



Supporting access and equity to mathematics in low-SES contexts: a systematic literature review

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Received: 14 January 2026 / Revised: 16 June 2026 / Accepted: 19 June 2026
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Abstract

Disparities in achievement and equity associated with socio-economic status (SES) are particularly pronounced in mathematics. Research highlights that students from low-SES backgrounds often experience less effective instruction and lower teacher expectations. Factors such as ability grouping and school environment significantly impact attitudes and performance in mathematics, with low-SES students tending to experience higher anxiety and lower self-concept than their more advantaged peers. International studies show that the relationship between achievement and socio-economic status varies across countries, suggesting that with appropriate support, overcoming a disadvantaged background is possible; how this can be realised by interventions is less clear; questions remain about what forms of support effectively promote equity, and under what conditions. This review contributes by exploring evidence-based research that aims to support students' access to mathematics. It explores how the interventions engage with complex contextual factors and reflects the forms of inequity they might disrupt. The analysis focuses on 29 empirical studies and is guided by Bronfenbrenner's Process-Person-Context-Time (PPCT) model and Enchikova et al.'s conceptualisation of Equity. Key findings emphasise the importance of pedagogies that support low-SES students' sense of relevance of the subject, impacting their attitudes and motivation. Adequate resources (tangible and intangible), and supportive environments reflecting high expectations are essential. Timing is key, with lower-secondary school reflecting an important inflection point. Perhaps most importantly, recognition of the centrality of the teacher, with sustained support, professional development and common planning time, is crucial to the development of the kinds of teaching and learning environments conducive to students' access and equity in mathematics.

Keywords Mathematics education · lower secondary · low-SES · educational disadvantage · systematic literature review

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Introduction

Disparities in educational opportunity and achievement associated with socio-economic status (SES) are prevalent across all subjects, but they are particularly stark in mathematics. Often regarded as a gatekeeper subject, mathematics plays a critical role in shaping students' academic and career trajectories (Yolcu, 2019), yet students from low-SES backgrounds consistently underperform compared to their more advantaged peers. Longitudinal data from the Trends in Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) underscore the scale and persistence of these disparities, revealing that they both stem from and contribute to a lack of equity.

Over the past two decades, Broer et al. (2019) have documented that few countries have succeeded in simultaneously raising national mathematics performance while narrowing the SES achievement gap. Their findings suggest that low-SES students tend to perform better in more homogenous and centralised education systems, where structural supports may buffer against the effects of socio-economic disadvantage. This highlights that the success of interventions aimed at reducing disadvantage is inherently dependent on broader systemic, social, and policy contexts (Broer et al., 2019). Furthermore, PISA results indicate that the strength of the relationship between SES and mathematics performance varies significantly across countries, further emphasising the role of contextual and systemic factors in mediating educational equity (Broer et al., 2019; OECD, 2010, 2013b).

In line with these international comparisons, research recognises that a wide range of factors interact to influence an individual's educational outcomes and opportunities. Some background characteristics – e.g., SES, family characteristics or the structure of education systems – may render access to educational opportunities more or less challenging, and are not easily altered (Broer et al., 2019; Enchikova et al., 2024; Holzberger et al., 2020). It is therefore necessary to identify factors that can be influenced to improve access and equity in mathematics.

Reviews examining factors associated with equality of opportunity, or poor academic performance among students from disadvantaged backgrounds have investigated various efforts that have been made to address these issues (e.g., Banerjee (2016) and Wang et al. (2023)). Other reviews have examined the impact of specific interventions on equality of outcome, or the “achievement gap” (Ashraf et al., 2021; Krowka et al., 2017). Another investigated the effects of interventions on equality of outcome for low-SES students in OECD/EU countries, in which achievement scores in standardised tests of reading and mathematics were explored (Dietrichson et al., 2017).

These previous reviews have made valuable contributions to the body of knowledge on which this paper builds. In this work, the authors recognise the limitations of focusing primarily on achievement, or “gap gazing”, which can inadvertently reinforce disadvantage and perpetuate stereotypical views of learners (Gutiérrez, 2008). Thus, rather than concentrating only on outcomes, this review considers how the complex challenges affecting students' access to mathematics interact with a broader conceptualisation of equity, one that encompasses outcome, opportunity, resilience and segregation (Enchikova et al., 2024).

Despite research and reports on the lack of equity, there remains a lack of understanding about the contextual factors that influence efforts to achieve equity for low-SES students. As both equity and the contextual elements in interventions are often left implicit, understanding how mathematics interventions work, for whom, and under what conditions remains a complex issue, and transferability cannot be taken for granted. In order to explore this, a theoretical framework that considers the whole ecosystem, such as Bronfenbrenner's Bioecological model, is particularly relevant (Bronfenbrenner & Morris, 2007).

At the same time, there is an urgent need to systematically investigate what works, in order to design teaching and school systems that make mathematics accessible to all students. To address this, we use a systematic literature review (SLR) to examine evidence-based research on strategies that aim to provide access to mathematics for low-SES students, and consider what can be extrapolated from these to inform future work. The specific aim of this article is to contribute to knowledge on the factors within intervention studies that have the potential to positively impact and sustain equity in mathematics for low-SES students. This review is thus guided by two questions:

1. Which mechanisms and contextual factors within mathematics interventions contribute most strongly to improving equity across opportunity, outcome, resilience, and segregation?
2. Given the challenges of context and transferability, what key considerations should be foregrounded to guide the development of future mathematics interventions aimed at promoting equity for low-SES students?

Theoretical Underpinnings

Human functioning is, according to Cleary and Kitsantas (2017), governed by reciprocal interactions among beliefs, behaviours, and environmental contexts. This complexity is reflected in the study at hand through the use of Bronfenbrenner's bioecological framework, specifically the Process, Person, Context and Time (PPCT) model (Bronfenbrenner & Morris, 2007). Understanding how factors relating to the PPCT components are understood and manipulated in any intervention aiming to address inequality is seen as being of key importance. Therefore, this model is used as a lens to identify and explore the key factors, and how they interact, in each of the selected articles in this SLR. Guiding this operationalisation of the PPCT model (Fig. 1), *Process* is conceptualised as the interactions between people, or what we, as educators do: it is our methods of instruction, pedagogy, in-class assessment etc. The *Person* – in this case the student – includes an individual's disposition, characteristics, abilities, and experiences. *Context* reflects the student's home, neighbourhood, and school environment. Finally, *Time* reflects the chronological age of the student and their stage in the educational journey, as well as the duration of the intervention. This theoretical approach provides a lens to examine and classify empirical research studies that aim to address access and equity.

