. work without considering the applicability to the author's context and in order to underscore the applicability (and citability) of work from a variety of national contexts.

In addition to scaling up, there is also a need for the larger quantitative studies to scale down: what, for example, do statistical analyses of large populations mean for an individual teacher in a particular context? This takes transformation work both on the part of the researcher and the teacher; if a too formulaic approach to implementation is utilised by researchers, this may lead to the discrete rationale being lost. Conversely, if researchers do not dare to cross the theory–practice divide, it is arguably a lot to expect educators to do so. A middle ground may be to develop research findings as an intellectual guidance for teachers. The science capital teaching approach (Godec, King and Archer 2017), which grew from the large scale/quantitative study ASPIRES, is one example. It provides approaches, not instructions. Nonetheless, it requires work on the part of the teacher to make it their own and can fail to be adopted. Clearly, finding the balance here is key. Realistically, such a balance will only be achieved following greater work which seeks to explore the application of theorisations in practice and shares null findings and failures as well as successes.

Limitations and further research

In 1998—the start of our review period—work on identity was a marginal (and marginalized) part of science education research. In the twenty-year period since, the work has not only grown, but also become a mainstream part of science education research. In using Web of Science, our review has been geared towards research that has been published in mainstream academic journals. However, this has necessarily meant that studies published in the grey literature of practitioner-oriented publications, blogs, pod casts and zines have not been reviewed. Here, we accept that the genre of journal publication may be distorting research and scholarship, in that required format for publication essentially encourages the easily packaged and the un-ambiguous result (see discussion in Ritchie 2022). That said, our review purposefully sought to take stock of the field of *academic* science identity

research which we defined as that being shaped in and by academic journal publications. The boundaries of our review are consequently set by what is perceived as worthy of publishing in academic journals. While this could be seen as a limitation, we would also note that in order to allow for cumulative knowledge production, it is important to stay within a framework of a common academic language and common theorisations. Nonetheless, we suggest that a productive future extension of the current research review would be to look beyond academic publications and explore how identity research is developed and understood by practitioners and activists.

A fundamental limitation of many research reviews, this one included, is that the focus is on the nature and direction of research, and not what shapes this direction such as funding streams, institutional resources and individual/institutional politics. Moreover, we fully accept that researchers may be consciously or unconsciously biased by particular trends in research directions indeed in conducting our review we were not blind to the relative frequency of some citations of scholars over others. While beyond the scope of our present study, we suggest that a longitudinal network analysis of citations would be useful in understanding which publications have become nodes in the research community over time (Smith & Brown 2020). Following this, an analysis of the politics of citation (Delgado 1984) in the field of science identities research could shine light on both whose ideas succeeded in shaping the field and quite what this dominance has meant for others attempting to gain a foothold in the field. The canon of science identities research may not be shaped by white men, but it does not mean that the structure of this field is immune to inequalities. Citing the important players in the field is a way to gain recognition. A potentially significant extension of this research review would thus be an analysis of citation practices in the field of science identities research, focused on how such practices accentuate certain scholars and ways of thinking, and in turn limit the exposure of others. As pointed out by Ahmed (2013), citations can be seen as ‘a rather successful reproductive technology, a way of reproducing the world around certain bodies’.

Where next for science identity research?

Considering the findings we discussed in this paper, we offer the following recommendations for the field:

- 1) Address the limitations created by a methodological homogeneity, where ethnographically inspired small-scale case studies have become so abundant that other methodological approaches are being missed and may be lost.

We see value in continuing to explore different methodological approaches, including those informed by wider identity literature that may not have been adopted in the science identities research. In selecting less cited and perhaps more unusual studies as our case studies, we have offered insight into the potential of less common approaches to studying science identities. Further, we would also urge scholars to engage in wider conversation, such as across different methodological approaches, in order to better build on each other’s work. In addition, we would urge scholars to reflect on the existence of politics of citation and engage in wider conversations—particularly across different national contexts (given the stark dominance of U.S. scholars in the field).

- 2) Work towards clearer and more coherent conceptualisations of identity, in order to contribute to cumulative knowledge.

Under-conceptualisation of identity not only leads to ambiguity in findings, but also makes it more difficult for studies to build on one another. We suggest finding a better balance between exploratory case studies and building on existing work (in terms of, for example, utilising the same theoretical framework) in order to contribute to cumulative knowledge.

- 3) Pay increased attention to the translation of research into practice, both in terms of making large-scale quantitative studies useful for teachers, and small-scale qualitative studies useful for policy-makers.

Increased efforts should be made to translate research for policy and practice, including seeking out and learning from accounts published in practitioner literature. Interventionist studies, in particular, are arguably ripe for informing approaches for better supporting young people's identity work more broadly and could lead the way in building impact.

In this review, we have shown a light on the variety of traditions in play and the strengths and weaknesses of each. In highlighting the relative prevalence of different methodologies in our sample, we hope that researchers will have a clearer sense of their place in research and see how their contributions can enable scholarship to mature, expertise to develop and specialisms to grow. We also hope that the instigation of greater methodological clarity in this field will support and foster greater responsibility for application of research ideas into practice.

Appendix 1 The overview of methods used in studies included in this paper

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Gilmartin, Shannon; Denson, Nida; Li, Erka; et al.	2007	Gender ratios in high school science departments: The effect of percent female faculty on multiple dimensions of students' science identities	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Mixed-method study (longitudinal survey (N=1,000) + Interviews (N=59))	US	Secondary	Formal	A
Taconis, Ruurd; Kessels, Ursula	2009	How choosing science depends on students' individual fit to 'science culture'	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Survey (N=54)	The Netherlands (comp with Germany)	Secondary	Formal	A
Falk, John H.; Storksdieck, Martin	2010	Science learning in a leisure setting	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=52)	US	Adult	Informal (science centre)	A
Hazari, Zahra; Somert, Gerhard; Sadler, Philip M.; Shanahan, Marie-Claire	2010	Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: a gender study.	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=3,829)	US	Secondary	Formal	A
Boe, Maria Vellesester	2012	Science choices in Norwegian upper secondary school: what matters?	SCIENCE EDUCATION	Survey (N=1,628)	Norway	Secondary	Formal	A
Marchand, Gwen C.; Taasobshirazi, Gita	2013	Stereotype threat and women's performance in physics	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Quasi-experiment (N=312)	US	HE	Formal	A
Andersen, Hanne Moeller; Krogh, Lars Brian; Lykkegaard, Eva	2014	Identity matching to scientists: differences that make a difference?	RESEARCH IN SCIENCE EDUCATION	Mixed method (Interviews (N=499) & survey (N=approx. 880))	Denmark	Secondary	Formal	A

