Studies in Science Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rsse20

Science capital as a lens for studying science aspirations – a systematic review

Sini Kontkanen, Teija Koskela, Oksana Kanerva, Sirpa Kärkkäinen, Katariina Waltzer, Mirjamaija Mikkilä-Erdmann & Sari Havu-Nuutinen

To cite this article: Sini Kontkanen, Teija Koskela, Oksana Kanerva, Sirpa Kärkkäinen, Katariina Waltzer, Mirjamaija Mikkilä-Erdmann & Sari Havu-Nuutinen (08 Aug 2024): Science capital as a lens for studying science aspirations – a systematic review, Studies in Science Education, DOI: 10.1080/03057267.2024.2388931

To link to this article: https://doi.org/10.1080/03057267.2024.2388931

STUDIES IN SCIENCE EDUCATION
https://doi.org/10.1080/03057267.2024.2388931

Science capital as a lens for studying science aspirations – a systematic review

Sini Kontkanen [a], Teija Koskela [b], Oksana Kanerva [c], Sirpa Kärkkäinen [a], Katariina Waltzer [d], Mirjamaija Mikkilä-Erdmann [b] and Sari Havu-Nuutinen [a]

[a]School of Applied Educational Sciences and Teacher Education, University of Eastern Finland, Joensuu, Finland; [b]Department of Teacher Education, University of Turku, Turku, Finland; [c]Department of Psychology, University of Turku, Turku, Finland; [d]School of Education and Psychology, University of Eastern Finland, Joensuu, Finland

ABSTRACT
This article presents the findings of a systematic review that considers research conducted on science capital. Science capital includes what an individual knows about science, what they think about science, and who they know in science. These dimensions are related to science understanding in different cultural and social contexts and are affected to science aspirations. The research questions focus on how science capital is studied and contextualised and on what has been discovered about science capital. The materials were selected from three scientific databases using seven keywords. This article provides an overview of 32 selected articles published in peer-reviewed scientific journals from 2000–2021. The data were analysed using both qualitative data-driven and theory-guided content analyses. Although the review shows that science capital is studied using a diverse range of methods in different contexts, the studies have mainly focused on formal teaching and secondary and high school education in Europe, particularly on science-related social capital and subjective sense of self. The findings further reveal that the conceptual coherence of science capital still needs more accurate consideration to promptly explain its causes and consequences.

KEYWORDS
Science capital; systematic review; science education; qualitative content analysis; literature review

Introduction

Science capital encompasses an individual's knowledge of science, their attitudes towards science and their connections within the scientific community (Archer, Dawson, et al., 2015). Science-related skills, aspirations, and science capital are intertwined elements that reinforce and support each other. Developing skills enhances aspirations, which drive skill acquisition, and both aspirations and skills contribute to the accumulation of science capital (Sheldrake et al., 2017). The goal of science education is to develop a scientifically literate society, that is, to support the science capital of all students (Archer, Dawson, et al., 2015; Glaze, 2018). Science education aims to increase people's understanding of science

CONTACT Sini Kontkanen sini.kontkanen@uef.fi

and the construction of knowledge, as well as to promote scientific literacy and responsible citizenship (e.g. Hazelkorn et al., 2015; Holbrook & Rannikmäe, 2007). However, according to Potvin (2021), students individually develop a range of models, schemas, and ideas in making sense of scientific phenomena, and this can, obviously, lead to robust misconceptions that must be recognised and reconstructed in science education, and thus they are hard to change. These misconceptions must be recognised and reconstructed in science education in a way that makes scientific learning more relevant and promotes societal engagement (Ratcliffe & Grace, 2003).

The issue of widening and increasing access to science participation for the general population remains open (Darling-Hammond et al., 2020). Of interest, cultural background and gender have been found to affect scientific aspirations, identity, and, eventually, commitment to science-related learning (cf. Makarova et al., 2019; Sheldrake et al., 2017). Educational equity is particularly important in supplying a sufficient science talent pool for access to branches of industry and technology (Makarova et al., 2019; Sheldrake et al., 2017). Research on science, technology, engineering, and mathematics (STEM) subjects shows that ethnic majority students from solid socio-economic backgrounds are prevalent in higher STEM education (Smith & White, 2011; Wong et al., 2022), while students from cultural minorities and low-income families are generally underrepresented in STEM studies in elementary and middle school (Macdonald, 2014). Further, gender inequality remains relatively stable over decades (Diekman et al., 2017; Smith, 2011). In particular, girls have been found to choose STEM subjects less than boys (Mellén & Angervall, 2021), and girls' values, attitudes, and motivation towards STEM studies are lower than boys' (Gok, 2021). Females tend to be interested in biology and males in technology and engineering (May et al., 2022; Naukkarinen & Bairoh, 2020; Wang & Degol, 2017). However, the gender gap appears to be smaller among high-performing students and among students at prestigious schools (Delaney & Devereux, 2019).

Overall, educational inequity is a well-acknowledged global challenge. The concept of science capital has been developed to discover and consider cultural and social differences, especially in science literacy, with the aim of increasing equity in science education (Archer, Dawson, et al., 2015). This paper provides a systematic and overall analysis of existing research on science capital to increase the understanding of the concept and to identify the gaps to be addressed by future research. The research explored in this paper shows that performance in science education and the ability to foster aspirations in science are rooted in several dimensions and that the academic community should consider the dimensions more profoundly to reach a shared understanding of the significance of the dimensions in discussions of science education.

Theoretical background

The concept of science capital was developed by the research group directed by (Archer, DeWitt, Osborne, et al., 2013) as a conceptual and methodological tool for understanding the socio-economical structures of participation, aspirations, engagement, and achievement in science education among children and young people. The interest of Archer and her colleagues in questions about equal participation in sciences is in line with their earlier observations that white, middle-class, male students and researchers dominate the contexts of higher education (Archer & Hutchings, 2000) and that despite their science aspirations, young black people do not find studying science thinkable for themselves (Archer, DeWitt, et al., 2015, p. 33). Archer, Dawson, et al. (2015) used Bourdieu's concepts of social and cultural capital as a starting point (Bourdieu, 1984; Bourdieu & Wacquant, 1992). Social capital is a conceptual tool for exploring how social relations, such as family, networks, and relationships, can promote – or, when lacking, inhibit – individuals' possibilities to succeed in society (Bourdieu, 1984). Cultural capital refers to the embodied, objectified, and institutional states. Educational qualifications are included in the institutional states of cultural capital (Bourdieu, 1984, 1986). Through the concept of social and cultural capital, Bourdieu (1984) aimed to reveal the reproduction of inequity in education.

Science capital is viewed as a lens instrumental for defining mechanisms that shape future science-related educational and occupational aspirations in young individuals (Archer, Dawson, et al., 2015). According to Archer, Dawson, et al. (2015), science capital comprises three core dimensions: scientific forms of cultural capital, science-related behaviours and practices, and science-related forms of social capital. These dimensions include eight sub-dimensions and contribute to the formation of two dependent variables – science aspirations and science identity. In this review paper, we have decided to refer to the dimension of science aspirations and identity arising from the other core dimensions as 'the science-related subjective sense of self' because of the self-oriented nature of science aspirations and science identity. Further, Archer, Dawson, et al. (2015) described cross-cutting themes such as socio-economic and cultural background and gender, which influence all the dimensions.

The first dimension of science capital refers to scientific forms of cultural capital and includes three sub-dimensions: scientific literacy, dispositions towards science, and knowledge of the transferability of science. Scientific literacy could be conceptualised broadly as scientific knowledge, skills, and an understanding of scientific mechanisms (Archer, Dawson, et al., 2015). It also includes the capacity to use and apply these abilities (Howell & Brossard, 2021). Dispositions and preferences in relation to science involve how valuable a person considers science to be for society. Knowledge of the transferability of science means that knowledge of the extrinsic value and potential of science qualifications can be converted into job opportunities (Godec et al., 2017).

The second dimension of science capital refers to science-related forms of social capital. Archer, Dawson, et al. (2015) distinguished three sub-dimensions of science-related forms of social capital: family science capital (the extent to which a person's family has science capital), knowing people in science-related roles (the family, friends, peer, and community that young people have access to), and talking about science with others (how much and with whom the students talk about science in their daily lives).

The third dimension of science capital concerns science-related behaviours and practices. This dimension generally involves two sub-dimensions: the consumption of science-related media – that is, television, magazines, books, and internet content (Godec et al., 2017) – and involvement in out-of-school science-learning contexts. Out-of-school science learning contexts can be considered informal science learning contexts, including designed spaces of museums, community spaces such as after-school science clubs, and everyday contexts at home (Archer, Dawson, et al., 2015).

These three core dimensions of science capital are considered important in shaping future educational or professional aspirations towards science and contribute to the formation of science identity. Archer, Dawson, et al. (2015) described these as dependent variables, and in this review paper, we refer to these variables as the dimension of 'science-related subjective sense of self'. Researchers have used different conceptualisations regarding the determinants of science identity. Archer et al. (2012) highlighted the influence of gender, socio-economic background, and cultural norms on students' science identities. Their work emphasises the significance of recognising and addressing the social and cultural dimensions that shape individuals' engagement with science. Archer, DeWitt, and Willis (2013) argued that promoting a positive science identity among all students, especially those from underrepresented groups, is crucial for fostering a more inclusive and diverse scientific community. There is also critique that science identity research has focused on the under-representation of girls and women in science, as well as Western, middle-class norms of scientific practice, neglecting the diversity of scientific knowledge systems and practices found across different cultures and communities (e.g. Carlone & Johnson, 2007; Dou et al., 2019; Gonsalves, 2018; Gonsalves, Daniel, et al., 2021; Hazari et al., 2013; Sanchez et al., 2023).