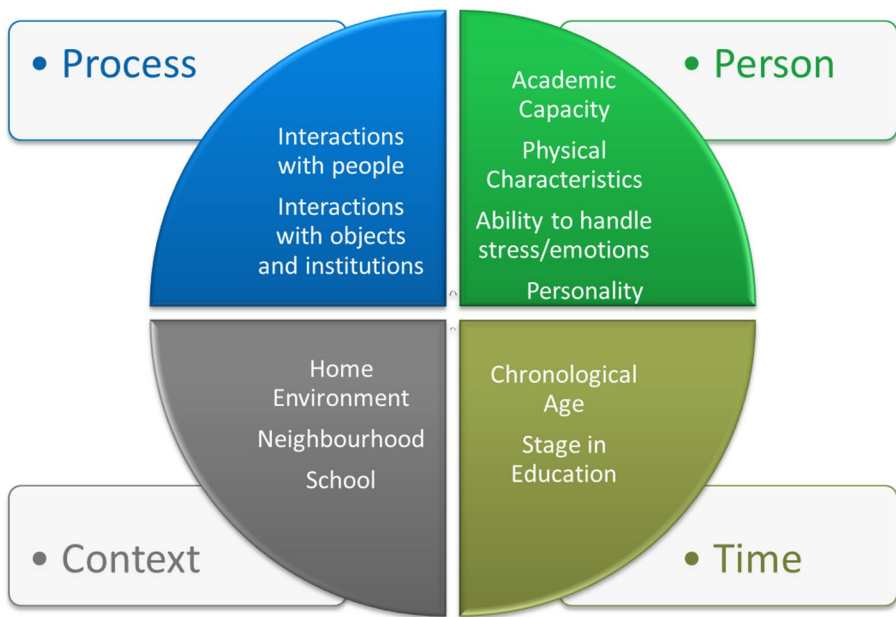


Fig. 1 PPCT model

Furthermore, while applying the PPCT model to support our understanding of intervention research in this area, it is essential that we recognize and discuss our analysis in terms of whether any form of equity is achieved. For this purpose, we draw on the work of Enchikova et al. (2024) who differentiate between four diverse conceptualisations of equity: *equality of outcome*, *equality of opportunity*, *segregation*, or *resilience*. In their work, equality of outcome refers to differences in educational results, regardless of the reason; equality of opportunity relates to the relationship between background and results; resilience refers to an individual's capacity to overcome educational disadvantage; and segregation refers to the uneven distribution of characteristics, such as SES, across groups of students (Fig. 2).

The four forms of equity are not only interrelated but are also influenced by factors within and beyond the classroom, aligning with the PPCT model and including social stigma, access to resources, learning conditions in the classroom and students' sense of belonging and hope (Penteado & Skovsmose, 2011).

To theoretically frame this paper, we begin by making a deductive reading of selected research through the lens of the PPCT and equity frameworks to identify core factors and how they relate to each other. In this manner, we acknowledge the complexity in how educational equity can be approached and reached. Equity is in turn understood as relating to the interactions between the individual and educational processes in a specific context, and how this can change over and with time. Finally, the theoretical approach provides a scaffold to explore whether and how the problem areas identified are being addressed, allowing for recommendations and guidance to be drawn.

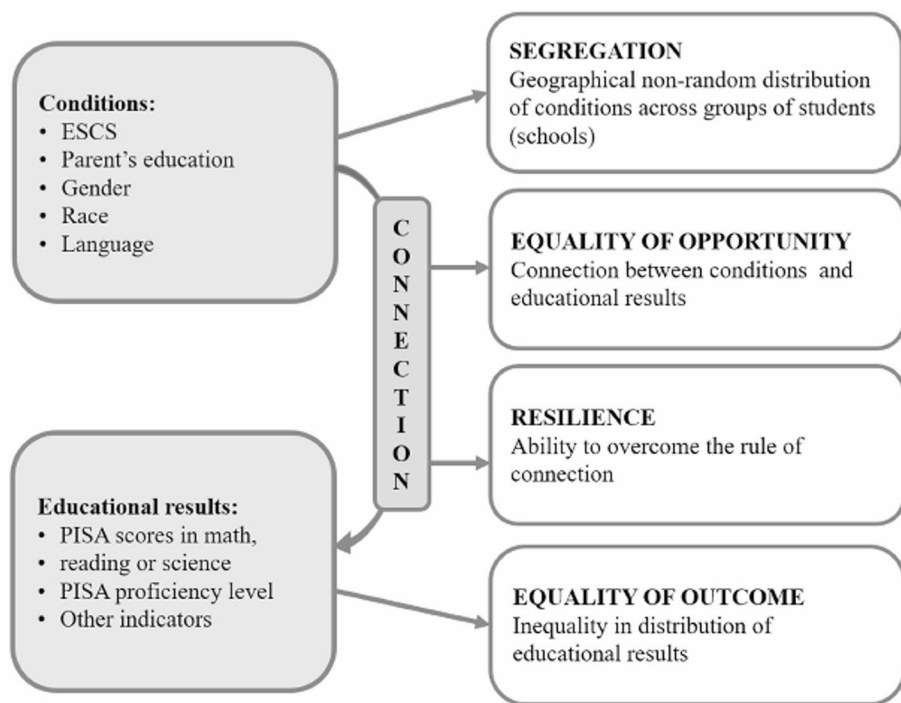


Fig. 2 Categorisation of equity (Enchikova et al., 2024)

Materials and methods

The goal of this study is to review empirical research reporting on interventions that aim to address issues in mathematics education associated with low-SES, with a particular focus on the secondary education sector. Earlier research points to the relevance of the intertwined components of the PPCT model in describing how disadvantage stemming from low-SES may influence how a student is granted access to mathematics (Wang et al., 2023). In order to address the research questions, we have performed a systematic literature review (SLR). The SLR methodology following a predefined PICOS (Population-Intervention-Outcome-Comparator-Study) protocol with explicit inclusion/exclusion criteria (Table 1) and used a Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) diagram (Fig. 4) to minimise bias and enhance the reliability of the findings (Cumpston et al., 2019; Page et al., 2021).

In the sections that follow, we first outline the procedures used to select appropriate research, and then the processes used for analysis.

Search procedure

Six databases were utilised in the search: ERIC (EBSCOhost), British Education Index, Academic Search Complete, SCOPUS, Web of Science, and APA PsycAr-

Table 1 Eligibility Criteria - PICOS framework

Include	Exclude
Population	
Reference to disadvantaged cohorts	No reference to disadvantage
Students:	Students or teachers of
-Upper primary	-Further/higher education
-Lower secondary	-Primary school only
-Ages 11-19	-Early years
Teachers of above groups	
Intervention/Exposure	
Explicit mathematics focus	Subjects other than mathematics
	STEM without a specific focus on mathematics
Comparison population	None
Control group	
None (observaton only)	
Outcome	
Student	Other
-attainment	
-engagement	
-motivation	
-attitude	
-Utility value etc.	
Teacher	
-Self-efficacy	
-Beliefs	
-Expectations	
Study Characteristics	
Quantitative	Meta analysis
Qualitative	SLR
Mixed methods	

ticles. As the primary focus of this paper is education, a decision was made to explore primarily humanities and social science databases, extended by the multidisciplinary of Academic Search Complete. For the purpose of our SLR, the aim was to identify trends in research conducted in recent years, both in terms of bioecological (PPCT) and equity focus. The reason for this is connected to our theoretical underpinnings and understanding of interventions and individuals' development as time sensitive, in terms of frequency or extent of exposure, but also historical time. Therefore, given the rapidly changing world, we limited our search to research published in the period from 2013 to end of 2023, when the search process was conducted. Search terms for *Subject* (mathematics), *Education Level*, *Disadvantage*, and *Interventions* were combined using the AND operator in each database. The searches were con-

ducted across title and abstract (using the OR operator). To ensure that all relevant papers were returned by this search, a wide range of terminology and synonyms was used, (see Fig. 3, an example from Eric). In addition, we consulted with the university librarian and used the in-built thesauri in the databases to explore alternative phrasings. Although various terms were used to reflect our target group's underrepresented status, throughout this paper, we refer to this group of students as those from low-SES backgrounds. While we recognise that this cannot be considered as a homogeneous group, it does broadly support identification of those targeted by the kinds of interventions considered in this paper. Once duplicates were removed, a total of 537 studies remained for title and abstract screening.

Screening process

A PICOS framework (Table 1) was used to clarify inclusion and exclusion criteria to support the identification of relevant articles (Cumpston et al., 2019). To increase the inter-rater reliability of the study, all the authors were involved in the screening process, with each of the titles/abstracts screened by two of the three researchers. Guided by the PICOS framework, there was approximately 90% agreement on the inclusion/exclusion of articles, with any conflicts either resolved by the third reviewer, or following a discussion between reviewers.