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Andersen, Lori; Ward, Thomas J.	2014	Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students: a comparison between Black, Hispanic, and White students	SCIENCE EDUCATION	Survey (N=1,757)	US	Secondary	Formal	A
Kier, Meredith W.; Blanchard, Margaret R.; Osborne, Jason W.; et al.	2014	The development of the STEM career interest survey (STEM-CIS)	RESEARCH IN SCIENCE EDUCATION	Survey (N=1061)	US	Secondary	Formal	A
Ing, Marsha	2014	Gender differences in the influence of early perceived parental support on student mathematics and science achievement and STEM career attainment	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Survey (N=3,000)	US	Secondary	Informal	A
Jack, Brady Michael; Lin, Huang-Shiyang; Yore, Larry D.	2014	The synergistic effect of affective factors on student learning outcomes	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=31,461)	Taiwan and Canada	Secondary	Formal	A
Yang, Kuay-Keng; Hong, Zuway-R; Liu, Ming-Chin; et al.	2015	Exploring the role of visitors' self-identity in marine museum learning	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION PART B-COMMUNICATION AND PUBLIC ENGAGEMENT	Mixed-method study (survey (N=144) & interview (N=17))	Taiwan	Secondary & Adult	Informal	A
Robnett, Rachael D.; Chemers, Martin M.; Zurbriggen, Eileen L.	2015	Longitudinal associations among undergraduates' research experience, self-efficacy, and identity	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=251)	US	HE	Formal	A

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Conner, Laura D. Carstair, Danielson, Jennifer	2016	Scientist role models in the classroom: how important is gender matching?	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Mixed-method study (N=238)	US	Primary & Secondary	Formal	A
Means, Barbara; Wang, Harwen; Young, Viki; et al.	2016	STEM-focused high schools as a strategy for enhancing readiness for postsecondary STEM programs	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Quasi-experimental (N=17 schools)	US	Secondary	Formal	A
Gottfried, Adele Eskeles; Preston, Kathleen Suzanne Johnson; Gottfried, Allen W.; et al.	2016	Pathways from parental stimulation of children's curiosity to high school science course accomplishments and science career interest and skill	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Survey/test (N = 118)	US	Primary + Secondary	Informal and Formal	A
Kouli, Ravinder; Lerdpoikulrat, Thanita; Poondej, Chanut	2016	Gender compatibility, math-gender stereotypes, and self-concepts in math and physics	PHYSICAL REVIEW EDUCATION RESEARCH	survey (N=170)	Thailand	Secondary	Formal	A
Falk, John H.; Dieking, Lynn D.; Swanger, Lisa Prendergast; et al.	2016	Correlating science center use with adult science literacy: an international, cross-institutional study	SCIENCE EDUCATION	Survey (N=6,089)	US	Adult	Informal	A

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Jennifer, Santer, Jennifer, Singer, Silvia; Solli, Anne; et al.								
Falk, John H., Staus, Nancy; Dierking, Lynn D.; et al.	2016	Understanding youth STEM interest pathways within a single community: the Synergies project	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION PART B: COMMUNICATION AND PUBLIC ENGAGEMENT	Survey (N=85)	US	Secondary	Formal	A
Thomas, Almut E.	2017	Gender differences in students' physical science motivation: are teachers' implicit cognitions another piece of the puzzle?	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Quasi-experiment (N=1,686)	Austria	Secondary	Formal	A
Skinner, Ellen; Saxton, Emily; Currie, Caitlin; et al.	2017	A motivational account of the undergraduate experience in science: brief measures of students' self-system appraisals, engagement in coursework, and identity as a scientist	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Survey (N=1,013)	US	HE	Formal	A
Benjamin, Thomas E.; Marks, Bryant; Demetriopoulos, Melissa K.; et al.	2017	Development and validation of scientific literacy scale for college preparedness in STEM with freshmen from diverse institutions	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Survey (N=1,349)	US	Secondary & HE	Formal	A

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Alicia, Muldrow, Lycurgus L.								
Vincent-Ruz, Paultette; Schunn, Christian D.	2017	The increasingly important role of science competency beliefs for science learning in girls	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=2,900)	US	Secondary	Formal and Informal	A
Means, Barbara; Wang, Harwen; Wei, Xin, et al.	2017	Expanding STEM opportunities through inclusive STEM-focused high schools	SCIENCE EDUCATION	Survey (N=5,100)	US	Secondary	Formal	A
Childers, Gina; Jones, M. Gail	2017	Learning from a distance: high school students' perceptions of virtual presence, motivation, and science identity during a remote microscopy investigation	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Survey (N=72)	US	Secondary	Formal (online)	A
Jones, M. Gail; Childers, Gina; Andre, Thomas; Corin, et al.	2018	Citizen scientists and non-citizen scientist hobbyists: motivation, benefits, and influences	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION PART B-COMMUNICATION AND PUBLIC ENGAGEMENT	Mixed-method study (interviews (N=207) & survey (N=2,864))	US	Adult	Informal	A
Dou, Remy; Brewe, Eric; Powin, Geoff; et al.	2018	Understanding the development of interest and self-efficacy in active-learning undergraduate physics courses	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Other (social network surveys) (N=221)	US	HE	Formal	A

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Solanki, Sabrina M.; Xu, Di	2018	Looking beyond academic performance: the influence of instructor gender on student motivation in STEM fields	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Other (N=9,766)	US	HE	Formal	A
Vincent-Ruz, Paulette; Schunn, Christian D.	2018	The nature of science identity and its role as the driver of student choices	INTERNATIONAL JOURNAL OF STEM EDUCATION	Survey (N=1,300)	US	Secondary	Formal	A
Williams, Difafruz R.; Brule, Heather; Kelley, Sybil S.; et al.	2018	Science in the Learning Gardens (SciLG): a study of students' motivation, achievement, and science identity in low-income middle schools	INTERNATIONAL JOURNAL OF STEM EDUCATION	Survey (N=113)	US	Primary & Secondary	Formal	A
Wang, Jianlan; Hazzani, Zahra	2018	Promoting high school students' physics identity through explicit and implicit recognition	PHYSICAL REVIEW EDUCATION RESEARCH	Survey (N=134)	US	HE	Formal	A
Seyranian, Viviane; Madva, Alex; Duong, Nicole; et al.	2018	The longitudinal effects of STEM identity and gender on flourishing and achievement in college physics	INTERNATIONAL JOURNAL OF STEM EDUCATION	survey (N=200)	US	HE	Formal	A
Hills, Alexis; Part, Rachel; Bernacki, Matthew L.	Jul-05	The roles of social influences on student competence, relatedness, achievement, and retention in STEM	SCIENCE EDUCATION	Survey (N=206)	US	HE	Formal	A
Piatek-Jimenez, Katrina; Cribbs, Jennifer; Gill, Nicole	2018	College students' perceptions of gender stereotypes: making	INTERNATIONAL JOURNAL OF	Survey (N=499)	US	HE	Formal	A