Furthermore, closely related to identity, aspirations can be understood as valued goals in an individual's lifespan and how the person acts towards achieving these goals (Jones et al., 2011). Although secondary school students in different countries have different career aspirations, their similarities are pronounced. First, many young people exclude STEM studies and occupational careers even if this choice was relatively popular earlier on (e.g. Van Tuijl & van der Molen, 2016), and this outcome is more or less explicitly connected with the growing need for more STEM experts in working life. Second, the question of under- and over-represented groups in STEM education highlights the other side of the same phenomenon: STEM education as an issue of equal opportunities (Kerkhoven et al., 2016) and how a social environment guides young people to make choices concerning their education and careers (Smith & White, 2011).

Research has shown that students' aspirations in STEM subjects are based on the complex interaction between goals, self-efficacy, and expected results (e.g. Lent et al., 2013). Students' stereotypical beliefs about STEM careers negatively influence their self-efficacy in STEM activities and their expectations of career-related outcomes. This effect is due to a lack of understanding about STEM professions (e.g. Luo et al., 2021). Thus, Tomperi et al. (2022) indicated that it is important to increase informal learning opportunities inside and outside school and improve career counselling for secondary school students.

With cross-cutting themes or 'other items', Archer, Dawson, et al. (2015) captured the socio-economic and cultural background and gender. Cross-cutting themes are deemed to influence patterns of how each dimension of science capital is represented in individuals and how these core dimensions translate into identifying oneself as a person of science, as well as the willingness to pursue post-compulsory science education and careers in science.

Previous studies clearly indicate a need to consider science capital conceptually (Jensen & Wright, 2015; Krarup & Munk, 2016). The concept of science capital is used as a critical tool to analyse science education (Claussen & Osborne, 2013) and as an analytical lens through which to consider student engagement in science education (Adamuti-Trache & Andres, 2008; Elmesky & Tobin, 2005). The concept of science capital cannot avoid the general critique of Bourdieu's capital, which highlights its excessive flexibility and all-encompassing use of content in the social sciences (Jensen & Wright, 2015; Krarup & Munk, 2016). For example, Jensen and Wright (2015) questioned the role of science capital as a concept by asking whether it is only one form of cultural capital. Thus, capital should not be separated from its field, which defines all values of capital (Krarup & Munk, 2016).

In light of the theoretical discussion of the concept of science capital in previous research, we aim to examine the contribution of contemporary research on the uses of science capital in different forms of education to the field of science education. The specific research questions (RQ) that guided the review process were as follows:

RQ1: How is science capital studied in the reviewed studies?

RQ2: Who is in focus in the reviewed studies?

RQ3: How are the dimensions of science capital discussed in the reviewed studies in the context of science education?

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were applied in this study for identifying, screening, and including articles (Page et al., 2021). The review process included (1) searching for potential articles in databases (identification), (2) screening articles at the title and abstract levels, (3) screening articles meeting inclusion criteria at the full-text level (screening), and (4) analysing the included articles (see Figure 1). The exclusion of articles was described only in full-text screening, which is consistent with the PRISMA guidelines and previous research (Bramer et al., 2017). In the next section, each phase of the review process is described in more detail.

Literature search and identification

The literature search of articles was conducted separately by two researchers in August 2021 using three online databases: ERIC, Web of Science, and EBSCOhost. ERIC is a free, peer-reviewed education database with access to approximately 1.2 million publications. The Web of Science contains over 33,000 journals, books, and citation databases, and EBSCOhost is a wide, multidisciplinary database. The search phrases used in all databases were: (‘Science capital’) AND (‘education’ or ‘school’ or ‘learning’ or ‘teaching’ or ‘classroom’ or ‘education system’). The search was limited to peer-reviewed articles (in EBSCOhost: scholarly [peer-reviewed] journals) and articles published after 2000. ERIC returned 35 articles, Web of Science returned 74 articles, and EBSCOhost returned 224 articles. A total of 291 articles were screened after duplicates ($n = 42$) were removed.

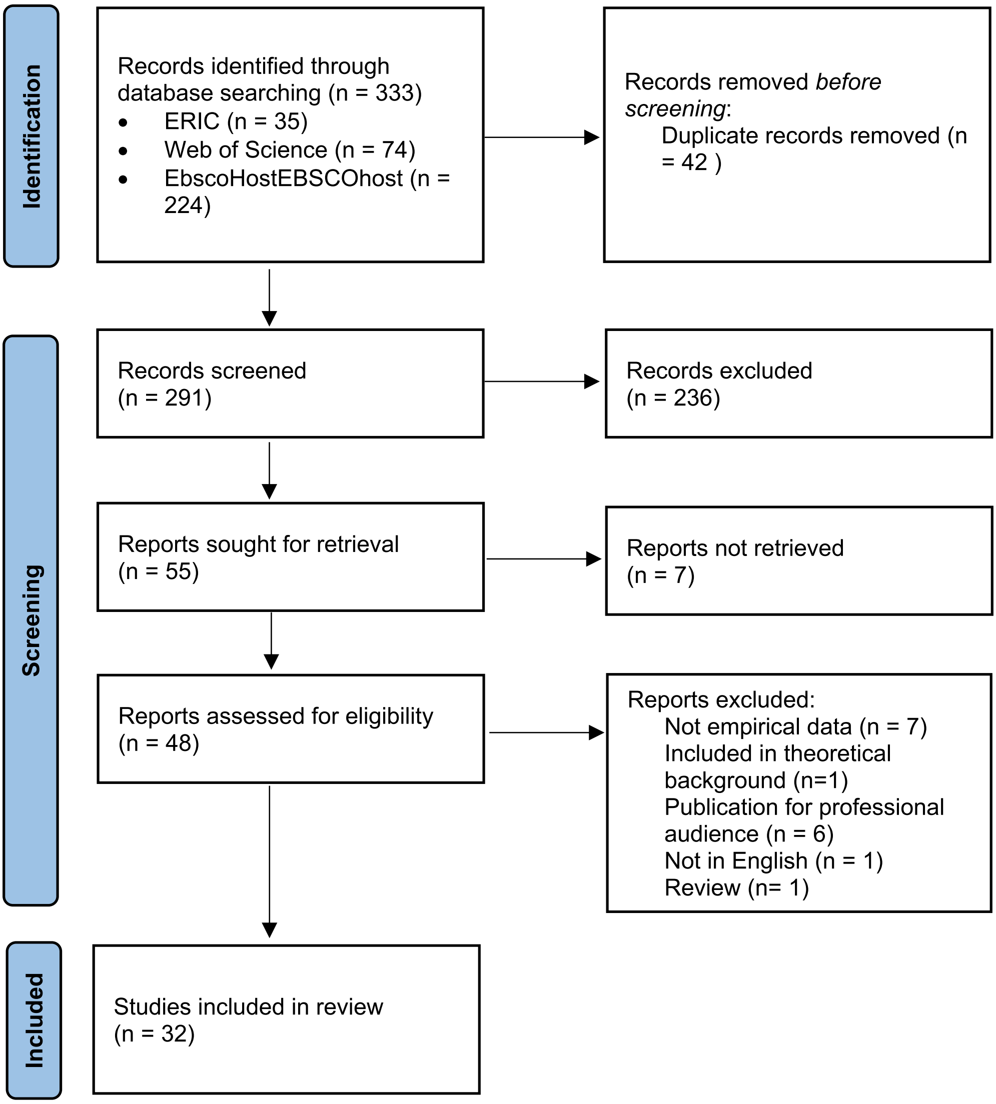

Figure 1. PRISMA flow diagram of the research protocol (adapted from Page et al., 2021).

Screening

Two researchers independently reviewed all 291 articles by screening the titles and abstracts. They used inclusion and exclusion criteria to identify studies for the full-text eligibility review (Table 1). This search yielded 55 articles. At this point, full-text articles were downloaded from the university library system or through an internet search. As seven articles could not be retrieved, the remaining 48 articles were further screened.

In the second phase of screening, three researchers read the full texts of the selected 48 articles, 16 of which were removed from further close review. Articles were eliminated for the following reasons: the study did not have empirical data

Table 1. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Study focus	Studies related to science capital and education, school, learning, teaching, classroom or education system	Study of science capital that is included in the theoretical background of this article (Archer, Dawson, et al., 2015).
Type of study	Studies with empirical data	No empirical data in the study, reviews
Type of publication	Peer-reviewed scientific publication	Publications for a professional audience (no scientific form of publication)
Language	English	
Time of publication	Published between January 2000 and August 2021	
Accessibility	Publication is open to access through university systems or internet search	

(7), the articles were included in the theoretical background of this review (1), the articles were a review article (1), the articles were published for a professional audience (6), and the articles were not in English (1). After this phase, the dataset consisted of 32 articles.

Qualitative analysis of studies

Three of the authors analysed the selected articles. For preliminary analysis, the authors collected basic information (bibliographical information, database source, method, data, target group, context, aim/research questions, key outcomes) from the articles included ($n = 32$) in the review in a Microsoft Excel spreadsheet. The task of the final analysis were divided between four researchers for a closer review of the articles: one researcher concentrated on method, data, and target group; one concentrated on contexts and aims/research questions, and two concentrated on key outcomes. During the analysis process, all the authors went through others' analyses to obtain a more nuanced and trustworthy analysis. The authors also gathered for several meetings to discuss their individual classifications and to reach a shared understanding.

Method, data, target group, contexts, and aims/research questions were analysed to answer RQ1: 'How is science capital studied in the reviewed studies?' and RQ2: 'Who is in focus in the reviewed studies?'. The categorisation of these followed a data-driven qualitative content analysis process (Elo & Kyngäs, 2008; Krippendorff, 2019). To answer RQ 3: 'How are the dimensions of science capital discussed in the reviewed studies in the context of science education?', the key outcomes of the included articles were analysed. In this analysis, qualitative theory-guided content analysis (Kyngäs & Kaakinen, 2020) was used; that is, coding was conducted in accordance with original science capital core dimensions – cultural capital, social capital, and behaviours and practices (Archer, Dawson, et al., 2015) – alongside the dimension of science-related subjective sense of self raised from the data concerning the key outcomes. The dimension of science-related subjective sense of self was identified by Archer, Dawson, et al. (2015) as dependent variables. Additionally, cross-cutting themes (*other items* in Archer, Dawson, et al., 2015) were coded. The codes used are shown in Table 2.