Of the articles considered in the first screening (title and abstract), 457 studies were deemed irrelevant, leaving 80 for full-text review. A further 51 papers were deemed ineligible according to the inclusion/exclusion criteria after the second screening (full texts), resulting in a final 29 papers remaining for data extraction. This process is illustrated in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) diagram in Fig. 4 (Page et al., 2021). Each of the papers that were deemed eligible for review were subjected to a process of data

Database	Date of searches	Date range	Number of hits	Search string (Maths)	Search string (Education level)	Search string (Disadvantage)	Search string (Interventions)
ERIC (EBSCOhost)	05/12/2023	2013-2023	150	TI math* OR AB math* OR DE "Mathematics"	TI (secondary or "middle school" or "high school" OR postprimary OR "post primary" Or "Junior high") OR AB (secondary or "middle school" or "high school" OR postprimary OR "post primary" Or "Junior high") OR DE "Secondary Education"	TI ("achievement gap" OR "low income" OR minority OR "socio economic status" OR SES OR underrepresented OR inequalit* OR disadvantage* OR depriv*) OR AB ("achievement gap" OR "low income" OR minority OR "socio economic status" OR SES OR underrepresented OR inequalit* OR disadvantage* OR depriv*) OR ((DE "SOCIOECONOMIC status") OR (DE "SOCIOECONOMICALLY disadvantaged students")) OR (DE "POVERTY")) OR (DE "DISADVANTAGED schools" OR DE "Economically Disadvantaged" OR DE "Low Income" OR DE "Low Income Groups" OR DE "Low Income Students")	(TI (outreach OR "summer school"* OR "widen* access" OR "widen* participation" OR "access programme" OR intervention OR "engagement program*" OR "experimental design" OR investigation)) OR (AB (outreach OR "summer school"* OR "widen* access" OR "widen* participation" OR "access programme" OR intervention OR "engagement program*" OR "experimental design" OR investigation))

Fig. 3 Example of search strings for ERIC database

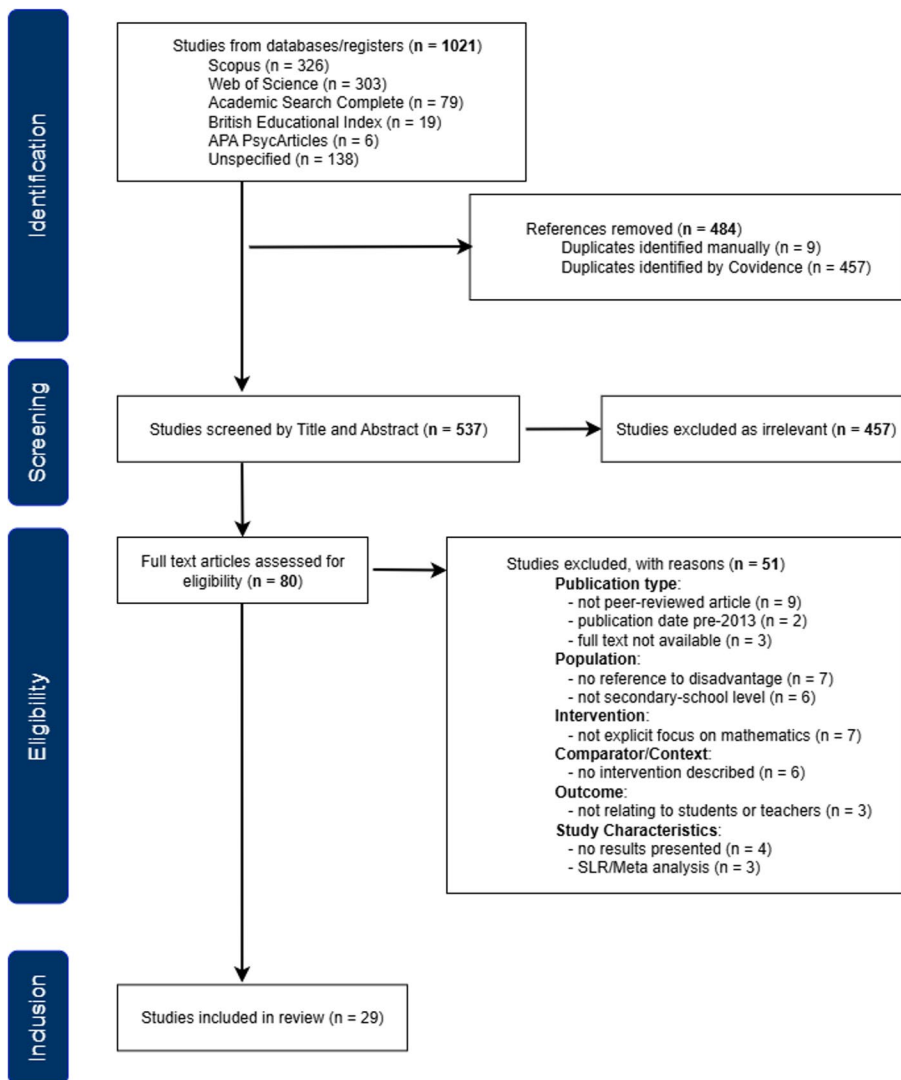


Fig. 4 PRISMA diagram

extraction and quality assessment to gauge their methodological robustness. For a detailed overview of the 29 papers, see the Appendix.

Data analysis

The analysis aimed to explore how the PPCT constructs of *Person*, *Process*, *Context* and *Time*, as well as the interactions between them and the types of equity considered, emerge in intervention research aimed at creating access and equity for low-SES students. Like Wang et al. (2023), we utilised the PPCT framework to explore the wide range of factors and processes that predict student development. Our work

High teacher control in the classroom, coupled with students' lower self-efficacy, are likely to decrease students' sense of agency and competence, key aspects of motivation in Self-Determination Theory (Ryan and Deci 2000). According to Ryan and Deci (2000), motivation moves from extrinsic to increasingly intrinsic the more three basic psychological needs are met: the needs for autonomy (a sense of control and agency), competence (a sense of aptitude), and

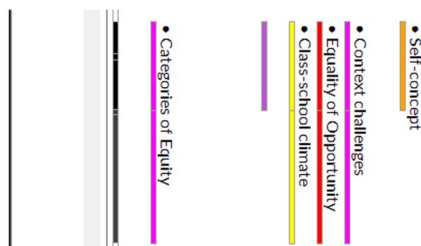


Fig. 5 Portion of text from Morris and Barton (2022) coded for PPCT and equity in NVivo 14

Study Identifier	Country	Setting	Resilience (Solution)	Equality of Outcome (Problem)	Person (PPCT)	Context (PPCT)
Dudley 2023	USA	Rural-remote middle school	The current study may help rural schools identify an unconventional method to help with math achievement, as the canines help focus on social and emotional learning, which opens the mind to learn. The data analysis concluded that math scores increased significantly from 7th to 8th grade. This score increase was significant because of the national below-average scores on the NAEP 8th-grade assessment (NCES, 2022). We know therapy dogs improve reading skills (Bassetie & Taber-Doughty, 2016; Fung, 2016; Kopp & Shupp, 2017; le Bouet et al., 2014), and this improvement in scores tells us therapy dogs can improve math scores... females improved scores more than males when exposed to an AA...	The specific problem is the struggle for students to achieve the STAARs passing standards in middle school math.	Therapy dogs ensured that every aspect of a student's social and emotional needs was met.	Access to the therapy dogs was tied to attendance, tardies, or desired behaviors for students that needed extra support. For example, if Janie came to class every day this week, she held the therapy dog during the lecture on Friday. If Timmy gets to class on time, he can take the puppy outside at the end of the period. Therapy dogs ensured that every aspect of a student's social and emotional needs was met. One of the ways dogs helped was by the dog having opportunities to shop. Shopping is when a canine walks up and down the aisle or around the room and alerts someone. Often, the alert is a student that needs extra attention and has needs not visible to the teacher. This process encouraged students and provided a much-needed cortisol boost during class. Shopping was where many of the strongest canine/student bonds were formed (Davis, 2022).