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		connections to the underrepresentation of women in STEM fields	SCIENCE EDUCATION					
Gottlieb, Jessica J.	2018	STEM career aspirations in Black, Hispanic, and White ninth-grade students	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=18,000)	US	HE	N/A	A
Robnett, Rachael D.; Nelson, Paul A.; Zurbruggen, Eileen L.; et al.	2018	Research mentoring and scientist identity: insights from undergraduates and their mentors	INTERNATIONAL JOURNAL OF STEM EDUCATION	Survey (N=66)	US	HE	Informal (mentorship, research, apprenticeship)	A
Thiry, Heather; Laursen, Sandra L.	2011	The role of student-advisor interactions in apprenticing undergraduate researchers into a scientific community of practice	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Interviews (N=110)	US	HE	Formal	B
Shanahan, Marie-Claire; Nieswandl, Martina	2011	Science student role: evidence of social structural norms specific to school science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Mixed-method study (survey (N=95) & interviews (N=157))	Canada	Secondary	Formal	B
DeWitt, Jennifer; Archer, Louise; Osborne, Jonathan; et al.	2011	High aspiration but low progression: the science aspirations-careers paradox amongst minority ethnic students	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Survey (N=300)	UK	Primary	Formal	B

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Archer, Louise; DeWitt, Jennifer; Osborne, Jonathan; et al.	2012	Science aspirations, capital, and family habitus: how families shape children's engagement and identification with science	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Mixed-method study (survey (N=approx. 9,000) & longitudinal interviews (N=160))	UK	Secondary	Formal	B
Hughes, Roxanne M.; Nzekwe, Brandon; Molyneux, Kristen J.	2013	The single sex debate for girls in science: a comparison between two informal science programs on middle school students' STEM identity formation	RESEARCH IN SCIENCE EDUCATION	Mixed-method study (survey, interviews & observations (N=59))	US	Secondary	Informal	B
Archer, Louise; DeWitt, Jennifer; Willis, Beatrice	2014	Adolescent Boys' Science Aspirations: Masculinity, Capital, and Power	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Mixed-method study (survey (N=14,600) & interviews (N=177))	UK	Primary & Secondary	Formal	B
DeWitt, Jennifer; Archer, Louise; Osborne, Jonathan	2014	Science-related aspirations across the primary-secondary divide: evidence from two surveys in England	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Mixed-method study (survey (N=14,600) & interviews (N=85))	UK	Secondary	Formal	B
Archer, Louise; Dawson, Emily; DeWitt, Jennifer; et al.	2015	Science capital: a conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the Arts	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=3,658)	UK	Secondary	Formal	B
Brown, Bryan A.; Henderson, J. Bryan; Gray, Salina; et al.	2016	From description to explanation: an empirical exploration of the African-American	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Survey (N=611)	US	HE & Professional	Formal	B

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Patterson, Alexis; Wagstaff, William		pipeline problem in STEM						
DeWitt, Jennifer; Archer, Louise; Mau, Ada	2016	Dimensions of science capital: exploring its potential for understanding students' science participation	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Survey (N=7,463)	UK	Secondary	Formal	B
Blank, Lisa M.; Almquist, Heather; Estrada, Jen; et al.	2016	Factors affecting student success with a Google Earth-based earth science curriculum	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Intervention (N=233)	US	Secondary	Formal	B
DeWitt, Jennifer; Archer, Louise	2017	Participation in informal science learning experiences: the rich get richer?	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION PART B: COMMUNICATION AND PUBLIC ENGAGEMENT	Mixed-method study (survey (N=5,961) & interviews (N=500))	UK	Secondary	Informal	B
Archer, Louise; Moore, Julie; Francis, Becky; et al.	2017	The exceptional physics girl: a sociological analysis of multimethod data from young women aged 10-16 to explore gendered patterns of post-16 participation	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Mixed-method study (survey (N=approx. 13,000) & interviews (N=70))	UK	Secondary	Formal	B
Rainey, Katherine; Dancy, Melissa; Mickelson, Roslynn; et al.	2018	Race and gender differences in how sense of belonging influences decisions to major in STEM	INTERNATIONAL JOURNAL OF STEM EDUCATION	Mixed-method study (interviews & graphical representation (N=2011))	US	HE	Formal	B
Godec, Spela; King, Heather; Archer, Louise; et al.	2018	Examining student engagement with science through a Bourdieusian notion of field	SCIENCE & EDUCATION	Observation-based study (N=14)	UK	Secondary	Formal	B

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Calabrese Barton, Angela	1998	Teaching science with homeless children: pedagogy, representation, and identity	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=3)	US	Secondary	Informal (after school programme)	C
Richmond, Gail; Kurth, Lori A.	1999	Moving from outside to inside: high school students' use of apprenticeships as vehicles for entering the culture and practice of science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=27)	US	Secondary	Formal	C
Brickhouse, Nancy W.; Lowery, Patricia; Schultz, Katherine	2000	What kind of a girl does science? The construction of school science identities	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=4)	US	Secondary	Formal and Informal	C
Hughes, Gwyneth	2001	Exploring the availability of student scientist identities within curriculum discourse: an anti-essentialist approach to gender-inclusive science	GENDER AND EDUCATION	Interviews (N=6)	UK	Secondary	Formal	C
Brickhouse, Nancy W.; Potter, Jennifer T.	2001	Young women's scientific identity formation in an urban context	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=2)	US	Secondary	Formal, Informal	C
Norman, Obed; Ault Jr.; Charles R.; Benz, Bonnie; et al.	2001	The black-white achievement gap as a perennial challenge of urban science education: A sociocultural and historical overview with implications for research and practice	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=24)	US	Secondary		C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Gilbert, Andrew; Yerrick, Randy	2001	Same school, separate worlds: A sociocultural study of identity resistance, and negotiation in a rural, lower track science classroom	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=9)	US	Secondary	Formal	C
Kozoll, Richard H.; Osborne, Margery D.	2004	Finding meaning in science: lifeworld, identity, and self	SCIENCE EDUCATION	Interviews (N=5)	US	HE	Formal	C
Revelles, John M.; Cordova, Ralph; Kelly, Gregory J.	2004	Science literacy and academic identity formulation	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=17)	US	Primary	Formal	C
Carlone, Heidi B.	2004	The cultural production of science in reform-based physics; girls' access, participation, and resistance	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=28)	US	Secondary	Formal	C
Brown, Bryan A.	2004	Discursive identity: Assimilation into the culture of science and its implications for minority students	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (video-observation (N=2 school classes))	US	Secondary		C
Elgar, Ann G.	2004	Science textbooks for lower secondary schools in Brunei: issues of gender equity	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Other (text analysis)	Brunei	Secondary	Formal	C
Miller, Brant G.; Roehrig, Gillian	2005	Indigenous cultural contexts for STEM experiences: snow snakes' impact on students and the community	CULTURAL STUDIES OF SCIENCE EDUCATION	Intervention (N=14)	US	Primary	Formal	C
Tapia, Ingrid Sanchez; Krajcik, Joseph; Reiser, Brian	2005	We do not know what is the real story anymore: Curricular contextualization principles that support	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Intervention (N=80; N=6; N=42)	Mexico	Primary	Formal	C