Table 2. Codebook.

Study Dimensions	Codes
Method type (RQ1)	Quantitative, qualitative, mixed
Research design (RQ1)	Open (e.g. case study, interview)
Target group (RQ2)	Students, teachers, families
Age group/school level (RQ2)	Open (e.g. 7–11-year-old or Middle school)
Country (RQ2)	Open (e.g. Australia)
Context (RQ2)	Formal, informal, non-formal
Key outcomes (RQ3)	Cultural capital, social capital, behaviours and practices, science-related subjective sense of self, cross-cutting themes

In this process, the complexity of the concept of science capital emerged, and in many cases, the key outcomes were connected to several science capital dimensions. Therefore, in reporting key outcomes, the repetition of some aspects could not be avoided.

Results

How is science capital studied in the reviewed studies?

The first research question focuses on the methodological approaches used in the research of science capital. Overall, 14 of the reviewed articles reported qualitative data analysis, 13 reported quantitative analysis, and 5 articles utilised mixed methods in the research. The qualitative data included transcript verbal utterances, such as individual or focus group interviews, recordings of group meetings and workshops, transcription of verbal feedback, and audio records from a field trip. Some data focused on individuals' voices, and some of these data focused on a shared understanding of science capital. Besides verbal data, the data included visual material, such as video diaries and photographic evidence. An interpretive approach was used when data were collected and analysed based on reflective narratives, field notes, and evaluation questionnaires.

In the quantitative reports, the number of participants in a survey varied from 352 to 23,998. Four of these reports were conducted with a longitudinal design, and most (nine reports) were cross-sectional studies. The reports mentioned analysing data using various approaches, such as interrelationship (correlational analysis, exploratory, and confirmatory factor analysis), multivariate (logistic and linear regression analysis), and multilevel analysis (Rasch model and structural equation modelling).

The five articles that utilised mixed methods all collected survey data and had different qualitative data collection methods, such as workshops, interviews, and small group discussions. In these reports, qualitative data quotes were used mainly to illustrate the survey data.

Who is in focus in the reviewed studies?

We analysed 32 articles: 28 focused on students' and pupils' science capital, 3 focused on teachers' science capital, and 1 on the combination of students and their families. Out of the 28 studies focusing on students, 15 engaged secondary-level students, and 7 engaged upper secondary school/high school-level students. Additionally, university students were the target group in three studies and vocational students in one study. One study concentrated on primary school students, and one focused on both primary and secondary school students.

The educational contexts of 24 of the research papers were in formal education. Formal education takes place in pre-primary, primary, and secondary education, as well as in the institutions of upper secondary and higher education. Five studies were carried out in informal educational contexts, such as museums and science-related projects, and three studies were conducted in non-formal educational contexts, such as co-operative programmes. The majority of the research reported in the 32 articles was conducted in Europe (22 studies), whereas 17 studies were conducted in the United Kingdom, 2 in Germany, and 1 each in Ireland, Italy, and Norway.

In two articles (Wilson-Lopez et al., 2018; Wong, 2015), the focus group was defined by their ethnic backgrounds. Wilson-Lopez et al. (2018) concentrated on Hispanic and Latin youth from working-class families, and Wong (2015) recruited students with black Caribbean and Asian backgrounds in London, who came mostly from working-class families. Students with special educational needs were the main target group in one article (Cerrato et al., 2018). In both articles, the aim was to prevent school dropout and enhance equity in the labour market. Wong (2015) found ethnic background to be meaningful when young people plan their futures and consider possible occupational careers. Choosing a science-related career based on personal interests is not enough; it must also involve support from other sources, such as encouragement from family and opportunities to access different science-related environments and knowledge (Wong, 2015).

How are the dimensions of science capital discussed in the reviewed studies in the context of science education?

The analysis of this research question focused on the three core dimensions of science-related capital (Archer, Dawson, et al., 2015). These dimensions have eight sub-dimensions. Alongside these existing core dimensions, we formulated a new dimension of science-related subjective sense of self (titled as dependent variables in Archer, Dawson, et al., 2015), because it had an essential role in data analysis and significant outcomes regarding conceptual understanding of science capital. This new dimension was further subdivided into two sub-dimensions. The data also revealed one sub-dimension of cultural background and gender issues, which was categorised under cross-cutting themes (similar to Archer, Dawson, et al., 2015). The results of the categorisations in the data analysis are outlined in Figure 2.

Science-related cultural capital

Science literacy. Science literacy was highlighted in the research outcomes of five reviewed articles (Christidou et al., 2021; DeWitt et al., 2016; King et al., 2015; Teo et al., 2018; Wilson-Lopez et al., 2018). This was the primary sub-dimension used by teachers to integrate science capital into their activities (King et al., 2015). Science literacy was also mobilised in the students' project work described by Wilson-Lopez et al. (2018). In particular, the study showed that previously acquired formal scientific knowledge, a good command of English and Spanish, internet literacy, and practical problem-solving skills that concerned repairing and designing things

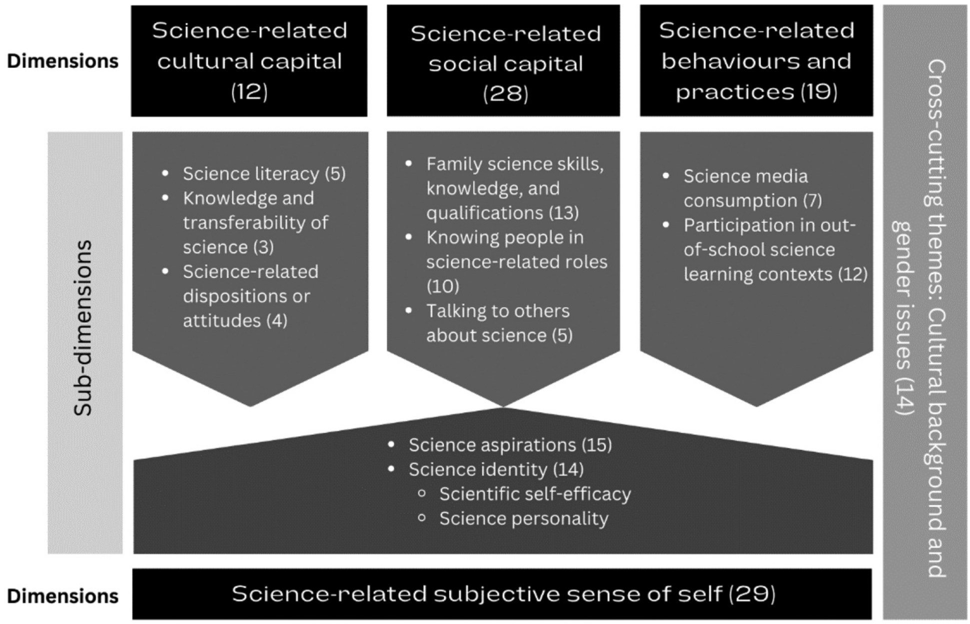

Figure 2. Categorisation of science capital article research outcomes.

at home contributed to the outcomes of students' engineering projects. Science literacy was identified as one of the dimensions of science capital directly linked to UK students' future participation and identity in science (DeWitt et al., 2016). Christidou et al. (2021) highlighted medium and high science capital scores as good levels of scientific literacy. More advanced knowledge and understanding of how science works were significant predictors of better performance in scientific reasoning tasks among regular academic students in Singapore, whereas for technical students, the significant predictor was their views about science teachers (Teo et al., 2018).

Knowledge of the transferability of science. Knowledge of the transferability of science was connected to the research outcomes of three reviewed articles (Black & Hernandez-Martinez, 2016; DeWitt et al., 2016; Mujtaba et al., 2018). In two of these articles, students' knowledge about the utility and transferability of science qualifications was connected to their future aspirations or participation in science (DeWitt et al., 2016; Mujtaba et al., 2018). Black and Hernandez-Martinez (2016) found that students were aware that science qualifications hold a symbolic value that can be translated into job opportunities and that these qualifications can be transferred to other related fields of science.

Science-related dispositions or attitudes. Science-related dispositions or attitudes were discussed in four of the reviewed articles (Christidou et al., 2021; King et al., 2015; Moote et al., 2020; Rüschenpöhler & Markic, 2020b). Teachers most often connected and conceptualised this sub-dimension of science-related dispositions and attitudes, alongside science literacy, to science capital (King et al., 2015). Christidou et al. (2021) found that nerd identity, the stereotypical images of scientists and perceived overall difficulty of science at school, was found to shape negative attitudes towards science as well as limit potential participation in science-related activities. By contrast, the authors showed that creativity in teaching science, a focus on practice, and the application of diverse methodologies enhanced students' interest in science and formed positive attitudes towards it. Moote et al. (2020) highlighted that engineering and maths attitudes have a stronger relationship with science capital than technology attitudes. In chemistry learning, general learning identity is associated with the development of chemistry identity (Rüschenpöhler & Markic, 2020b).

Science-related social capital

Family science skills, knowledge, and qualifications. Family science skills, knowledge, and qualifications were mentioned in the outcomes of 13 reviewed articles (Black & Hernandez-Martinez, 2016; Ceglie, 2021; DeWitt & Archer, 2015; DeWitt et al., 2016; Diamond, 2020; Du & Wong, 2019; Jones et al., 2020, 2021; Mujtaba et al., 2018; Rüschenpöhler & Markic, 2020a, 2020b; Stahl et al., 2021; Turnbull et al., 2020). Rüschenpöhler and Markic (2020b) pointed out that chemistry capital was unevenly distributed, and those who did not have connections in their families with chemistry exhibited a tendency to apply to schools with lower entry requirements. Families' chemistry capital was linked and translated into students' individual chemistry capital. Four of the reviewed articles highlighted families' influence on students' future science participation or aspirations to pursue a career in science (DeWitt & Archer, 2015; DeWitt et al., 2016; Diamond, 2020; Du & Wong, 2019).