Fig. 6 Deductive coding sample 1

differs however, in our specific focus on research with interventions that aim to disrupt inequity and create access in different ways. Therefore, both the PPCT model and Enchikova et al.'s (2024) conceptualisation of equity have been used as a lens for deductive analysis, to explore the interventions identified through the search process. Directed Content Analysis Techniques (Hsieh & Shannon, 2005), which use pre-defined categories or themes to guide the coding and analysis of data, were utilised to categorise the aspects of the PPCT model that were being addressed in each paper, as well as the types of equity that were considered. The qualitative analysis software NVivo14 supported this process.

Firstly, each of the four pre-defined categories of PPCT and the four forms of equity were created as a-priori codes in NVivo. Each of the papers were then analysed by the first author, who assigned portions of text to relevant codes (e.g., Fig. 5).

These were subsequently shared and discussed with the other authors and amended as necessary. This led to a corpus of data containing the Equity and PPCT factors in all the selected studies. Two illustrative examples of coded sections of text from the papers by Dudley and Knight (2023) and Lokhande and Müller (2019) are provided in Figs. 6 and 7. In the Dudley example, person and context are evident whilst the Lokhande and Müller is an example in which the PPCT focus of the intervention is solely on the person. This illustrates our consideration of the ways in which the different studies were presented and to recognise this in the coding process, through the use of the established framework.

Subsequently, a more emergent/inductive process of open coding was undertaken within each of the PPCT categories, applying the constant comparative technique of Strauss and Corbin (2008). This allowed the disentanglement of specific aspects within the broad PPCT categories in terms of how they connected to disrupting gaps

Study Identifier	Country	Setting	Equality of Opportunity (Problem)	Resilience (Solution)	Person (PPCT)
Lokhande 2019	Germany	German educational context: Integrated Secondary School.	Students' achievements in school can be negatively affected due to various sources of disadvantages. Particularly gender differences and differences between students with and without an immigrant background have been well documented in the literature. Our student sample reflects this as well as it represents low-performing students who were channeled into various schools that provide the lowest level of secondary education in the state. The study was conducted in the German state of Berlin in schools where many risk factors combine. For instance, most students come from socially disadvantaged families and schools are challenged by a serious teacher shortage.	a self-affirmation intervention to improve academic achievement for students with a "double-jeopardy status" of belonging to two potentially disadvantaged groups at the same time: girls with a minority background. (1) double-jeopardy in math performance exists, as shown by independent negative effects of female gender and Turkish or Arab minority group membership; (2) Girls from all ethnic backgrounds and students with Turkish immigrant background in the intervention group performed significantly better in the mathematics test immediately after the intervention than their peers in the control group. (3) Eight weeks later, the intervention effect only persisted for students with minority ethnic backgrounds: Turkish and Arabic students in the intervention group scored significantly higher in the standardized mathematics test compared to their peers in the control group.	Using an experimental study design, we tested the effect of self-affirmation on achievement among students who attended "Integrated Secondary Schools" in the state of Berlin over the fall of 2016. As opposed to the alternative school type of a "Gymnasium", the "Integrated Secondary School" does not necessarily lead to a university entrance qualification, but also to an enrollment in vocational training. Compared to the population in the "Gymnasium", the average achievement in standardized tests and SES of "Integrated Secondary Schools" students are usually lower.

Fig. 7 Deductive coding sample 2

in equity. The analytical separation of the categories also enabled us to explore how they interacted with each other. For example, within the category of Process, two sub-categories were identified: Effective Instruction, associated with issues relating to the importance of effective teaching and assessment generally, e.g.:

As opposed to traditional instructional programs in which a teacher assigns a grade and continues with the scope and sequence of the course and creates what Stiggins (2007) called losing streaks for students not mastering content, district and school leaders charged PP teachers with creating new and innovative ways to ensure learning of three key standards for each unit of study. (Baete & Hochbein, 2014, p. 494)

and Pedagogic Approaches (discussion of specific pedagogies), e.g.,

Does using more CRI [career relevant instruction] cause students to report higher levels of school valuing? Is family income a significant moderator of the impact of CRI on students' school valuing? (Rose & Akos, 2014, p. 545)

Furthermore, in line with the bioecological understanding of individuals development, we explored the interaction between the PPCT categories by searching for overlaps between these categories, sub-categories and the categories of equity, in order to further explore and reveal success factors that could be used as strategies to support access to mathematics, in research and practice.

Findings: factors that can promote equity for low-SES students

This section of the paper presents the analysis of the reviewed articles on interventions to promote access and equity in mathematics for low-SES students. The review is presented using the components of Bronfenbrenner's PPCT model as thematic headings, representing the deductive part of the analysis. The inductive analysis within each of these broad themes is presented as sub-themes therein. Hence, the sub-themes represent the factors identified as being of importance for promoting equity for low-SES students. The interrelatedness of themes and sub-themes, and their connection to equity, are explored in the subsequent section.

Process

In this work, *Process* is taken to reflect what we, as educators do; it is our methods of instruction, pedagogic approaches, in-class assessment etc. This section is divided into two sub-headings, reflecting findings from inductive analysis within this theme. The first reports on the research that has been categorised as broadly associated with issues relating to instruction generally, followed by those that address specific pedagogies.

Effective instruction

Under the issues associated with *process*, it was noted by Ekmekci et al. (2019) that students in schools that serve low-SES areas are more likely to be exposed to ineffective teaching than their more affluent peers. The work of Baete and Hochbein (2014) and Jerrim et al. (2015) both evaluated large-scale interventions (Project Proficiency and Mathematics Mastery respectively) that aimed to improve mathematics instruction. Both were professional development interventions, and both explore the impact of the teacher intervention on student attainment. In the two articles, the professional development approach involved facilitation of significant teacher collaboration and peer-support. The specific goal of Mathematics Mastery (MM) (Jerrim et al., 2015) was to support the collaborative development of approaches and lessons that would deepen students' conceptual understanding. However, the teachers involved found the implementation difficult and had concerns about their ability to comprehensively cover the curriculum using the approach. The student outcomes for this programme were also not wholly positive. No statistically significant differences were identified across the broad achievement measures, although students eligible for free school meals did achieve statistically significantly higher on the aspects of the test that related specifically to the MM curriculum. For Project Proficiency (PP) (Baete & Hochbein, 2014), teachers seem to have been very well supported by their school and district leaders, with schedules altered to provide common planning time and alignment of classes to facilitate re-grouping of students when required. In terms of student outcomes, the reported impact of Project Proficiency on mathematics is significant. The authors claim that "In the 110 classrooms studied, significant reductions in between-classroom variation in mathematics achievement suggested that PP impacted instruction at the classroom level" (p. 505). This may suggest a causal relationship between the level of support provided to the teachers and the student outcomes.

Banerjee (2017) conducted an extensive exploration into the effectiveness of students' sustained participation in extra-curricular STEM programmes that were designed to improve their understanding of mathematics. The factor that linked the programmes selected for review, was their inclusion of a practical element involving active participation of students in out-of-school contexts. Results found no identifiable effect on GCSE results.

The impact of in-class assessment on instruction is well recognised and two of the reviewed papers addressed this to some extent. Morris and Barton (2022) explore the effect of using a different grading mechanism – specifications grading (SG) – on

students' motivation and affect. SG provides students with greater control and agency over their assessment, permitting them to pick the grade they would like to receive in a module. Each grade band is associated with a required set of assignments or assessments that must be completed, with higher grades requiring more, or more challenging, assignments. The authors found that the students in SG classes experience more interest in the subject and self-efficacy than those in traditional classes. They also note that the use of SG leads to decreased stress, and a greater emphasis on learning for mastery rather than for performance. Assessment is also considered in the paper by Wang et al. (2022), who explore the use of a digital tool to diagnose the level of mathematics learning strategies of students, with those who are identified as having poor strategies suggested an improvement plan. While the study reported positive results, it is very limited in scale.