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		indigenous students in understanding natural selection						
Russell, Melody L.; Atwater, Mary M.	2005	Traveling the road to success: a discourse on persistence throughout the science pipeline with African American students at a predominantly White institution	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=11)	US	Secondary & HE	Formal	C
Tobin, Kenneth	2005	Building enacted science curricula on the capital of learners	SCIENCE EDUCATION	Observation-based study	Australia	Secondary	Formal	C
Brown, Bryan A.; Revelles, John M.; Kelly, Gregory J.	2005	Scientific literacy and discursive identity: A theoretical framework for understanding science learning	SCIENCE EDUCATION	Observation-based study (N=2 school classes)	US	Primary	Formal	C
Knain, Erick	2005	Identity and genre literacy in high-school students' experimental reports	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Observation-based study (N=2(40))	Norway	HE	Formal	C
Buxton, Cory A.	2005	Creating a culture of academic success in an urban science and math magnet high school	SCIENCE EDUCATION	Observation-based study (N=8)	US	Secondary	Formal	C
Ford, Danielle J.; Brickhouse, Nancy W.; Lottero-Perdue, Pamela, et al.	2006	Elementary girls' science reading at home and school	SCIENCE EDUCATION	Interview (N=77)	US	Primary	Informal/Formal (reading at home and in school)	C
Brown, Bryan A.	2006	It isn't no slang that can be said about this stuff: Language, identity, and	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=29)	US	Secondary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
		appropriating science discourse						
Furman, Melina; Calabrese Barron, Angela	2006	Capturing urban student voices in the creation of a science mini-documentary	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (student-produced documentaries (N=2))	US	Secondary	Informal (after-school programme)	C
Carlone, Heidi B.; Johnson, Angela	2007	Understanding the science experiences of successful women of color: science identity as an analytic lens	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=15)	US	HE		C
Hunter, Anne-Barrie; Laursen, Sandra L.; Seymour, Elaine	2007	Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development	SCIENCE EDUCATION	Interviews (N=367)	US	HE	Formal	C
Olitsky, Stacy	2007	Facilitating identity formation, group membership, and learning in science classrooms: What can be learned from out-of-field teaching in an urban school?	SCIENCE EDUCATION	Observation-based study (N=33)	US	Secondary	Formal	C
Cross, Dionne; Taasobshirazi, Gita; Hendricks, Sean; et al.	2008	Argumentation: a strategy for improving achievement and revealing scientific identities	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Intervention (N=28)	US	Primary & Secondary	Formal	C
Teixeira, Adlia B. M.; Villani, Carlos E.; do Nascimento, Silvania S.	2008	Exploring modes of communication among pupils in Brazil: gender	GENDER AND EDUCATION	Observation-based study	Brazil	Secondary	Formal	C

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		issues in academic performance						
Brown, Bryan A.; Spang, Eliza	2008	Double talk: synthesizing everyday and science language in the classroom	SCIENCE EDUCATION	Observation-based study (N=27)	US	Primary	Formal	C
Tan, Edna; Barton, Angela Calabrese	2008	From peripheral to central, the story of Melanie's metamorphosis in an urban middle school science class	SCIENCE EDUCATION	Observation-based study (N=1)	US	Primary	Formal	C
Reveles, John M.; Brown, Bryan A.	2008	Contextual shifting: teachers emphasizing students' academic identity to promote scientific literacy	SCIENCE EDUCATION	Observation-based study (N=2)	US	Primary	Formal	C
Barton, Angela Calabrese; Tan, Edna; Rivet, Ann	2008	Creating hybrid spaces for engaging school science among urban middle school girls	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Observation-based study (N=20)	US	Secondary	Formal	C
Basu, Sreyashi Jhumki	2008	How students design and enact physics lessons: five immigrant Caribbean youth and the cultivation of student voice	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=5)	US	Secondary	Formal	C
Barton, Angela Calabrese; Tan, Edna	2009	Funds of knowledge and discourses and hybrid space	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Intervention (N=6)	US	Primary	Formal	C
Danielsson, Anna Teresa; Linder, Cedric	2009	Learning in physics by doing laboratory work: towards a new conceptual framework	GENDER AND EDUCATION	Interview (N=1)	Sweden	HE	Sweden	C