There are clear associations between the science capital of the family and students' aspirations, self-concepts, and abilities (Mujtaba et al., 2018; Rüschenpöhler & Markic, 2020a). However, Turnbull et al. (2020) did not find a significant connection between parents' value of science and students' science self-concept, and minority students, in particular, did not receive social capital from their parents or community (Ceglie, 2021). In their study, Stahl et al. (2021) stressed that the geographies of place and parent – child relationships largely affected family science capital. In addition, one study indicated the positive effects of family-based achievements on students' perceptions and task values (Jones et al., 2021).

Knowing people in science-related roles. Knowing people in science-related roles was highlighted in the results of 10 of the reviewed articles (Black & Hernandez-Martinez, 2016; Ceglie, 2021; Diamond, 2020; Jones et al., 2021; Kelly et al., 2019; King et al., 2015; Rüschenpöhler & Markic, 2020b; Stahl et al., 2021; Turnbull et al., 2020; Wilson-Lopez et al., 2018). King et al. (2015) found that teachers were less confident about developing approaches to leveraging connections with someone holding a position in science, establishing contacts with such people, or benefiting from parental knowledge and science qualifications. In Wilson-Lopez et al. (2018) study, students used their connections to experts, decision-makers, institutions, and peers to ensure the quality of their study projects in the process of completing them. The study also highlighted uneven representations of institutional science capital across project participants. Having a scientist as a family member and a higher socio-economic status were positively associated with university aspirations in science for Jewish students in Israel (Diamond, 2020). Both Stahl et al. (2021) and Jones et al. (2021) stressed the importance of students' social networks and connections with people in science as a foundation for future motivation and interest in science. Similarly, in their qualitative study, Black and Hernandez-Martinez (2016) highlighted the meaning of inspirational science teachers to students' scientific social capital. If a home environment does not offer any science career role models, it is important for teaching methods to support students, especially girls, in developing a science identity (Rüschenpöhler & Markic, 2020b). Turnbull et al. (2020) found a positive association between the number of generations in the family to have attended university and students' science self-concepts. Ceglie (2021) emphasised that social capital is a valuable constituent of science capital, particularly in terms of communication outside of the class environment, which allows for the exchange of scientific views and ideas and improves scientific literacy, as well as engagement in science. Kelly et al. (2019) found one main cause of fewer women in science to be a lack of role models. These role models can be achieved in different contexts by talking with diverse people and avoiding stereotypical discourses.

Talking to others about science. Five articles touched on the sub-dimension of talking others about science (Ceglie, 2021; DeWitt & Archer, 2017; King & Nomikou, 2018; Stahl et al., 2021; Turnbull et al., 2020). Through interviews, Stahl et al. (2021) discovered the role of family as a resource of meaning making, as the majority of the interviewed students spoke about their science experiments and science-related activities with their family members. This was considered an important way to contribute to the students' science identities. DeWitt and Archer (2017) considered talking with family or friends about science an everyday science activity and perceived these activities as distinct elements in the STEM learning ecosystem. Participation in these everyday science activities was quite common, and it did not diminish with age. In this study, black students were more likely to participate in these everyday activities. According to King and Nomikou (2018), talking with school students about science was highlighted as one of the ways to strengthen teacher's agency while implementing a science capital teaching approach. At the university level, interview data from university faculty members and staff revealed that science-related out-of-class behaviours and interactions in these environments aimed at exchanging ideas about science are valuable contributors to the successful completion of science degrees by underrepresented students, such as women (Ceglie, 2021). In Turnbull et al. (2020) study, university students' beliefs that science was the sphere in which they could achieve success were strongly influenced by supportive and enthusiastic teachers during high school, by communication with peers about the value of science, and, to some extent, by having several generations in the family who attended university.

Science-related behaviours and practices

Consumption of science media. Consumption of science media was mentioned in the results of seven of the reviewed articles (Black & Hernandez-Martinez, 2016; Christidou et al., 2021; DeWitt & Archer, 2017; King et al., 2015; Rüschenpöhler & Markic, 2020b; Turnbull et al., 2020; Wilson-Lopez et al., 2018). DeWitt and Archer (2017) highlighted different types of science-related activities outside of science lessons, which also included science media consumption; however, teachers still needed to develop approaches to address this area (King et al., 2015). Additionally, television was reported as the main source of science-related information, with only a few students mentioning books and magazines (Christidou et al., 2021). In acquiring chemistry capital, students reported following chemistry-related YouTube channels (Rüschenpöhler & Markic, 2020b). In Wilson-Lopez et al. (2018) study, all students used various ICTs, such as smartphones, laptops, applications, games, and software, to acquire or communicate scientific information in their science projects. A case study of a few physics' students revealed how consumption of science media in family supported their aspirations to study physics (Black & Hernandez-Martinez, 2016). Turnbull et al. (2020) demonstrated that access to science-related resources was not a significant predictor of science self-concept.

Participation in informal science learning contexts or science learning experiences. Participation in informal science learning contexts or science learning experiences was pointed out in 12 of the articles reviewed (Ceglie, 2021; Cerrato et al., 2018; Christidou et al., 2021; DeWitt & Archer, 2015, 2017; DeWitt et al., 2016, 2019; Godec et al., 2021; Jones et al., 2020, 2021; King et al., 2015; Mujtaba et al., 2018). Three of these articles discussed different forms of out-of-school science learning (Christidou et al., 2021; DeWitt & Archer, 2017; DeWitt et al., 2019). Out-of-school science learning contexts of children aged 15–16 were connected to fishing and hiking in Christidou et al. (2021) study. Interestingly, no one in this study mentioned attending coding clubs as an out-of-school context (Christidou et al., 2021). DeWitt et al. (2019) discussed engagement with museum content, such as exhibits and artefacts. Even though participants had relatively low science capital, they seemed to have other elements of capital, such as curiosity and a tendency to ask questions, expertise in a certain field, or an opportunity to perform during the visits, which facilitated engagement in the museum context. Godec et al. (2021) discussed informal science education participation and found that it was patterned by ethnicity and social class. Nevertheless, non-participation was not due to a lack of interest in STEM. The study concluded that there is a need to support minority young people in participating in out-of-school science activities.

One of the reviewed articles evaluated the degree of participation in out-of-school science learning as well as school-led science enrichment (DeWitt & Archer, 2017). School-led science enrichment was reported to be relatively rare, and participation in these out-of-school activities varied considerably among secondary school students. King et al. (2015) reported that teachers felt less confident about participation in out-of-school learning contexts. Four of the articles discussed the effects of in-school and out-of-school science learning, science-related activities, and experiences (Christidou et al., 2021; DeWitt & Archer, 2015; Jones et al., 2021; Mujtaba et al., 2018). Mujtaba et al. (2018) found a connection between science aspirations and engagement in extra-curricular activities, whereas DeWitt and Archer (2015) found a connection between young people's aspirations and experiences of school science. Science-related activities were also connected to higher self-efficacy by Christidou et al. (2021). Exposure to science experiences was also emphasised as laying the groundwork for science motivation and putting greater value on engaging with science in the future (Jones et al., 2021). Similarly, DeWitt et al. (2016)

found that unstructured science experiences were closely related to future science participation and identity.

Jones et al. (2020) found that engagement in science-related out-of-school activities, along with individuals' science self-concept and self-efficacy, the perceived future importance and utility of science, family's science achievement, and the value of science as an asset, were equally important for the formation of science-based career aspirations. Ceglie (2021) found that science-related behaviours serve as one of the key factors that strengthen students' science capital and help them achieve success in science. Such behaviours were defined as out-of-class activities and interactions with science faculty in laboratories or other research environments. For students with low science capital, coding workshops served as an empowering experience (Cerrato et al., 2018).

Science-related subjective sense of self

Science aspirations. Science aspirations were connected with the research outcomes of 15 of the reviewed articles (Archer, DeWitt, Osborne, et al., 2013; Cooper & Berry, 2020; DeWitt & Archer, 2015; DeWitt et al., 2016; Diamond, 2020; Du & Wong, 2019; Emembolu et al., 2020; Essex & Haxton, 2018; Godec et al., 2021; Jones et al., 2020, 2021; Moote et al., 2020, 2021; Mujtaba et al., 2018; Wong, 2015). One of these studies found a connection between the amount of science capital and the degree of science aspiration (Moote et al., 2020, 2021). In Moote et al. (2021) study, students with high science capital were relatively more likely to choose a STEM career after completing compulsory school. Further, Moote et al. (2020) found that science capital was strongly connected to science aspirations in physics and engineering but had no connection with aspirations in mathematics or technology (Moote et al., 2020). In Israel, in contrast to majority students whose higher socio-economic status and having a scientist in the family were closely connected to higher aspirations to study science at university, minority students did not exhibit such a tendency (Diamond, 2020). For minority ethnic students, a clear dichotomy between science aspiration and science attainment disclosed the heterogeneous nature of this group with regard to science capital in the UK (Wong, 2015). Cooper and Berry (2020) found a connection between socio-economic status and participation in different science domains. Emembolu et al. (2020) found that primary school interventions with a special focus on scientific career knowledge and aspirations towards science had a positive effect, especially on girls. The aspiration to become an engineer increased during the intervention for both boys and girls (Emembolu et al., 2020). One article discussed five patterned representations of science aspirations among boys – young professors, cool/footballer scientists, behaving/achieving boys, popular masculine boys, and laddish boys – and young professors and cool/footballer scientists were associated with high science aspirations (Archer, DeWitt, Osborne, et al., 2013). Science aspirations were found to be shaped by social identities, family attitudes, and young people's own experiences of in-school science activities, with social inequality acting as an obstacle to the pursuit of a career in science (DeWitt & Archer, 2015). One article discussed the different connecting lines between science capital and the science aspirations of students in China and the UK (Du & Wong, 2019). In both countries, family background, learning results, and science capital were found to be applicable to explaining students' science aspirations, but some elements of science capital were not as relevant to aspirations towards science among

Chinese students compared to those of the UK. Jones et al. (2020) found a connection between science self-efficacy and self-concept, the number of out-of-school activities, dispositions, and attitudes, and science aspirations, regardless of the gender and cultural background of the participants in the study.