Pedagogic approaches

Megowan-Romanowicz et al. (2013) raised the issue that in schools that serve low-SES areas, pedagogic approaches tend to be more traditional and didactic, emphasising controlling behaviours that can have a negative impact on students' interest and engagement with mathematics. Four pedagogic approaches were explored in five papers, with the goal of each to better engage the participating students by making the subject more relevant and authentic. The impact of a radical re-design of a middle school serving a cohort of largely low-SES, using project-based learning (PBL) as a guiding construct, was the focus of the research of Cervantes et al. (2015). The authors identified statistically significant differences in achievement for grade 7 and 8 students, favouring students attending the PBL school. Holmes and Hwang (2016) also explore the effects of implementing PBL at a whole-school level. Their results suggest that engaging in PBL reduces the effect of SES, race and ethnicity on achievement.

Place-Based Learning was investigated in the work of Rubel et al. (2016), who designed a 15-week curriculum focusing on the lottery, and framed within mathematical and critical spatial perspectives. This small study was conducted with a remedial class of students in a low-SES neighbourhood. Student engagement was increased by connecting with a familiar theme (lottery) and its implications for social justice. Results were broadly positive, with the authors noting that "students who largely struggled with entry-level high school mathematics were engaged and successful with sophisticated mathematics topics of combinatorics and probability" (p. 20).

The pedagogy of Career-Relevant Instruction (CRI) was the focus of the research of Rose and Akos (2014), who sought to increase students' perception of the value of education in relation to their future success, by making the subject more relevant to their lives. Results indicate that exposure to the pedagogy does increase students' valuing scores, and that the effect does not differ between high- and low-SES students.

In addition to exploration of specific pedagogies, five papers focused on contextualising the subject in an attempt to make the instruction more effective and relevant. Three of the articles reported on interventions that were small scale and of short duration (Aji & Javed Khan, 2020; Cloutier et al., 2016; Ni Shuilleabhain et al., 2021). They were all situated in out-of-school contexts and aimed to impact non-

academic outcomes such as interest, attitudes and confidence. The work of Aji and Javed Khan (2020), and Cloutier et al. (2016) are particularly small in scale, and cannot be considered methodologically robust. Despite its small scale however, the study by Ni Shuilleabhain et al. (2021), offers insight into the power of co-creating learning experiences with undergraduate students of mathematics education, who proceed to facilitate the intervention with school students, while also acting as near-peers. Participating school students reported higher levels of confidence in mathematics at the end of the four-week programme.

De Loof et al. (2022) aimed to situate the learning of mathematics and science in contexts that are relevant to the students in terms of societal and ecological problems, with a goal of increasing affective engagement and STEM career aspirations. The study was conducted over two years and across 39 schools. Results were broadly positive, with aspirations of the experimental group remaining stable over time compared to a decrease in those of the control group.

The work of Louie et al. (2022) examines the impact of a series of data investigation modules that explore social justice issues, on students' data literacy and interest. The modules were implemented by seven high school mathematics teachers from six cities in the USA, in schools that serve low-SES and minority cohorts. Results were positive, and statistically significant, both with respect to the students' understanding of assessed concepts, and their individual interest.

Person

The Person in this research, is the student, with their individual disposition, characteristics, abilities, and experiences. Research highlights that students attending schools in low-SES neighbourhoods tend to have more negative attitudes towards mathematics, higher levels of mathematical anxiety and lower self-concept in mathematics (Banerjee, 2016; Ni Shuilleabhain et al., 2021). It is interesting to note that none of the papers reviewed explicitly addressed mathematical anxiety in their research. However, our analysis noted that attitudes/motivation, and lower self-concept were explored in various papers, these two sub-topics are considered below.

Attitudes and motivation

It has long been acknowledged that attitude and motivation are interconnected (Peak, 1955). Three of the reviewed papers aim to impact both via Utility Value (UV) Interventions, building on the work of Eccles (1983), Eccles and Wigfield (2002) and Gaspard et al. (2015). Utility Value is described as the perceived individual usefulness of a task in relation to the individual's future goals, and is seen as the most malleable construct in Expectancy Value Theory (Eccles, 1983; Eccles & Wigfield, 2002). The three reviewed papers were all medium-large scale (> 100 participants), and all used a randomised control design. The geographical context of two of the papers was Germany (Häfner et al., 2017; Weidinger et al., 2022), with one situated in the USA (Silverman et al., 2023). The UV interventions in each of the papers involved asking students to engage with material relating to the utility of mathematics, followed by a written exercise in which they consider how the subject may be relevant to them.

While the study duration varied between the papers, the intervention itself was brief and low-cost. All three papers noted positive effects on participants' UV, particularly for more disadvantaged students.

The intervention described by Sibieta et al. (2014) was also designed to impact student motivation, but in this case the authors use incentives (financial rewards or end-of-term events) to act on the learners extrinsic motivation and thus, potentially, the effort they expend. While the results of the intervention for the full sample did not reach statistical significance, the end-of-term event condition is reported to have led to statistically significant increase in mathematics achievement for pupils with low levels of prior attainment.

Self-concept

Three of the reviewed papers reported on research that aimed to address students' self-concept – the perception that we have of ourselves – particularly for students who may be subject to what is known as stereotype-threat. This is a situational predicament whereby “stigmatized group members may underperform on diagnostic tests of ability through concerns about confirming a negative societal stereotype” (Pennington et al., 2016, p. 1). The research in all three studies was based on the work of Cohen et al. (2006), who describe an intervention that aims to improve the performance of minority students by engaging them in a writing exercise to reaffirm their sense of personal adequacy and integrity. The written exercises involved in these “self-affirmation” interventions differ from those in UV interventions, in that they do not have any connection to a curricular subject. Rather, students are asked to write an essay about certain values that are personally meaningful. The three self-affirmation papers all used a randomised control design and were medium to large in scale. Two were situated in the USA (Bancroft et al., 2017; Borman et al., 2016), with one in Germany (Lokhande & Müller, 2019). The work of Lokhande and Müller (2019) and Borman et al. (2016) reported some level of positive effect on the academic outcomes of minority students who may be subject to stereotype threat. The research of Bancroft et al. (2017) did not identify any significant results for the majority of students. However, for female, minority students in high-track classes, a statistically significant positive effect was identified.

Context

Context challenges identified can be categorised as connected to the *environment* itself – the neighbourhood, school or classroom being less conducive to educational achievement; less ready access in such environments to tangible or intangible *resources*; and to the issues associated with hiring and retaining well-qualified *teachers* to work in such contexts. Each of these three areas – environment, resources, and teachers – is addressed below.

Environment

Rubel et al. (2016) use place-based learning (as described in the Process section) to attempt to empower students in low-SES contexts to “view mathematics as an agentive tool that can support [them] to fight for the neighborhood and demand justice and equity on its behalf” (p. 2). In this way the authors aim to meaningfully connect the mathematics to the environment that the students inhabit. Ni Shuilleabhain et al. (2021) recognise the importance of learning environment in their research. They situated their workshops on the university campus, in an attempt to habituate the students with the belief that they have a right to be there, and the design of the learning space was intentionally different to a traditional classroom “to allow for creative and collaborative explorations of the content during workshops” (p. 137). Dudley and Knight’s (2023) introduction of a therapy dog into the classroom environment of remote, rural, low-SES middle-school classroom had statistically significant positive impact on student achievement, with female students benefitting more than males in the experimental group.

Resources

Resources can be viewed as tangible objects such as digital devices, books, etc., or intangible supports deriving from social capital or access to role models and mentors. Through their research on the Tenmarks summer school, Lynch and Kim (2017) investigate whether the provision of a laptop had an effect over and above general participation. Their analysis revealed that access to this resource “caused children to report significantly higher levels of summer home and family mathematics engagement compared with children in the randomly chosen control group” (p. 46). These higher levels of engagement did not however, translate to improved achievement outcomes beyond the summer school.