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Fields, Deborah Anne	2009	What do students gain from a week at science camp? Youth perceptions and the design of an immersive, research-oriented astronomy camp	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interviews (N=15)	US	Secondary	Informal (summer astronomy camp)	C
Malone, Karen Ror; Barabino, Gilda	2009	Narrations of race in STEM research settings: identity formation and its discontents	SCIENCE EDUCATION	Interviews (N=24)	US	HE	Formal	C
Hsu, Pei-Ling; Roth, Wolf-Michael; Marshall, Anne; et al.	2009	To be or not to be? Discursive resources for (dis-)identifying with science-related careers	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=13)	Canada	Secondary	Formal	C
France, Bev; Bay, Jacquie L.	2010	Questions students ask: bridging the gap between scientists and students in a research institute classroom	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Intervention (N=399)	New Zealand	Secondary	Formal	C
Kang, Hosun; Lundeberg, Mary A.	2010	Participation in science practices while working in a multimedia case-based environment	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Intervention (N=56)	US and Zimbabwe	HE	Formal and Informal	C
Archer, Louise; Dewitt, Jennifer; Osborne, Jonathan; et al.	2010	Doing science versus being a scientist: examining 10/11-year-old schoolchildren's constructions of science through the lens of identity	SCIENCE EDUCATION	Interviews (N=42)	UK	Primary		C
Aschbacher, Pamela R.; Li, Erika; Roth, Ellen J.	2010	Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Mixed-method study (interviews (N=33) & survey (N=approx. 1000))	US	Secondary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Barton, Angela Calabrese, Tan, Edna	2010	We be burnin'! Agency, identity, and science learning	JOURNAL OF THE LEARNING SCIENCES	Observation-based study (N=20)	US	Secondary	Informal	C
Olinsky, Stacy; Flohr, Linda Loman; Gardner, Jessica; et al.	2010	Coherence, contradiction, and the development of school science identities	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=33)	US	Secondary	Formal	C
Polman, Joseph L.; Miller, Diane	2010	Changing stories: trajectories of identification among African American youth in a science outreach apprenticeship	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Observation-based study (N=7)	US	Secondary	Informal (science outreach apprenticeship programme)	C
Katz, Phyllis	2011	A case study of the use of internet photobook technology to enhance early childhood scientist identity	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Intervention (N=1)	US	Primary	Informal (use of photobooks)	C
Fies, Carmen; Langman, Juliet	2011	Bridging the worlds: measuring learners' discursive practice in a partism supported biology lesson	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Intervention (N=17)	US	Secondary	Formal	C
Yerrick, Randy; Schiller, Jennifer; Reisfeld, Jennifer	2011	Who are you callin' expert?: using student narratives to redefine expertise and advocacy lower track science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Intervention	US	HE	Formal	C
Kidman, Joanna; Abrams, Eleanor; McRae, Hritia	2011	Imaginary subjects: school science, indigenous students, and knowledge-power relations	BRITISH JOURNAL OF SOCIOLOGY OF EDUCATION	Interview (N=32)	New Zealand	Secondary	Formal	C
Stolle-McAllister, Kathy; Domingo, Mariano R. Sto; et al.	2011	The Meyerhoff way: how the Meyerhoff Scholarship Program helps Black students succeed in the sciences	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Interview (N=156)	US	Secondary & HE	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Varelas, Maria; Kane, Justine M.; Wylie, Caitlin; Donahue	2011	Young African American children's representations of self, science, and school: making sense of difference	SCIENCE EDUCATION	Interviews (N=25)	US	Primary	Formal	C
Johnson, Angela; Brown, Jaweer; Carlone, Heidi; et al.	2011	Authoring identity amidst the teacherous terrain of science: a multiracial feminist examination of the journeys of three women of color in science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=3)	US	Professional	N/A	C
Cowie, Bronwen; Jones, Alister; Otrell-Cass, Kathrin	2011	Re-engaging students in science: issues of assessment, funds of knowledge and sites for learning	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Meta-analysis study (N=>1,600)	New Zealand	Primary & Secondary	Formal	C
Carlone, Heidi B.; Haun-Frank, Julie; Webb, Angela	2011	Assessing equity beyond knowledge- and skills-based outcomes: a comparative ethnography of two fourth-grade reform-based science classrooms	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=18)	US	Primary	Formal	C
Cervoni, Cleti; Ivinson, Gabrielle	2011	Girls in primary school science classrooms: theorising beyond dominant discourses of gender	GENDER AND EDUCATION	Observation-based study (N=4 school classes, interviews (N=46))	UK + US	Primary	Formal	C
Danielsson, Anna T.	2012	Exploring woman university physics students 'doing gender' and 'doing physics'	GENDER AND EDUCATION	Interview (N=5)	Sweden	HE	Formal	C
Wong, Billy	2012	Identifying with science: a case study of two 13-year-old 'high achieving	INTERNATIONAL JOURNAL OF	Interviews (N=2)	UK	Secondary	Formal	C