Current extrinsic motivation towards science and intrinsic interest in science were strongly connected to students' aspirations to study non-compulsory science in the future (Mujtaba et al., 2018). Science capital was found to determine engagement in informal science learning behaviours in outreach activities designed at visitor centre science venues (Essex & Haxton, 2018). Jones et al. (2021) found that the home environment played a key role in supporting the development of science interest and forming motivation for future value and engagement in science. The nature of science orientations was found to affect the degree of interest in science and science career aspirations (Wong, 2015). Godec et al. (2021) showed that inclusion in informal STEM education practices is especially relevant to the formation and development of science interests and science career aspirations in students with minority backgrounds. As mentioned in earlier sections, DeWitt et al. (2016) connected science literacy, knowledge of transferability, family attitudes, and out-of-school experiences to science aspirations and science identity.

Science identity. The sub-category of science identity was further divided into two groups: scientific self-efficacy and science personality. Scientific self-efficacy was highlighted in the results of three reviewed articles (Christidou et al., 2021; Du & Wong, 2019; King & Nomikou, 2018). Christidou et al. (2021) found that higher science capital scores correlated with higher self-efficacy as related to involvement in science-related activities and contexts. However, self-efficacy in science did not have a significant association with science aspirations among Chinese and UK students (Du & Wong, 2019). King and Nomikou (2018) found that participation in a programme focusing on fostering science capital in students from socially and ethnically diverse backgrounds to increase their engagement in science learning had a positive effect on teachers' professional development. In particular, it increased their sense of purpose, mastery, autonomy, reflexibility, and ability to appeal to students' life experiences in teaching science.

Science personality as a trait was discussed in 11 reviewed articles (Archer, DeWitt, Osborne, et al., 2013; Black & Hernandez-Martinez, 2016; DeWitt et al., 2016; Gonsalves, Cavalcante, et al., 2021; Jones et al., 2020; Kelly et al., 2019; Mujtaba et al., 2018; Rüschenpöhler & Markic, 2020a; Stahl et al., 2021; Teo et al., 2018; Turnbull et al., 2020). Black and Hernandez-Martinez (2016) claimed that the presence of science identity mediated the acquisition of science capital and mobilised engagement in science learning activities. This may also explain the appreciation of the value of science in the form of exchange and reward. Jones et al. (2020) indicated that individuals' confidence in being able to learn and do science well, as well as their awareness that others see them as people who are keen on science, contribute significantly to their science career aspirations. Notably, Rüschenpöhler and Markic (2020a) found that a clear connection was missing between chemistry self-concept and students' chemistry capital, and a strong self-concept appeared apart from the level of chemistry capital in the family.

Another study focused on a group of science majors and found that they became aware of their science identity early on and that others already regarded them as science people at school (Gonsalves, Cavalcante, et al., 2021). Among 7th-grade students in Singapore, self-evaluation of science learning was a significant predictor of their skills in scientific reasoning (Teo et al., 2018). In another study, female STEM undergraduates felt less confident about their own intelligence and the amount of knowledge they had about the latest discoveries compared to their male counterparts (Kelly et al., 2019). Turnbull et al. (2020) emphasised that males had a higher level of scientific self-concept, and the influence of passionate high school science teachers on students' self-concept was emphasised. Two types of boys' discursive performances, such as young professors and cool/footballer scientists, were connected to science personality (Archer, DeWitt, Osborne, et al., 2013). Mujtaba et al. (2018) found that school students' scientific self-concept had relevant associations with certain teaching approaches, family science capital and encouragement from teachers and family. Stahl et al. (2021) demonstrated that urban and rural locations and familial relationships affected the formation of students' science identities in distinct ways. The study emphasised the importance of taking students' lifeworld experiences into account in developing pedagogical approaches to fostering science capital. Lastly, DeWitt et al. (2016) found that future science participation and science identity were closely connected to science literacy, family attitudes towards science, informal science-related experiences, and knowledge about the transferability of science.

In summary, the results of the reviewed articles about the science-related subjective sense of self dimension showed connections and relationships with all other dimensions. However, the research designs used in the reviewed articles did not allow the interpretation of causalities. Both science aspirations and science identity were related to general science capital, science-related social capital, and science-related behaviours and practices. In addition, science identity was connected to science-related cultural capital.

Cross-cutting themes

Cultural background and gender issues. In addition to family and social networks, cultural background and gender issues were highlighted in the results of 14 reviewed articles (Adams-Wiggins et al., 2019; Archer, DeWitt, Osborne, et al., 2013; Ceglie, 2021; Cooper & Berry, 2020; DeWitt & Archer, 2015, 2017; Diamond, 2020; Du & Wong, 2019; Emembolu et al., 2020; Godec et al., 2021; Kelly et al., 2019; Moote et al., 2021; Turnbull et al., 2020; Wong, 2015). Only one of these studies connected both gender and cultural backgrounds to science capital. Moote et al. (2021) showed that the level of science capital was shaped by gender and ethnicity, as well as by cultural capital and science attainment at school.

The effect of science-related social capital on personal outcomes in science education was relevant with regard to sociocultural background in Diamond's (2020) study. DeWitt and Archer (2017) stressed that science capital is unevenly or inequitably distributed across different groups. In their study, everyday science activities reached black students well, whereas informal science activities or designed spaces were less accessible. Wong (2015) noted that participation in science was diverse among minority ethnic students. Godec et al. (2021) found that young minorities were interested in STEM but did not often participate in designed and community STEM activities. Ceglie (2021) indicated that not having science-related social capital supported by parents or community members created a void of opportunities for underrepresented groups, such as minority students. DeWitt and Archer (2017) found patterns of participation in science activities based on ethnicity. One common feature of the whole cohort was that students from higher social backgrounds engaged more in informal science learning. Further, science aspirations were found to be reliably patterned by social identities and social inequalities (DeWitt & Archer, 2015). Du and Wong (2019) highlighted the importance of recognising cultural and national differences when operationalising science capital. In Australia, socio-economic status significantly predicted participation in chemistry, biology, physics, and earth/space sciences; gender predicted participation in biology and physics, but not chemistry or earth/space sciences; and indigenous status negatively correlated with participation in chemistry, biology, and physics but showed no effect on involvement in earth/space sciences (Cooper & Berry, 2020). Adams-Wiggins et al. (2019) highlighted the importance of noting the different statuses of students in enquiry-based science lessons, since this affects the equity of students. Overall, faculty members in Ceglie's (2021) study perceived that minority students did not have science-related social capital.

Five studies highlighted gender issues. Archer, DeWitt, Osborne, et al. (2013) discussed five discursive performances of masculinity that are connected to boys' aspirations. Two of these were connected to science: young professors and cool/footballer scientist. By contrast, Kelly et al. (2019) discussed female STEM students' explanations for why there are fewer women in STEM professions and leadership positions. The main reasons were social bias, balancing work and family life, and a lack of role models. In addition, females tended to claim less often that they were intelligent and knew enough about the latest discoveries than males did (Kelly et al., 2019). Moote et al. (2021) findings showed that among older (17–18 years) students, science capital was patterned by gender, and compared with the effect sizes of previous findings from younger cohorts' analysis, there was a small but significant increase in the proportion of boys with high science capital. According to Turnbull et al. (2020, p. 13), 'students who self-identified as male had higher levels of science self-concept, even after accounting for social and cultural factors in our theoretical model'. Emembolu et al. (2020) noted that long-lasting interventions had positive effects, especially on girls' science capital.

Discussion

This literature review aimed to analyse the areas on which existing science capital-related research is focused and discussed. The first and second research questions clarified how the studies were methodologically conducted and who was in focus in the research. The third question clarified the dimensions of science capital discussed in the studies' findings. In general, the analysis reveals that the conceptual coherence of science capital still needs more detailed consideration to explain its causes and consequences. This is in line with previous studies (Jensen & Wright, 2015; Krarup & Munk, 2016). Attitudes towards science, as well as aspirations towards STEM education, are mediated widely through the cultural environment in which people live and study (Archer, DeWitt, Osborne, et al., 2013; Francis et al., 2017; Kolesnikova & Kudenko, 2021). However, there is no clear evidence of the extent of the effects of the cultural environment and the significance of its role compared to other variables, such as political or religious issues. Thus, limiting science capital research to specific dimensions is not valid without a discussion of related societal and cultural backgrounds in general. The conceptual definition still needs more discussion in connection with Bourdieu's approach (see also Jensen & Wright, 2015). By contrast, the science capital dimensions by Archer, Dawson, et al. (2015) seem to leave out some individual values of studying STEM subjects, and the one-dimensional analyses of core dimensions can be misleading (Black & Hernandez-Martinez, 2016).

Although Bourdieu's theory of capital (Bourdieu, 1986) highlights the role of education in maintaining the unequal distribution of cultural capital, several of the reviewed articles focused on formal education and provided insights into how science capital or its core dimensions are supported in formal education. Thus, the conceptual understanding of science capital could potentially use a framework that explores areas of how formal and informal education should be developed.

Science capital has been studied using several descriptive qualitative methods, alongside quantitative surveys and mixed methods. Cross-sectional studies on scientific capital were emphasised in quantitative studies, revealing the need for longitudinal studies. The longitudinal studies could provide, for example, better options to analyse how the different dimensions of science capital are mediated in different phases of one's education. Although the qualitative data varied, the survey results highlighted the need to design intervention studies that would more carefully address disparities in science engagement and participation (DeWitt et al., 2016).

Globally, one of the challenges of researching science capital seems to be context-dependently produced data, such as interviews, which cannot be interpreted over cultural traditions or societal structures. In different societies, the values, roles, or stereotypes are constructed in the historical traditions of society and institutions; thus, the outcomes cannot be interpreted in every culture as itself. This is especially evident in interpreting the gender and ethnic group differences in aspirations towards science (see, e.g. Jensen & Wright, 2015) or the role of families or teachers in science aspirations (Black & Hernandez-Martinez, 2016).