Wilson and Grigorian (2019) and Ni Shuilleabhain et al. (2021) capitalise on the concept of “near-peers” by securing third-level undergraduates as facilitators and mentors for upper-secondary students. While it is difficult to determine the outcome in the work of the former, Ni Shuilleabhain et al. (2021) report positive effects on student confidence.

Teachers

The influence of teachers on the school context that students inhabit should not be underestimated. It is imperative that students are supported by well-qualified teachers who have high expectations for them, and in turn, that teachers are provided with supportive and positive working conditions.

Five of the reviewed articles included aspects of professional development (PD) to ensure that teachers in these schools were well-qualified and confident. These include the studies by Aji and Javed Khan (2020) (a week long PD workshop with flight-simulation technology) and Chirinda (2021) (supporting teachers’ problem-solving) that are methodologically limited by their small scale. The other three studies (Holmes & Hwang (2016) – Project-Based Learning; Jerrim et al. (2015) – Mathematics Mas-

tery; and Baete and Hochbein (2014) – Project Proficiency) were all also categorised and described in the Process section of this paper in relation to effective instruction and pedagogy.

Within the Project Proficiency study, Baete and Hochbein (2014) also provide a mechanism for developing teachers' collective efficacy through Professional Learning Communities. In this way, their work can be seen as aiming to address the difficult working conditions that teachers can experience in schools that serve underrepresented populations. The addition of this collaborative support is likely to have been an important factor in the success of the Project Proficiency intervention in comparison with the Mathematics Mastery study by Jerrim et al. (2015), in which the participating teachers were less supported, and experienced difficulties with the implementation of the programme.

Time

It is well recognised that the initial years in second level reflect a critical juncture in a young person's educational journey, as performance at this point tends to act as a gatekeeper to higher-level mathematics and STEM courses. There is also strong evidence to suggest that the achievement gap between higher and lower-SES cohorts widen significantly at this time (McKenna et al., 2015). The importance of this educational stage is reflected in the findings of this SLR: while the search criteria included all lower- and upper-second level, 22 (76%) of the papers had at least some focus on lower-second level, with 20 (69%) focusing exclusively on that phase.

In order to address the issues of equity of access to higher-level mathematics, Atteberry et al. (2019) explored the effects of “detracking” the Advanced Placement and International Baccalaureate courses in a large, diverse high school, over the course of 18 years, thereby keeping courses open to all students at this crucial time in their educational development. “Tracking” refers to the process of assigning students to a particular class group based on their perceived ability or academic achievement. Thus, “detracking” reverses this process, leading to more heterogeneous classes. This greatly widened the participation in these courses, moving away from serving only a few, elite students, to including the majority of students in the school. Despite the increased numbers of students taking the courses, and the resulting mix of abilities, it was found that achievement did not decline; “to the contrary, for IB math, the detracking initiative led to an increase in the number of students taking IB classes, as well as the same or higher performance on math IB tests across the full range of the prior achievement distribution” (p. 4). While tracking may not be common practice across all contexts, many systems employ some means of ability grouping as students progress through their secondary education, whether that be within or between classes or schools. The work of Atteberry et al. (2019) highlight that such grouping practices should be avoided for as long as possible.

In an attempt to address the widening of achievement gaps between low-SES students and their more advantaged peers, the work of Cortes et al. (2013), Gorard et al. (2015), and Gutiérrez and Rodrigo (2014) all focus on providing additional instruction time to at-risk students. Cortes et al. (2013) explored the impact of “doubling-up” mathematics instruction for students who scored below the national average in public

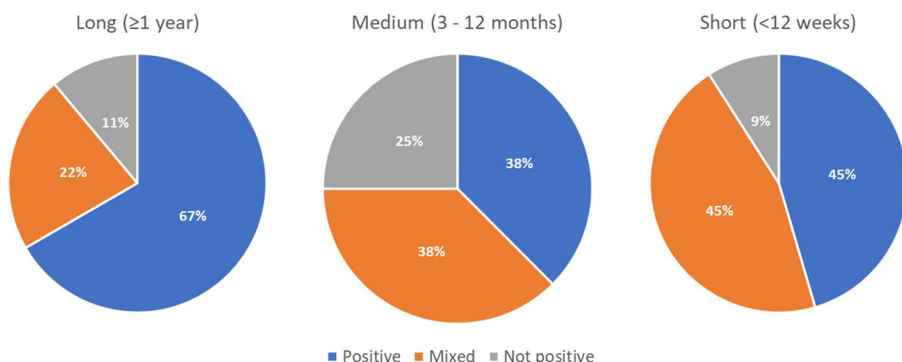


Fig. 8 Duration of study in relation to outcome

schools in a large, poor, urban, school district in Chicago. This large-scale, longitudinal study demonstrated evidence of “positive and substantial long-run impacts of one particular form of intensive math instruction on college entrance exam scores, high school graduation rates and college enrollment rates” (p. 5).

The effect of additional instruction by way of a four-week summer school, as described by Gorard et al. (2015), had negligible effects on student achievement, although the participants enjoyed their time on the course. The authors comment that this may have had a positive impact on their subsequent transition to second-level education. Gutiérrez and Rodrigo (2014) on the other hand, noted positive effects on previously low-achieving students’ grades after their participation in free, additional mathematics classes, taught over the course of 10 weeks, by undergraduate students.

The duration of each of the studies is also worth commenting on under the categorisation of time. Of the studies reviewed, nine were classified as “long” (≥ 1 year), eight were medium (3–12 months), 11 were short (< 12 weeks) and one was unspecified. Therefore, both in real terms and proportionally, the longer-term studies reported more positive results (Fig. 8).

Forms of equity

In terms of the forms of equity addressed in the intervention studies, it appears that Equality of Opportunity is the most commonly identified form of inequity that the research aims to address, with 20 of the studies (69%) classified as identifying this as focus of the work. Perhaps even more notable is that every one of these studies identified improving Resilience as a means to address issues of inequity (Table 2).

Table 2 Categorisation of Equity – Note some papers classified as addressing more than one component

Categorisation of Equity	Segregation	Equality of Opportunity	Resilience	Equality of Outcome
Problem	5	20	2	6
Solution	0	6	22	4

Of the five papers that identified Segregation as contributing to the problem, three saw Equality of Opportunity as the solution (Aji & Javed Khan, 2020; Atteberry et al., 2019; Gutiérrez & Rodrigo, 2014), while two focused on the importance of Resilience (Ni Shuilleabhain et al., 2021; Sibieta et al., 2014).

The work of Morris and Barton (2022) and Rose and Akos (2014) identified poor Resilience, stemming from lack of student agency and motivation, as problematic. The interventions in both of these papers aimed to support the development of Resilience in the participants.

It is very interesting to note that Equality of Outcome is the explicit problem of focus identified in only six of the papers, although many more of them target performance or achievement implicitly, with an expectation that improved Equality of Opportunity or Resilience is likely to lead to better outcomes in this regard. This comparatively low number of papers that focus on equality of outcome may reflect a shift in focus away from the issue of “gap gazing” identified by Gutiérrez (2008). Of the six papers, four focus on addressing Equality of Opportunity (Baete & Hochbein, 2014; Banerjee, 2017; Cortes et al., 2013; Lynch & Kim, 2017), with the two others aiming to improve students’ Resilience (Chirinda, 2021; Dudley & Knight, 2023).

Exploring the interaction between the PPCT and the Equity frameworks, the following patterns were identified.

Process and equity

Sixteen of the reviewed papers addressed some element of Process. Eleven of these papers (69%) focused on equality of opportunity as the key equity issue that they were aiming to address, with ten (63%) seeing resilience as the key factor in addressing the issues. One of the remaining papers had a sole focus on resilience, with two seeing equality of outcome and two identifying issues around segregation as key problem areas.