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		working class' British Asian girls	SCIENCE EDUCATION					
Arnold, Jenny	2012	Science students' classroom discourse: Tasha's Umwelt	RESEARCH IN SCIENCE EDUCATION	Observation-based study	Australia	Secondary	Formal	C
Zimmerman, Heather Toomey	2012	Participating in science at home: recognition work and learning in biology	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=1)	US	Primary & Secondary	Informal and Formal	C
Kane, Justine M.	2012	Young African American children constructing academic and disciplinary identities in an urban science classroom	SCIENCE EDUCATION	Observation-based study (N=4)	US	Primary	Formal	C
Watermeyer, Richard	2012	Confirming the legitimacy of female participation in science, technology, engineering and mathematics (STEM): evaluation of a UK STEM initiative for girls	BRITISH JOURNAL OF SOCIOLOGY OF EDUCATION	Survey (N=136)	UK	Secondary	Informal	C
Juelskjaer, Malou	2013	Gendered subjectivities of spacetime matter	GENDER AND EDUCATION	Interview (N=1)	Denmark	Secondary	Formal	C
DeWitt, Jennifer; Archer, Louise; Osborne, Jonathan	2013	Nerdy, brainy and normal: children's and parents' constructions of those who are highly engaged with science	RESEARCH IN SCIENCE EDUCATION	Interview (N=170)	UK	Primary	Formal	C
Wilson, Rachel E.; Kittleson, Julie	2013	Science as a classed and gendered endeavor: persistence of two White female first-generation college students within an undergraduate science context	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interviews (N=2)	US	HE	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Ormond, Paul; Merry, Stephen; Callaghan, Arthur	2013	Communities of practice and ways to learning: charting the progress of biology undergraduates	STUDIES IN HIGHER EDUCATION	Interviews (N=30)	UK	HE	Formal	C
Krogh, Lars Brian; Andersen, Hanne Moeller	2013	Actually, I may be clever enough to do it: using identity as a lens to investigate students' trajectories towards science and university	RESEARCH IN SCIENCE EDUCATION	Mixed-method study (Longitudinal Mixed-method study (Interview + observation (N=14) + questionnaire (N=275))	Denmark	Secondary & HE	Formal	C
Middleton, Michael; Dupuis, Juliann; Tang, Judy	2013	Classrooms and culture: the role of context in shaping motivation and identity for science learning in indigenous adolescents	INTERNATIONAL JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION	Observation-based study (and interviews (N=36))	Taiwan and Belize	Secondary	Formal and Informal	C
Tan, Edna; Barton, Angela Calabrese; Kang, Hosun; et al.	2013	Desiring a career in STEM-related fields: how middle school girls articulate and negotiate identities-in-practice in science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=16)	US	Secondary	Formal + Informal	C
Chen, Junjun; Cowie, Bronwen	2013	Developing 'Butterfly Warriors': a case study of science for citizenship	RESEARCH IN SCIENCE EDUCATION	Observation-based study (N=28)	New Zealand	Primary	Formal	C
Barton, Angela Calabrese; Kang, Hosun; Tan, Edna; et al.	2013	Crafting a future in science: tracing middle school girls' identity work over time and space	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Observation-based study (N=36)	US	Secondary		C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Gonsalves, Allison; Rahm, Irene; Carvalho, Alice	2013	We could think of things that could be science: girls' re-figuring of science in an out-of-school-time club	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=6)	US	Secondary	Informal	C
Jackson, Phoebe A.; Selter, Gale	2013	Science identity trajectories of latecomers to science in college	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (Reflective journals, online forums, Interviews (N=18))	Canada	HE	Formal	C
Andree, Maria; Hansson, Lena	2013	Marketing the 'Broad Line': Invitations to STEM education in a Swedish recruitment campaign	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Other (text analysis)	Sweden	Secondary	Formal	C
Gazley, J. Lynn; Remich, Robin; Naffziger-Hirsch, et al.	2014	Beyond preparation: identity, cultural capital, and readiness for graduate school in the Biomedical Sciences	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interview (N=52)	US	HE & professional	Formal	C
Mautucci, Maria S. Rivera; Brown, Bryan A.; Grey, Salina T., et al.	2014	Urban middle school students' reflections on authentic science inquiry	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interview/Other (N=6)	US	Primary	Formal	C
Holmegaard, Henriette Tolstrup; Madsen, Lene Møller; Ulrikken, Lars	2014	To choose or not to choose science: constructions of desirable identities among young people considering a STEM higher education programme	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interviews (N=19)	Denmark	Secondary	Formal	C
Clegg, Tamara; Kolodner, Janet	2014	Scientizing and cooking: helping middle-school learners develop scientific dispositions	SCIENCE EDUCATION	Interviews (N=2)	US	Secondary	Informal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Buschor, Christine Bieri, Kappeler, Christa; Frei, Andrea Keck; et al.	2014	I want to be a scientist/a teacher: students' perceptions of career decision-making in gender-typed, non-traditional areas of work	GENDER AND EDUCATION	Mixed-method study (survey (N=1460) & interviews (N=24))	Switzerland	Secondary	Formal	C
Thompson, Jessica	2014	Engaging girls' sociohistorical identities in science	JOURNAL OF THE LEARNING SCIENCES	Observation-based study (N=17)	US	Secondary	Informal (Lunchtime Science, a 4-week lunchtime intervention for girls' failing their science courses)	C
Irving, Paul W.; Sayre, Eleanor C.	2014	Conditions for building a community of practice in an advanced physics laboratory	PHYSICAL REVIEW SPECIAL TOPICS-EDUCATION RESEARCH	Observation-based study (N=18)	US	HE	Formal	C
Carlone, Heidi B.; Scott, Catherine M.; Lowder, Cassi	2014	Becoming (less) scientific: a longitudinal study of students' identity work from elementary to middle school science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=3)	US	Primary & Secondary	Formal	C
Dawson, Emily	2014	Not designed for us: how science museums and science centers socially exclude low-income, minority ethnic groups	SCIENCE EDUCATION	Observation-based study (N=84)	UK	Adult	Informal	C
Polman, Joseph L.; Hope, Jennifer M. G.	2014	Science news stories as boundary objects affecting engagement with science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (observation notes, article artifacts, and interviews (N=16))	US	Secondary	Informal and Formal (ECA)	C
Levrini, Olivia; Fantini, Paola; Tasquer, Giulia;	2015	Defining and operationalizing appropriation for science learning	JOURNAL OF THE LEARNING SCIENCES	Intervention (N=10)	Italy	Secondary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Pecori, Barbara, Levin, Mariana								
Rodriguez, Idaykis; Goertzen, Renee Michelle; Brewe, Eric, et al.	2015	Developing a physics expert identity in a biophysics research group	PHYSICAL REVIEW SPECIAL TOPICS- EDUCATION RESEARCH	Intervention (N=6)	US	HE	Formal	C
Irving, Paul W.; Sayre, Eleanor C.	2015	Becoming a physicist: the roles of research, mindsets, and milestones in upper-division student perceptions	PHYSICAL REVIEW SPECIAL TOPICS- EDUCATION RESEARCH	Interview (N=20)	US	HE	Formal	C
Holmegaard, Henriette Tolstrup	2015	Performing a choice-narrative: a qualitative study of the patterns in STEM students' higher education choices	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interview (N=38)	Denmark	Secondary	Formal	C
Burgin, Stephen R.; McConnell, William J.; Flowers, Alonzo M., III	2015	I actually contributed to their research: the influence of an abbreviated summer apprenticeship program in science and engineering for diverse high-school learners	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Intervention (N=8)	US	Secondary	Informal	C
Wong, Billy	2015	Careers from but not in science: why are aspirations to be a scientist challenging for minority ethnic students?	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Interview (N=46)	UK	Secondary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Hazari, Zahra; Cass, Cheryl; Beattie, Carrie	2015	Obscuring power structures in the physics classroom: linking teacher positioning, student engagement, and physics identity development	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Mixed-method study (N=3,829) and video-observations, interviews etc. (N=29)	US	Secondary	Formal	C
Archer, Louise; Dewitt, Jennifer; Osborne, Jonathan	2015	Is science for us? Black students' and parents' views of science and science careers	SCIENCE EDUCATION	Mixed-method study (survey (N=4,600) & interviews (N=170))	UK	Secondary	Formal	C
Ryu, Mjinjung	2015	Positionings of racial, ethnic, and linguistic minority students in high school biology class: implications for science education in diverse classrooms	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N= 1 school class)	US	Secondary	Formal	C
Varelas, Maria; Tucker-Raymond, Eli; Richards, Kimberly	2015	A structure-agency perspective on young children's engagement in school science: Carlos's performance and narrative	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=1)	US	Primary	Formal	C
Carlone, Heidi B.; Webb, Angela W.; Archer, Louise; et al.	2015	What kind of boy does science? A critical perspective on the science trajectories of four scientifically talented boys	SCIENCE EDUCATION	Mixed-method study (N=11)	US	Primary	Formal	C
Carlone, Heidi B.; Johnson, Angela; Scott, Catherine M.	2015	Agency amidst formidable structures: how girls perform gender in science class	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=13)	US	Primary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Carlone, Heidi B.; Huffling, Lacey D.; Tomasek, Terry; et al.	2015	Undrinkable' selves: identity boundary work in a summer field ecology enrichment program for diverse youth	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Observation-based study (N=15)	US	Secondary	Informal (summer enrichment programme)	C
Kane, Justine M.	2015	The structure-agency dialectic in contested science spaces: do earthworms eat apples?	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=21)	US	Primary	Formal	C
Sullivan, Florence R.; Wilson, Nicholas C.	2015	Playful talk: negotiating opportunities to learn in collaborative groups	JOURNAL OF THE LEARNING SCIENCES	Observation-based study (N=23)	US	Primary	Formal	C
Ryu, Minjung	2015	Understanding Korean transnational girls in high school science classes: beyond the model minority stereotype	SCIENCE EDUCATION	Observation-based study (N=6)	US	Secondary	Formal	C
Gurgel, Iva; Pietrocola, Mauricio; Watanabe, Graciella	2016	The role of cultural identity as a learning factor in physics: a discussion through the role of science in Brazil	CULTURAL STUDIES OF SCIENCE EDUCATION	Intervention (N=46)	Brazil	Secondary	Formal	C
Lock, Robynne M.; Hazari, Zahra	2016	Discussing underrepresentation as a means to facilitating female students' physics identity development	PHYSICAL REVIEW EDUCATION RESEARCH	Intervention (N=approx. 1,500)	US	Primary & Secondary	Formal	C
Rahm, Irene; Moore, John C.	2016	A case study of long-term engagement and identity-in-practice: Insights into the STEM pathways of four underrepresented youths	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Intervention (N=4)	US	Secondary & HE	Informal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Lykkegaard, Eva; Ullriksen, Lars	2016	Choices and changes: Eccles' Expectancy-Value model and upper-secondary school students' longitudinal reflections about their choice of a STEM education	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interviews (N=15)	Denmark	Secondary	Formal	C
McGee, Ebony O.	2016	Devalued Black and Latino racial identities: a by-product of STEM college culture?	AMERICAN EDUCATIONAL RESEARCH JOURNAL	Interviews (N=38)	US	HE	Formal	C
Rosa, Katemari; Mensah, Felicia Moore	2016	Educational pathways of Black women physicists: stories of experiencing and overcoming obstacles in life	PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH	Interviews (N=6)	US	Professional	Professional	C
Gonsalves, Allison J.; Danielsson, Anna; Petersson, Helena	2016	Masculinities and experimental practices in physics: The view from three case studies	PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH	Observation-based studies (N=11; N=13) & Interview (N=22)	Sweden + US + Canada	HE & Professional	Formal	C
Wong, Billy	2016	Minority ethnic students and science participation: a qualitative mapping of achievement, aspiration, interest and capital	RESEARCH IN SCIENCE EDUCATION	Observation-based study (N=16) & Interviews (N=46)	UK	Secondary	Formal	C
Kane, Justine M.	2016	Young African American boys narrating identities in science	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Observation-based study (N=2)	US	Primary	Formal	C
Archer, Louise; Dawson, Emily; Seakins, Amy; et al.	2016	Disorientating, fun or meaningful? Disadvantaged families' experiences of a science museum visit	CULTURAL STUDIES OF SCIENCE EDUCATION	Observation-based study (N=20)	UK	Secondary	Informal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Irving, Paul W.; Sayre, Eleanor C.	2016	Identity statuses in upper-division physics students	CULTURAL STUDIES OF SCIENCE EDUCATION	Observation-based study (N=3)	US	HE	Formal	C
Archer, Louise; Dawson, Emily; Seakins, Amy; et al.	2016	I'm being a man here: urban boys' performances of masculinity and engagement with science during a science museum visit	JOURNAL OF THE LEARNING SCIENCES	Observation-based study (N=36)	UK	Secondary	Informal (museum)	C
Cink, Ruth B.; Song, Youngjin	2016	Appropriating scientific vocabulary in chemistry laboratories: a multiple case study of four community college students with diverse ethno-linguistic background	CHEMISTRY EDUCATION RESEARCH AND PRACTICE	Observation-based study (N=4)	US	HE	Formal	C
Brown, Bryan A.; Cooks, Jamal; Cross, Kerth	2016	Lyricism, identity, and the power of lyricism as the third space	SCIENCE EDUCATION	Observation-based study (N=5)	US	HE	Informal	C
Swanson, Lauren H.; Coddington, Lorelei R.	2016	Creating partnerships between teachers and undergraduates interested in secondary math and science education	TEACHING AND TEACHER EDUCATION	Observation-based study (N=5)	US	HE	Formal/Summer school	C
Close, Eleanor W.; Conn, Jessica; Close, Hunter G.	2016	Becoming physics people: development of integrated physics identity through the learning assistant experience	PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH	Other (written student reflections (N=61). Program applications (N=30), & interviews (N=12))	US	HE	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Chapman, Angela; Feldman, Allan	2017	Cultivation of science identity through authentic science in an urban high school classroom	CULTURAL STUDIES OF SCIENCE EDUCATION	Intervention (N=12)	US	Secondary	Formal	C
Van Home, Katie; Bell, Philip	2017	Youth disciplinary identification during participation in contemporary project-based science investigations in school	JOURNAL OF THE LEARNING SCIENCES	Intervention (N=76)	US	Secondary	Formal	C
Gilliam, Melissa; Jagoda, Patrick; Fabyyi, Camille; et al.	2017	Alternate reality games as an informal learning tool for generating STEM engagement among underrepresented youth: a qualitative evaluation of the source	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Intervention (N=144)	US	Secondary	"Informal"	C
Ulriksen, Lars; Holmegård, Henriette T.; Madsen, Lene Møller	2017	Making sense of curriculum-the transition into science and engineering university programmes	HIGHER EDUCATION	Interview (N=20)	Denmark	Secondary & HE	Formal	C
Hayes, Aneta L.; Mansour, Nasser	2017	Confidence in the knowledge base of English language learners studying science: using agency to compensate for the lack of adequate linguistic identity	Research in Science Education volume	Interview (N=25)	Bahrain	Secondary => HE	Formal	C
Allen, Carrie D.; Eisenhart, Margaret	2017	Fighting for desired versions of a future self: how young women negotiated STEM-related identities in the discursive landscape of educational opportunity	JOURNAL OF THE LEARNING SCIENCES	Interview (N=4)	US	Secondary	Formal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Nadelson, Louis S.; McGuire, Sharon Paterson; Davis, Kirsten A.; et al.	2017	Am I a STEM professional? Documenting STEM student professional identity development	STUDIES IN HIGHER EDUCATION	Interviews (N= approx. 20)	US	HE	Formal	C
Archer, Louise; Dawson, Emily; DeWitt, Jennifer; et al.	2017	Killing curiosity? An analysis of celebrated identity performances among teachers and students in nine London secondary science classrooms	SCIENCE EDUCATION	Observation-based study (N= approx. 200) and interviews (N=68)	UK	Secondary	Formal	C
Jackson, Phoebe A.; Seiler, Gale	2017	Identity work in the college science classroom: The cases of two successful latecomers to science	SCIENCE EDUCATION	Observation-based study (N=2)	Canada	HE	Formal	C
Nasir, Na'ilah Suad; Vakil, Sepahr	2017	STEM-focused academies in urban schools: tensions and possibilities	JOURNAL OF THE LEARNING SCIENCES	Observation-based study (N=26)	US	Secondary	Formal	C
Riedinger, Kelly; McGinnis, J. Randy	2017	An investigation of the role of learning conversations in youth's authoring of science identities during an informal science camp	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, part B	Observation-based study (N=45)	US	Secondary	Informal (science camp)	C
Harper, Susan G.	2017	Engaging Karen refugee students in science learning through a cross-cultural learning community	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Observation-based study (N=9)	US	Primary	Informal/After school programme	C