The review revealed that studies of science capital have focused primarily on formal education and later years of education. Some studies that focus on university students or families exist, but these are a minority. Science capital concepts should be widely applied to different educational levels and target groups. There is a lack of studies in primary education, although several papers indicate early years and family effects on science capital (DeWitt & Archer, 2015; Gonsalves, Cavalcante, et al., 2021; Jones et al., 2021; Moote et al., 2020; Rüschenpöhler & Markic, 2020a; Stahl et al., 2021). There is little evidence supporting differences in science capital between ethnic groups and students with special educational needs. Different target groups have their own cultural backgrounds, and their core dimensions of science capital have been formulated differently. To promote science education, there is a need to consider these target groups systematically and deeply, focusing on several core dimensions simultaneously.

Further, there has been little focus on students in teacher education. The role of education and educational background was mentioned in several studies (Essex & Haxton, 2018; Gonsalves, Cavalcante, et al., 2021; King & Nomikou, 2018; King et al., 2015; Teo et al., 2018; Turnbull et al., 2020), but teacher education as a context does not appear in this review. It would be essential to follow students' science capital development in different phases of education; thus, teacher education and the role of teachers in this discussion could also be explored.

The reviewed studies were conducted mainly in Europe. Although the role of social background and ethnicity is evident in the discussion of science capital, there is not much research from other countries and continents. Family support and access to science knowledge vary in different countries (Du & Wong, 2019), thus emphasising the need to widen discussions relating to science capital to different cultural contexts. For example, the regional distribution of studies carried out in African and South American countries appears to be unbalanced.

The third research question focused on analysing the emerging dimensions of science capital in the research articles. The dimension of science capital mostly in focus is science-related social capital and science-related subjective sense of self. Several studies have clearly proven the associations between family support and students' individual science capital, aspirations, and performance in science (Black & Hernandez-Martinez, 2016; DeWitt & Archer, 2015; DeWitt et al., 2016; Diamond, 2020; Du & Wong, 2019; Jones et al., 2020, 2021; Mujtaba et al., 2018; Rüschenpöhler & Markic, 2020a, 2020b). However, there is a need for advanced research on how parents' roles can be fostered and conducted more explicitly in formal and informal education. This further suggests the need for a wider discussion of science capital among parents. Recently, Suortti et al. (2023) revealed that Finnish parents' residential areas and educational degrees had a significant relationship with different science capital dimensions, although these variables did not affect parents' engagement in everyday science activities with their children.

This review reveals that a science-related subjective sense of self – that is, science aspirations and science identity – plays a significant role in science capital. This is in line with Archer, Dawson, et al. (2015) original idea of science aspirations and science identity being dependent variables. Several studies have indicated the role of science identity and self-efficacy (Archer, DeWitt, Osborne, et al., 2013; Black & Hernandez-Martinez, 2016; Christidou et al., 2021; DeWitt et al., 2016; Du & Wong, 2019; Gonsalves, Cavalcante, et al., 2021; Jones et al., 2020; Kelly et al., 2019; King & Nomikou, 2018; Mujtaba et al., 2018; Rüschenpöhler & Markic, 2020a; Stahl et al., 2021; Teo et al., 2018; Turnbull et al., 2020). However, the role of self-efficacy in science aspirations is not evident in all cultures (Archer, Dawson, et al., 2015).

Science-related cultural capital remains the least studied dimension. Only a few studies have focused on science literacy, the transferability of science, and science-related attitudes, despite evidence that the role of these dimensions of science capital is closely related to anticipated future participation and identity in science (DeWitt & Archer, 2015). This is associated with the behaviour and practice dimensions, in which the media plays a crucial role. The use of social media as a reference for science capital has not been discussed in the extant literature. However, its role in everyday media consumption has increased, and current societies need good science literacy and media consumption skills to critically review offered information and solve global challenges (Sinatra & Lombardi, 2020). Further, the ubiquitous presence of technology in modern culture affects all societal structures and practices, leading to an increased need for science education and citizenship skills (Prieur & Savage, 2013).

The concept of science capital and its dimensions provide a relevant framework for developing science education. Including the core dimensions of science capital reviewed in curriculum work in formal education would open up several methodological options for improving teaching and supporting students' science literacy and science aspirations. However, there is still work to be done on how to operationalise the core dimensions of science capital and reformulate them into pedagogical actions. Although it seems that the core dimensions of science capital can be distinguished, in everyday contexts, several drives and variables act simultaneously, and causes and consequences are difficult to recognise. Further, existing educational systems may hinder the implementation of core dimensions of science capital in school pedagogies. For example, the roles of families, media, and practices are very different in different cultures (Reznik et al., 2023).

Alongside formal education, there should be more emphasis on informal learning environments when fostering science capital among students. The existing literature discusses the role of out-of-school activities in greater levels of science self-concepts, science values, and the utility of science (Jones et al., 2020). Fostering science capital in informal educational settings should also be considered and further researched to enhance the possibilities of building science capital for those who do not gain benefits in formal educational settings.

One limitation of this study is apparent in the literature search, which could have possibly been expanded with more education-related keywords than what we used; for example, the keyword ‘studying’ could have been used. However, in this research, we wanted to focus specifically on learning and teaching, and adding the studying perspective would not have provided additional information for this purpose. Another limitation of this study relates to the language of the materials in the review. In this review, all papers were published in English. Future systematic reviews could include other languages, such as Spanish, German, or French, in the analysis. The findings of this review indicate the strong role of cultural capital, and several of the studies were conducted in different cultural contexts. Thus, the impact of language is essential.

Conclusion

This paper provides a systematic and overall analysis of existing research on science capital to increase the conceptual understanding of the concept and to reveal the need for future research. Several studies have indicated the relevance of the science capital concept when assessing the influences on science aspirations and science careers. To increase science competence, we need a profound understanding of the significance of the dimensions of science capital and how they are regulated or controlled by different drivers. The papers often described the specific core dimension of science capital or focused on crosscutting themes, such as cultural background or gender. The papers indicated relations between science capital or its core dimensions with several drivers, such as family background and education, aiming to explain significance or different specific contextual drivers. The results are still sometimes contradictory. There is an urgent need for more systematic quantitative, large-scale analyses and intervention studies to indicate the causes and consequences and to provide suggestions for science education policies in different countries. The scarcity of research results on the science-related social capital dimension observed in this review highlights the need for research on the subject. This study’s findings will clearly increase awareness of the importance of science-related cultural capital for social equity. This study calls for future research that focuses more on the contextual and cultural drivers of science capital. It seems that science capital is strongly connected to cultural contexts, and its role should be more evident when analysing science capital. Therefore, this role should be taken into account more systematically to adequately assess cultural drivers and to create a theoretical and conceptually coherent understanding of science capital.

This review also reveals how the understanding of science capital and its role has not been studied at all educational levels and contexts. Special education, primary level, and vocational education have not received attention among researchers. To better understand and support equity in education, more research is needed to determine the role of science capital in different educational contexts to make science education possible for all. Thus, the entire science education community should be aware of the complexity of science capital and its role in teaching and learning.

Acknowledgments

The project was funded by the Strategic Research Council (SRC) established within the Academy of Finland.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Sini Kontkanen works as a university lecturer at the University of Eastern Finland in the School of Applied Educational Sciences and Teacher Education. Her research interests relate to the professional development and competence of teachers and student teachers from the perspective of technological pedagogical content knowledge. In addition, she is interested in the development of digital competence in pre-primary and primary education and the educational use of information and communication technologies in different contexts.

Teija Koskela works as a university research fellow at the University of Turku in the Department of Teacher Education. She is the coordinator of the Centre for Research on Learning and Instruction (CERLI). Her research focuses on inclusive education and sustainable development in teacher education and schools. Her research emphasises sociological perspectives and educational equality.

Oksana Kanerva is a research fellow at Turku University. She investigates how epistemic emotions, such as awe, affect learning of scientific information. She also studies the role of awe in promoting engagement in science-related activities in informal settings, for examples in science museums. Finally, she researches whether awe has the power to make visitors to science museums more interested in the exhibition topics.

Sirpa Kärkkäinen is a Senior Lecturer in Biology and Geography at the University of Eastern Finland in the School of Applied Educational Science and Teacher Education. Her research areas are primarily focused on inquiry-based learning and collaborative learning. Her current research themes concern informal learning environments and environmental education.

Katariina Waltzer works as a university lecturer at the University of Eastern Finland in the School of Education and Psychology. Her research interests relate to subjective well-being and social and educational exclusion in society. She is also interested in inclusive learning environments.

Mirjamaija Mikkilä-Erdmann is professor of teacher education and head of the Centre for Research on Learning and Instruction (CERLI) at the University of Turku. She is an internationally experienced scholar in the field of educational sciences and an experienced teacher educator and supervisor who also investigates research-based teacher training. She is especially interested in science literacy, text comprehension and online methodologies for investigating comprehension processes while learning complex, counterintuitive scientific phenomena.

Sari Havu-Nuutinen is a professor of education, especially early years education, at the University of Eastern Finland in the School of Applied Educational Science and Teacher Education. She is involved in minor studies of pre-primary education, the international master's degree programme and postgraduate studies in education. She has more than 20 years' experience in teacher education in Finland and has actively participated in curriculum development in teacher education. She is an internationally collaborative researcher in her research field, addressing the teaching and learning of young children in science education. She has participated in science education research and developmental projects, both nationally and internationally. In addition, she is leading national school-related projects relating to science education and flexible learning environments.