Person and equity

Out of the 11 papers that were classified as conducting interventions focusing on the Person, nine identified Equality of Opportunity as the key issue, with one focusing on Equality of Outcome and one on Segregation. Every one of the papers whose interventions were classified as focusing on the Person, were also classified as identifying Resilience as the key to overcoming the lack of equity.

Context and equity

Once again, Equality of Opportunity appears to be the primary driver of inequity identified in the papers that focus on interventions relating to Context, making up eight of the 13 (62%). One also identified levels of Resilience as problematic, while four highlighted issues relating to Outcomes, and three highlighted Segregation as the primary root of inequity.

Regarding solutions, 10 of the papers see Resilience as key, with one of the 10 linking this to opportunity, and two others to outcome. Three of the 13 saw equality of opportunity as a solution.

Time and equity

Of the three papers that were classified as being interventions relating to Time, two saw segregation as the key problem area, with the other paper noting equality of opportunity and outcome as issues. Two of the papers saw equality of opportunity as the key indicator of success.

In terms of forms of equity, it can be concluded that most of the authors identify Equality of Opportunity, that is the connection between conditions and educational results, as the outcome variable of interest, with a majority of the interventions that focus on manipulating Process or Person variables connected to this outcome as a problem area. Perhaps unsurprisingly therefore, a majority of papers saw improving student Resilience as a possible means of addressing this, with all of the interventions focused on manipulating Person variables, and most of those focused on Process related variables, seeing bolstering Resilience as a solution. Segregation, or geographical non-random distribution of conditions across groups of students, was seen as problematic in five studies. It is important to note that the kinds of Segregation that a student might experience will necessarily differ according to their context. For some, it might reflect ability grouping within a school, and for others it may reflect different options for school type. Clearly therefore, Segregation is connected with Equality of Opportunity and Resilience, as is evidenced by this research. Finally, the relatively small number of papers with an explicit focus on student attainment is an interesting finding. Only six of the interventions explicitly noted a discrepancy in achievement as the outcome of interest. However, achievement was an implicit focus in most of the papers, with success generally viewed as higher levels of achievement.

Discussion: What matters, for whom and under what conditions

Understanding which mechanisms within mathematics interventions promote equity, and how they operate across diverse contexts, requires acknowledging the complexity of interactions between process, person, context, and time. The studies reviewed span markedly different national, cultural, and institutional settings, making it impossible to isolate variables cleanly. Given this diversity, it is essential to acknowledge that any recommendations emerging from this research will need to first take into account the national, local, cultural and political freedoms and constraints of any situation in which they may be implemented. However, through this work, and by connecting the PPCT and Equity frameworks, several consistent patterns have become visible.

In addition, it is important to interpret these findings in light of the methodological variation across the included studies. While large-scale and longitudinal studies provide more robust evidence of impact, many small-scale or short-term interventions offer valuable insights into mechanisms but limited generalisability. As such, the recommendations proposed here are informed primarily by patterns that emerge across the methodologically stronger studies.

Across the evidence base, the strongest mechanisms for improving Equity of Opportunity and reducing Segregation are structural rather than pedagogical. From a PPCT perspective, this suggests that systemic conditions (Context) exert a constraining influence on processes, thus limiting what pedagogy alone can achieve. In this sense, interventions that act only at the level of classroom practice may be insufficient unless they are supported by structural conditions that sustain equitable access over time. Interventions that keep advanced mathematics pathways open to all students, thereby maintaining high expectations tend to yield positive academic outcomes, particularly when paired with targeted instructional support for at-risk students (Atteberry et al., 2019; Cortes et al., 2013; Gutiérrez & Rodrigo, 2014). This reflects the findings of Broer et al. (2019), which indicate that low-SES students tend to succeed better in more homogenous and centralised education systems, in which structural supports can act as buffers. The mixed results of out of school programmes (e.g., summer schools or STEM outreach) suggest that *where* additional instruction occurs matters. When support is embedded within the regular school timetable, it appears more likely to influence sustained learning processes and positive experiences, consistent with PPCT's emphasis on recurring, developmentally meaningful interactions.

Ensuring that all students have access to the concrete resources that they need in order to access education in an equitable manner is clearly an important aspect to consider in relation to widening participation (Lynch & Kim, 2017). However, not all resources are tangible, and the review highlights the importance of social capital as an intangible resource often lacking in low-SES communities. Interventions that introduce “near-peers” or mentors function as mechanisms that strengthen students’ Resilience, enhancing motivation, confidence, and productive dispositions toward mathematics (Ni Shuilleabhain et al., 2021; Wilson et al., 2023).

It is interesting to note that a majority of the interventions focus on building student resilience as a possible solution to issues of equity; this emphasis may however, inadvertently shift responsibility for overcoming inequity onto learners themselves. From a PPCT perspective, this can be viewed as reflective of an overemphasis on the *Person* dimension, potentially obscuring contextual constraints and ‘individualising’ inequity. However, a recurring mechanism identified across successful interventions is the creation of learning environments in which students feel respected, connected and safe. While some examples (e.g., therapy dogs (Dudley & Knight, 2023) or university-based experiences (Ni Shuilleabhain et al., 2021)) may not be widely scalable, the underlying mechanism of belonging can be activated through more accessible pedagogical approaches. Place-based education, community-connected tasks, and a focus on social justice

can help students see mathematics as meaningful and relevant, strengthening both Resilience and Equity of Outcome (Louie et al., 2022; Rubel et al., 2016). These approaches situate learning within students' lived environment, aligning with PPCT's emphasis on the interaction between person and context.

Fundamentally, the student experience is what matters. While it is important not to ignore contextual constraints and focus solely on the person, it is essential to recognise that student motivation and attitudes – relating to Resilience – tend to be more negative in areas of low-SES (Banerjee, 2016; Megowan-Romanowicz et al., 2013; Ni Shuilleabhain et al., 2021). Interventions that explicitly address students' perceptions of the value and relevance of mathematics, such as Utility Value interventions (Häfner et al., 2017; Silverman et al., 2023; Weidinger et al., 2022) consistently improve motivation and attitudes. Similarly, contextualised pedagogies that draw on students' experiences and their communities support deeper engagement and improved outcomes (Cervantes et al., 2015; Holmes & Hwang, 2016; Louie et al., 2022; Ni Shuilleabhain et al., 2021; Rose & Akos, 2014; Rubel et al., 2016). These mechanisms operate at the level of process, shaping the quality of students' day-to-day interactions with mathematics and influencing their long-term developmental trajectories.

Perhaps the most notable finding emerging from the research examined in this paper reflects the central position held by the teacher in the experiences and outcomes of students. Teacher expectations, the learning environment, and the pedagogies that they employ, are all intrinsically linked with learners' experience, affecting both Equality of Opportunity and Resilience. This points to a need for teacher excellence particularly in areas in which students struggle the most. Despite this, the issues surrounding hiring and supporting well-qualified mathematics teachers in areas that serve disadvantaged communities are well-documented (Dotson & Foley, 2016; Evans & Mendez Acosta, 2023). Interventions that provided sustained professional development, common planning time, and strong communities of practice were more successful, suggesting that collective teacher efficacy is a critical contextual factor (Baete & Hochbein, 2014; Jerrim et al., 2015). Without such supports, even well-designed interventions can falter at the implementation stage.

Despite strong evidence linking low SES with elevated mathematics anxiety, the review reveals a striking lack of interventions directly targeting this issue. Given the well documented impact of anxiety on performance, persistence, and identity (Banerjee, 2016; Dowker et al., 2016; Martin et al., 2015; Ni Shuilleabhain et al., 2021; OECD, 2013a; Wang et al., 2023), this represents a significant gap in the field and a priority for future research.

Taken together, the findings reinforce the value of the PPCT framework as an analytical lens. Effective interventions are not those that target a single component, but those that align Process, Person, Context and Time in mutually reinforcing ways. Where misalignments occur – for example, when innovative pedagogies (Process) are introduced without sufficient teacher support (Context), or when interventions are poorly timed or limited in duration (Time) – their impact appears limited.