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Godwin, Allison; Potvin, Geoff	2017	Pushing and Pulling Sara: A Case Study of the Contrasting Influences of High School and University Experiences on Engineering Agency, Identity, and Participation	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (survey, interview, video (N=1))	US	HE	Formal	C
Tofel-Grehl, Colby; Fields, Deborah; Seafie, Kristin; et al.	2017	Electrifying engagement in middle school science class: improving student interest through E-textiles	JOURNAL OF SCIENCE EDUCATION AND TECHNOLOGY	Survey (N=155)	US	Secondary	Formal	C
Skagen, Darlene; McCollum, Brett; Morsch, Layne; et al.	2018	Developing communication confidence and professional identity in chemistry through international online collaborative learning	CHEMISTRY EDUCATION RESEARCH AND PRACTICE	Intervention (N=122)	US	HE	Formal	C
Wulff, Peter; Hazari, Zahra; Petersen, Stefan; et al.	2018	Engaging young women in physics: An intervention to support young women's physics identity development	PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH	Intervention (N=30)	Germany	Secondary	Informal (physics Olympiad)	C
Stromholt, Shelley; Bell, Philip	2018	Designing for expansive science learning and identification across settings	CULTURAL STUDIES OF SCIENCE EDUCATION	Intervention (N=9)	US	Primary	Formal	C
Morton, Terrell R.; Parsons, Eileen C.	2018	#BlackGirlMagic: the identity conceptualization of Black women in undergraduate STEM education	SCIENCE EDUCATION	Interview (N=10)	US	HE	Formal	C