ORCID

Sini Kontkanen http://orcid.org/0000-0002-3026-4037
Teija Koskela http://orcid.org/0000-0001-7331-5212
Oksana Kanerva http://orcid.org/0000-0001-7309-0623
Sirpa Kärkkäinen http://orcid.org/0000-0002-0515-0775
Katariina Waltzer http://orcid.org/0000-0001-6841-7556
Mirjamaija Mikkilä-Erdmann http://orcid.org/0000-0003-1569-794X
Sari Havu-Nuutinen http://orcid.org/0000-0001-5502-6361

References

Studies included in the review are marked with *

*Adams-Wiggins, K. R., Myers, M. N., & Dancis, J. S. (2019). Negotiating status hierarchies in middle school inquiry science: Implications for marginal non-participation. *Instructional Science*, *48*(4), 427–451. https://doi.org/10.1007/s11251-020-09514-5

Adamuti-Trache, M., & Andres, L. (2008). Embarking on and persisting in scientific fields of study: Cultural capital, gender, and curriculum along the science pipeline. *International Journal of Science Education*, *30*(12), 1557–1584. https://doi.org/10.1080/09500690701324208

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching*, *52*(7), 922–948. https://doi.org/10.1002/tea.21227

Archer, L., DeWitt, J., & Osborne, J. (2015). Is science for us? Black students' and parents' views of science and science careers. *Science Education*, *99*(2), 199–237. https://doi.org/10.1002/sce.21146

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. *American Educational Research Journal*, *47*(4), 881–908.

Archer, L., DeWitt, J., Osborne, J. F., Dillon, J. S., Wong, B., & Willis, B. (2013). *ASPIRES report: Young people's science and career aspirations, age 10–14*. King's College London.

*Archer, L., DeWitt, J., & Willis, B. (2013). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching*, *51*(1), 1–30. https://doi.org/10.1002/tea.21122

Archer, L., & Hutchings, M. (2000). 'Bettering yourself'? Discourses of risk, cost and benefit in ethnically diverse, young working-class non-participants' constructions of higher education. *British Journal of Sociology of Education*, *21*(4), 555–574. https://doi.org/10.1080/713655373

*Black, L., & Hernandez-Martinez, P. (2016). Re-thinking science capital: The role of 'capital' and 'identity' in mediating students' engagement with mathematically demanding programmes at university. *Teaching Mathematics and Its Applications: International Journal of the IMA*, *35*(3), 131–143. https://doi.org/10.1093/teamat/hrw016

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste*. Harvard University Press.

Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). Greenwood Press.

Bourdieu, P., & Wacquant, L. (1992). *An invitation to reflexive sociology*. University of Chicago Press.

Bramer, W. M., Milic, J., & Mast, F. (2017). Reviewing retrieved references for inclusion in systematic reviews using EndNote. *Journal of the Medical Library Association: JMLA*, *105*(1), 84. https://doi.org/10.5195/jmla.2017.111

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

*Ceglie, R. (2021). Science faculty's support for underrepresented students: Building science capital. *International Journal of Science and Mathematics Education*, *19*(4), 661–679. https://doi.org/10.1007/s10763-020-10090-w

*Cerrato, S., Rizzato, F., Tealdi, L., & Canel, E. (2018). A coding lab to increase science capital of school dropout teenagers. *Journal of Science Communication*, *17*(4), 3.https://doi.org/10.22323/2.17040803

*Christidou, D., Papavlasopoulou, S., & Giannakos, M. (2021). Using the lens of science capital to capture and explore children's attitudes toward science in an informal making-based space. *Information & Learning Sciences*, *122*(5/6), 317–340.https://doi.org/10.1108/ILS-09-2020-0210

Claussen, S., & Osborne, J. (2013). Bourdieu's notion of cultural capital and its implications for the science curriculum. *Science Education*, *97*(1), 58–79. https://doi.org/10.1002/sce.21040

*Cooper, G., & Berry, A. (2020). Demographic predictors of senior secondary participation in biology, physics, chemistry and earth/space sciences: Students' access to cultural, social and science capital. *International Journal of Science Education*, *42*(1), 151–166. https://doi.org/10.1080/09500693.2019.1708510

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Delaney, J. M., & Devereux, P. J. (2019). Understanding gender differences in STEM: Evidence from college applications. *Economics of Education Review*, *72*, 219–238. https://doi.org/10.1016/j.econedurev.2019.06.002

*DeWitt, J., & Archer, L. (2015). Who aspires to a science career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education*, *37*(13), 2170–2192. https://doi.org/10.1080/09500693.2015.1071899

*DeWitt, J., & Archer, L. (2017). Participation in informal science learning experiences: The rich get richer? *International Journal of Science Education*, *7*(4), 356–373. https://doi.org/10.1080/21548455.2017.1360531

*DeWitt, J., Archer, L., & Mau, A. (2016). Dimensions of science capital: Exploring its potential for understanding students' science participation. *International Journal of Science Education*, *38*(16), 2431–2449. https://doi.org/10.1080/09500693.2016.1248520

*DeWitt, J., Nomikou, E., & Godec, S. (2019). Recognising and valuing student engagement in science museums. *Museum Management & Curatorship*, *34*(2), 183–200. https://doi.org/10.1080/09647775.2018.1514276

*Diamond, A. H. (2020). The social reproduction of science education outcomes for high school students in Israel. *British Journal of Sociology of Education*, *41*(7), 1029–1046. https://doi.org/10.1080/01425692.2020.1806040

Diekman, A. B., Steinberg, M., Brown, E. R., Belanger, A. L., & Clark, E. K. (2017). A goal congruity model of role entry, engagement, and exit: Understanding communal goal processes in STEM gender gaps. *Personality and Social Psychology Review*, *21*(2), 142–175. https://doi.org/10.1177/1088868316642141

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10.1002/sce.21499

*Du, X., & Wong, B. (2019). Science career aspiration and science capital in China and UK: A comparative study using PISA data. *International Journal of Science Education*, *41*(15), 2136–2155. https://doi.org/10.1080/09500693.2019.1662135
Elmesky, R., & Tobin, K. (2005). Expanding our understandings of urban science education by expanding the roles of students as researchers. *Journal of Research in Science Teaching*, *42*(7), 807–828. https://doi.org/10.1002/tea.20079
Elo, S., & Kyngäs, S. H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x
* Emembolu, I., Padwick, A., Shimwell, J., Sanderson, J., Davenport, C., & Strachan, R. (2020). Using action research to design and evaluate sustained and inclusive engagement to improve children's knowledge and perception of STEM careers. *International Journal of Science Education*, *42*(5), 764–782. https://doi.org/10.1080/09500693.2020.1729442
Essex, J., & Haxton, K. (2018). Characterising patterns of engagement of different participants in a public stem-based analysis project. *International Journal of Science Education*, *8*(2), 178–1. https://doi.org/10.1080/21548455.2017.1423128
Francis, B., Archer, L., Moote, J., DeWitt, J., MacLeod, E., & Yeomans, L. (2017). The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics. *Sex Roles*, *76*(3–4), 156–174. https://doi.org/10.1007/s11199-016-0669-z
Glaze, A. L. (2018). Teaching and learning science in the 21st century: Challenging critical assumptions in post-secondary science. *Education Sciences*, *8*(1), 12. https://doi.org/10.3390/educsci8010012
*Godec, S., Archer, L., & Dawson, E. (2021). Interested but not being served: Mapping young people's participation in informal STEM education through an equity lens. *Research Papers in Education*, *37*(2), 221–248. https://doi.org/10.1080/02671522.2020.1849365
Godec, S., King, H., & Archer, L. (2017). *The science capital teaching approach: Engaging students with science, promoting social justice*. University College London.
Gok, T. (2021). The development of the STEM (science, technology, engineering, and mathematics) attitude and motivation survey towards secondary school students. *International Journal of Cognitive Research in Science, Engineering and Education*, *9*(1), 105–119. https://doi.org/10.23947/2334-8496-2021-9-1-105-119
Gonsalves, A. J. (2018). Gender, culture, and science identity: Indian and Indian-origin women choosing STEM in college. *Journal of Women and Minorities in Science and Engineering*, *24*(1), 1–24.
*Gonsalves, A. J., Cavalcante, A. S., Sprowls, E. D., & Iacono, H. (2021). "Anybody can do science if they're brave enough": Understanding the role of science capital in science majors' identity trajectories into and through postsecondary science. *Journal of Research in Science Teaching*. https://doi.org/10.1002/tea.21695
Gonsalves, A. J., Daniel, B., Jairam, D., & Victor, G. (2021). Science identity and the cognitive and cultural resources children of Indian origin bring to learning. *Cultural Studies of Science Education*, *16*(1), 307–327.
Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The science identity of college students: Exploring the intersection of gender, race, and ethnicity. *Journal of College Science Teaching*, *42*(5), 82–91.
Hazelkorn, E., Ryan, C., Beernaert, Y., Constantinou, C. P., Deca, L., Grangeat, M., Karikorpi, M., Lazoudis, A., Casulleras, R. P., & Welzel, M. (Eds.). (2015). *Science education for responsible citizenship: Report to the European commission of the expert group on science education*. Publications Office of the European Union.
Holbrook, J., & Rannikmäe, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education*, *29*(11), 1347–1362. https://doi.org/10.1080/09500690601007549
Howell, E. L., & Brossard, D. (2021). (Mis) informed about what? What it means to be a science-literate citizen in a digital world. *Proceedings of the National Academy of Sciences*, *118*(15), e1912436117. https://doi.org/10.1073/pnas.1912436117
Jensen, E., & Wright, D. (2015). Critical response to Archer et al. (2015) "science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. *Science Education*, *99*(6), 1143–1146. https://doi.org/10.1002/sce.21208

*Jones, M. G., Chesnutt, K., Ennes, M., Mulvey, K. L., & Cayton, E. (2021). Understanding science career aspirations: Factors predicting future science task value. *Journal of Research in Science Teaching*, *58*(7), 937–955. https://doi.org/10.1002/tea.21687

*Jones, M. G., Ennes, M., Weedfall, D., Chesnutt, K., & Cayton, E. (2020). The development and validation of a measure of science capital, habitus, and future science interests. *Research in Science Education*. *51*(6), 1549–1565. https://doi.org/10.1007/s11165-020-09916-y