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Farhang, Sanaz	2018	Contribution to activity: a lens for understanding students' potential and agency in physics education	CULTURAL STUDIES OF SCIENCE EDUCATION	Interview (N=15)	US	HE	Formal	C
Craig, Cheryl J.; Verma, Rakesh; Stokes, Donna; et al.	2018	The influence of parents on undergraduate and graduate students' entering the STEM disciplines and STEM careers	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interview (N=3)	US	HE	Formal/informal	C
Miller-Friedmann, Jamie; Childs, Ann; Hillier, Judith	2018	Approaching gender equity in academic chemistry: lessons learned from successful female chemists in the UK	CHEMISTRY EDUCATION RESEARCH AND PRACTICE	Interviews (N=4)	UK	Professional	Formal/informal	C
Wang, Jianlan; Hazari, Zahra; Cass, Cheryl; et al.	2018	Episodic memories and the longitudinal impact of high school physics on female students' physics identity	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Interviews (N=6)	US	Secondary	Formal	C
Archer, Louise; Dawson, Emily; DeWitt, Jennifer; et al.	2018	Using Bourdieu in practice? Urban secondary teachers' and students' experiences of a Bourdieusian-inspired pedagogical approach	BRITISH JOURNAL OF SOCIOLOGY OF EDUCATION	Observation-based study (N= approx. 200) and interviews (N=68)	UK	Secondary	Formal	C
Mark, Sheron L.	2018	A bit of both science and economics: a non-traditional STEM identity narrative	CULTURAL STUDIES OF SCIENCE EDUCATION	Observation-based study (N=1)	US	HE	Informal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
Fernandez, Roberto Gomez, Stry, Christina	2018	Opening up' a science task: an exploration of shifting embodied participation of a multilingual primary student	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Observation-based study (N=1)	Luxemburg	Primary	Formal	C
Kim, Mijung	2018	Understanding children's science identity through classroom interactions	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION	Observation-based study (N=15)	Canada	Primary	Formal	C
Gonsalves, Allison J.	2018	Exploring how gender figures the identity trajectories of two doctoral students in observational astrophysics	PHYSICAL REVIEW EDUCATION RESEARCH	Observation-based study (N=2)	Canada	HE	Formal	C
Gamez, Rebecca; Parker, Carolyn A.	2018	Becoming science learners: A study of newcomers' identity work in elementary school science	SCIENCE EDUCATION	Observation-based study (N=focusing 3)	US	Primary	Formal	C
Ward, Sarah J.; Price, Rebecca M.; Davis, Katie; et al.	2018	Songwriting to learn: how high school science fair participants use music to communicate personally relevant scientific concepts	INTERNATIONAL JOURNAL OF SCIENCE EDUCATION PART B-COMMUNICATION AND PUBLIC ENGAGEMENT	Other (artist statements (N=81))	US	Secondary	Informal (science fair)	C
Murakami, Christopher D.; Siegel, Marcelle A.	2018	Becoming Bermuda grass: mapping and tracing rhizomes to practice reflexivity	CULTURAL STUDIES OF SCIENCE EDUCATION	Other (rhizomatic research (N=1))	US	HE	Formal	C
Vedder-Weiss, Dana	2018	Won't you give up your snack for the sake of science? Emerging science identities in	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (self-ethnography (N=1))	Australia	N/A (Family)	Informal	C

Authors	Publication Year	Title	Source Title	Method	National context	Education level	Formal/Informal	A/B/C categorisation
		family everyday interaction						
Jackson, Phoebe A.; Selter, Gale	2018	I am smart enough to study postsecondary science: a critical discourse analysis of latecomers' identity construction in an online forum	CULTURAL STUDIES OF SCIENCE EDUCATION	Other (text analysis online)	Canada	HE	Formal	C
Yoon, Susan	2008	Using memes and memetic processes to explain social and conceptual influences on student understanding about complex socio-scientific issues	JOURNAL OF RESEARCH IN SCIENCE TEACHING	Other (N=18) students' written material)	US	Secondary	Formal	OTHER

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