Jones, M. G., Taylor, A., & Forrester, J. (2011). Developing a scientist: A retrospective look. *International Journal of Science Education*, *33*(12), 1653–1673. https://doi.org/10.1080/09500693.2010.523484

*Kelly, R., McGarr, O., Lehane, L., & Erduran, S. (2019). STEM and gender at university: Focusing on Irish undergraduate female students' perceptions. *Journal of Applied Research in Higher Education*, *11*(4), 770–787. https://doi.org/10.1108/JARHE-07-2018-0127

Kerkhoven, A. H., Russo, P., Land-Zandstra, A. M., Saxena, A., Rodenburg, F. J., & Dalby, A. R. (2016). Gender stereotypes in science education resources: A visual content analysis. *PLOS ONE*, *11*(11), e0165037. https://doi.org/10.1371/journal.pone.0165037

*King, H., & Nomikou, E. (2018). Fostering critical teacher agency: The impact of a science capital pedagogical approach. *Pedagogy Culture & Society*, *26*(1), 87–103. https://doi.org/10.1080/14681366.2017.1353539

*King, H., Nomikou, E., Archer, L., & Regan, E. (2015). Teachers' understanding and operationalisation of 'science capital'. *International Journal of Science Education*, *37*(18), 2987–3014. https://doi.org/10.1080/09500693.2015.1119331

Kolesnikova, E. M., & Kudenko, I. A. (2021). Schoolchildren about stem professions: General and gender-specific representations. *RUDN Journal of Sociology*, *21*(2), 239–252. https://doi.org/10.22363/2313-2272-2021-21-2-239-252

Krarup, T., & Munk, M. D. (2016). Field theory in cultural capital studies of educational attainment. *British Journal of Sociology of Education*, *37*(5), 761–779. https://doi.org/10.1080/01425692.2014.969398

Krippendorff, K. (2019). *Content analysis: An introduction to its methodology*. Sage Publications. https://doi.org/10.4135/9781071878781

Kyngäs, H., & Kaakinen, P. (2020). Deductive content analysis. In H. Kyngäs, K. Mikkonen, & M. Kääriäinen (Eds.), *The application of content analysis in nursing science research*. Springer. https://doi.org/10.1007/978-3-030-30199-6_3

Lent, R. W., Miller, M. J., Smith, P. E., Watford, B. A., Lim, R. H., Hui, K., Morrison, M. A., Wilkins, G., & Williams, K. (2013). Social cognitive predictors of adjustment to engineering majors across gender and race/ethnicity. *Journal of Vocational Behavior*, *83*(1), 22–30. https://doi.org/10.1016/j.jvb.2013.02.006

Luo, T., So, W. W. M., Wan, Z. H., & Li, W. C. (2021). STEM stereotypes predict students' STEM career interest via self-efficacy and outcome expectations. *International Journal of STEM Education*, *8*(1), 1–13. https://doi.org/10.1186/s40594-021-00295-y

Macdonald, A. (2014). "Not for people like me?" under-represented groups in science, technology and engineering. *Wise Campaign*. https://www.equalityanddiversity.net/docs/not_for_people_like_me.pdf

Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers in Education*, *4*. https://doi.org/10.3389/feduc.2019.00060

May, B. K., Wendt, J. L., & Barthlow, M. J. (2022). A comparison of students' interest in STEM across science standard types. *Social Sciences & Humanities Open*, *6*(1), 100287. https://doi.org/10.1016/j.ssaho.2022.100287

Mellén, J., & Angervall, P. (2021). Gender and choice: Differentiating options in Swedish upper secondary STEM programmes. *Journal of Education Policy*, *36*(3), 417–435. https://doi.org/10.1080/02680939.2019.1709130

*Moote, J., Archer, L., DeWitt, J., & MacLeod, E. (2020). Science capital or STEM capital? Exploring relationships between science capital and technology, engineering, and maths aspirations and attitudes among young people aged 17/18. *Journal of Research in Science Teaching*, *57*(8), 1228–1249. https://doi.org/10.1002/tea.21628

*Moote, J., Archer, L., DeWitt, J., & MacLeod, E. (2021). Who has high science capital? An exploration of emerging patterns of science capital among students aged 17/18 in England. *Research Papers in Education*, *36*(4), 402–422. https://doi.org/10.1080/02671522.2019.1678062

*Mujtaba, T., Sheldrake, R., Reiss, M. J., & Simon, S. (2018). Students' science attitudes, beliefs, and context: Associations with science and chemistry aspirations. *International Journal of Science Education*, *40*(6), 644–667. https://doi.org/10.1080/09500693.2018.1433896

Naukkarinen, J. K., & Bairoh, S. (2020). STEM: A help or a hinderance in attracting more girls to engineering? *Journal of Engineering Education*, *109*(2), 177–193. https://doi.org/10.1002/jee.20320

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., & Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 1–11. https://doi.org/10.1186/s13643-021-01626-4

Potvin, P. (2021). Response of science learners to contradicting information: A review of research. *Studies in Science Education*, *59*(1), 67–108. https://doi.org/10.1080/03057267.2021.2004006

Prieur, A., & Savage, M. (2013). Emerging forms of cultural capital. *European Societies*, *15*(2), 246–267. https://doi.org/10.1080/14616696.2012.748930

Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: Teaching socio-scientific issues*. McGraw-Hill Education (UK).

Reznik, G., Massarani, L., & Calabrese Barton, A. (2023). Informal science learning experiences for gender equity, inclusion and belonging in STEM through a feminist intersectional lens. *Cultural Studies of Science Education*, *18*(3), 959–984. https://doi.org/10.1007/s11422-023-10149-4

*Rüschenpöhler, L., & Markic, S. (2020a). How the home environment shapes students' perceptions of their abilities: The relation between chemistry capital at home and students' chemistry self-concept. *International Journal of Science Education*, *42*(12), 2075–2094. https://doi.org/10.1080/09500693.2020.1812010

*Rüschenpöhler, L., & Markic, S. (2020b). Secondary school students' acquisition of science capital in the field of chemistry. *Chemistry Education Research and Practice*, *21*(1), 220–236. https://doi.org/10.1039/C9RP00127A

Sanchez, K. A., Bevan, A. J., Vita, A. A., Royse, E. A., Januszkiewicz, E., & Holt, E. A. (2023). Grit matters to biology doctoral students' perception of barriers to degree completion. *Journal of Biological Education*, 1–24. https://doi.org/10.1080/00219266.2023.2192731

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2017). Science teaching and students' attitudes and aspirations: The importance of conveying the applications and relevance of science. *International Journal of Educational Research*, *85*, 167–183. https://doi.org/10.1016/j.ijer.2017.08.002

Sinatra, G. M., & Lombardi, D. (2020). Evaluating sources of scientific evidence and claims in the post-truth era may require reappraising plausibility judgments. *Educational Psychologist*, *55*(3), 120–131. https://doi.org/10.1080/00461520.2020.1730181

Smith, E. (2011). Women into science and engineering? Gendered participation in higher education STEM subjects. *British Educational Research Journal*, *37*(6), 993–1014. https://doi.org/10.1080/01411926.2010.515019

Smith, E., & White, P. (2011). Who is studying science? The impact of widening participation policies on the social composition of UK undergraduate science programmes. *Journal of Education Policy*, *26*(5), 677–699. https://doi.org/10.1080/02680939.2010.540676

*Stahl, G., Scholes, L., McDonald, S., & Lunn, J. (2021). Middle years students' engagement with science in rural and urban communities in Australia: Exploring science capital, place-based knowledges and familial relationship. *Pedagogy Culture & Society*, *29*(1), 43–60. https://doi.org/10.1080/14681366.2019.1684351

Suortti, E., Havu-Nuutinen, S., & Kärkkäinen, S. (2023). Finnish parents' science capital and its association with sociodemographic issues. *International Journal of Science Education, Part B: Communication and Public Engagement*, 1–20. https://doi.org/10.1080/21548455.2023.2263607

*Teo, T. W., Goh, J. W., Aye, K. M., & Yeo, L. W. (2018). Rethinking teaching and learning of science inference competencies of lower track students in Singapore: A rasch investigation. *Asia Pacific Journal of Education*, *38*(3), 1–24. https://doi.org/10.1080/02188791.2018.1476320

Tomperi, P., Kvivesen, M., Manshadi, S., Uteng, S., Shestova, Y., Lyash, O., Lazareva, I., & Lyash, A. (2022). Investigation of STEM subject and career aspirations of lower secondary school students in the North Calotte region of Finland, Norway, and Russia. *Education Sciences*, *12*(3), 192. https://doi.org/10.3390/educsci12030192

*Turnbull, S. M., Meissel, K., Locke, K., & O'Neale, D. R. J. (2020). The impact of science capital on self-concept in science: A study of university students in New Zealand. *Frontiers in Education*, *5*(27). https://doi.org/10.3389/feduc.2020.00027

Van Tuijl, C., & van der Molen, J. H. W. (2016). Study choice and career development in STEM fields: An overview and integration of the research. *International Journal of Technology & Design Education*, *26*(2), 159–183. https://doi.org/10.1007/s10798-015-9308-1

Wang, M. T., & Degol, J. L. (2017). Gender gap in Science, Technology, Engineering, and Mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

*Wilson-Lopez, A., Sias, C., Smithee, A., & Hasbun, I. M. (2018). Forms of science capital mobilized in adolescents' engineering projects. *Journal of Research in Science Teaching*, *55*(2), 246–270. https://doi.org/10.1002/tea.21418

*Wong, B. (2015). Minority ethnic students and science participation: A qualitative mapping of achievement, aspiration, interest and capital. *Research in Science Education*, *46*(1), 113–127. https://doi.org/10.1007/s11165-015-9466-x

Wong, B., Chiu, Y. L. T., Murray, Ó. M., & Horsburgh, J. (2022). End of the road? The career intentions of under-represented STEM students in higher education. *International Journal of STEM Education*, *9*(1), 51. https://doi.org/10.1186/s40594-022-00366-8