Conclusion and implications

The relationship between SES and educational outcomes is complex and multifaceted, requiring analytical approaches that can account for interacting influences across people, context and time. One important contribution of this article lies in demonstrating how the PPCT framework, combined with an explicit equity lens, can illuminate the mechanisms through which interventions succeed – or indeed fail – in promoting equity. The PPCT framework offers a structured way to analyse how interventions interact with learners, contexts, and developmental processes. By foregrounding equality of opportunity, outcome, resilience and segregation, this approach not only clarifies the mechanisms at play, but also highlights the necessary conditions for meaningful and sustained impact.

In addressing the first research question, the findings point to several key mechanisms and contextual factors that most strongly contribute to improving equity. Foremost amongst these is structural or institutional access, including detracking, extended instruction time and the provision of embedded supports within the school day, as well as access to tangible resources. Such structures are essential to expand opportunities for all students to access high quality mathematics instruction. Policies that maintain open pathways, reduce segregation, and provide additional support within the structure of the school day, create the conditions under which interventions can succeed.

Alongside this, it is clear that for interventions to meaningfully improve equity they should place students' lived experiences, motivations, and identities (Person) at the core. Pedagogy (Process) that emphasises the relevance of the subject to the students' lives emerged as critical in shaping both engagement and outcomes; when learning is connected to students' lived experiences, identities, and aspirations, it fosters not only achievement but also belonging. Therefore, designing for relevance, value, and belonging should be a starting point for equity interventions. This suggests that inclusive practices such as those proposed by Universal Design for Learning (UDL: udlguidelines.cast.org) could be a useful starting point for mathematics educators (Authors, in press).

In response to the second research question, the findings highlight several key considerations that should guide the design of future interventions. Central among these is the need for alignment across PPCT dimensions, ensuring coherence between the learner (Person), the learning processes (Process), the broader educational environment (Context), and the temporal dimension (Time). Interventions that fail to account for this alignment risk fragmentation and limited impact. Relatedly, the findings emphasise the importance of embedding interventions within school structures, as out-of-school or peripheral initiatives were less likely to produce sustained outcomes. Attention to timing is also critical, with successful interventions requiring sustained implementation and integration into ongoing classroom practices. At the same time, this review cautions against an over-reliance on resilience-based framings that may place the burden on the individual, highlighting the importance of addressing systemic and structural inequalities. Finally, the need for methodological robustness remains pressing, with stronger research designs required to enhance the reliability, validity, and transferability of findings across contexts.

These findings emphasise the centrality of the school as the primary environment in which the student encounters mathematics. While appropriate classroom practices are crucial, they must be supported by wider institutional and policy structures that support the conditions for success. For students to be exposed to the kinds of pedagogies, high-quality instruction, and high expectations that nurture positive attitudes to mathematics, their teachers need to be supported. Not only is it necessary to ensure that teachers are equipped with the appropriate pedagogical knowledge; research has shown that mathematics teachers in schools that serve low-SES neighbourhoods tend to be less-well qualified (Ekmekci et al., 2019; Holzberger et al., 2020), and are therefore more likely to also require support with content knowledge. Only two of the interventions examined provided large-scale support for teachers in such contexts, highlighting the importance of sustained professional development, with significant support and collaborative planning time for teachers. It is only with such sustained, context-specific support that the necessary pedagogical shifts that have the potential to support student success in mathematics in low-SES contexts, will become embedded.

Ultimately, the findings suggest that achieving equity in mathematics is not a matter of identifying isolated “effective” strategies, but of designing interventions that are ecologically coherent – aligning processes, people, contexts and time in ways that systematically address structural barriers while fostering meaningful engagement and sustained access for all learners.

Appendix

Table 3 1. Appendix

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2019	Atteberry et al. (2019)	Academic Focus	USA	A diverse suburban high school, Nassau County on Long Island, New York	All secondary	School reform (1 school)	Quant	Long (≥ 1 year)	Large (> 1000)	Achievement gap. No explicit analysis of SES or ethnicity, although likely.	Positive	Academic achievement IB exams
2020	Aji and Javed Khan (2020)	Academic focus; non-academic focus; teacher focus	USA	three rural middle schools located in economically depressed counties Three rural and one urban school districts.	Lower secondary	Extra Curricular: Summer camp	Quant	Short (< 12 weeks)	Small (10–100)	Low-SES, minority groups	Mixed	STEM concepts; Engagement in STEM; teachers' efficacy beliefs
2014	Baete and Hochbein (2014)	Teacher Focus	USA	Urban school district, grade 11, comprehensive high school	Upper secondary	Professional development	Quant	Long (≥ 1 year)	Large (> 1000)	Low-SES, minority groups	Positive	Planning, assessments and pedagogy.

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2017	Bancroft et al. (2017)	Non-academic Focus	USA	Public high schools in metropolitan area	Lower secondary	Valuing intervention: self-affirmation	Quant	Medium (3–12 months)	Large (> 1000)	Low-SES, minority groups	None	Aim to narrow maths achievement gaps through “affirmation” interventions that are not related to maths.
2017	Banerjee (2017)	Academic Focus	England	Schools in England registered with STEM activity providers	Lower secondary	Extra Curricular: STEM interventions	Quant	Long (≥ 1 year)	Large (> 1000)	Low-SES	None	Maths achievement in GCSE
2016	Borman et al. (2016)	Academic Focus; Non-academic Focus	USA	11 Urban schools	Lower secondary	Valuing intervention: self-affirmation	Quant	Medium (3–12 months)	Large (> 1000)	Ethnic minorities	Mixed	Maths scores in general; GPA - as a more holistic measure.
2015	Cervantes et al. (2015)	Academic Focus	USA	One middle school in South Texas	Lower secondary	Pedagogy (Problem-based Learning)	Quant	Medium (3–12 months)	Medium (100–1000)	Low-SES, minority groups	Positive	STAAR scores - standardised maths test scores

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2021	Chirinda (2021)	Teacher Focus	South Africa, Gauteng	Public secondary schools, at informal settlements	Lower secondary	Professional development	Qualitative	Medium (3–12 months)	Small (10–100)	Low-SES	Mixed	Teacher PD engaging in Mathematical Problem-Solving tasks.
2016	Cloutier et al. (2016)	Non-academic Focus	USA	Summer School (1 week). Middle school that ranked in the bottom 3% in student academic achievement of middle school campuses in Texas	Lower secondary	Extra Curricular - Summer school	Quant	Short (<12 weeks)	Very Small (<10)	Low-SES, minority groups	None	Student interest in STEM
2013	Cortes et al. (2013)	Academic Focus	USA	Chicago Public Schools - a large, poor urban school district.	Lower secondary	Extra tuition	Quant	Long (≥ 1 year)	Large (>1000)	Low-SES, minority groups	Positive	Effects on achievement of doubling the amount of instructional time.
2022	De Loof et al. (2022)	Academic Focus	Belgium	Flemish (the Dutch-speaking community of Belgium) schools that were part of STEM@School	Lower secondary	Contextualising learning through new integrated STEM modules	Quant	Long (≥ 1 year)	Medium (100–1000)	Broad study, analysis controlled for SES	Mixed	Change content and pedagogy to increase affective outcomes.

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2023	Dudley and Knight (2023)	Academic Focus	USA	Rural-remote middle school	Lower secondary	Therapy dogs in the classroom	Quant	Medium (3–12 months)	Medium (100–1000)	Low-SES	Positive	Passing rate on STAAR math tests from 7th to 8th grade
2015	Gorard et al. (2015)	Academic Focus	England	In three sites in London South-east. Summer school in 5–6 grade, preparation for move to secondary school. Deprived area and disadvantaged students	Transition	Extra curricular - Summer school	Quant	Short (<12 weeks)	Medium (100–1000)	Low-SES	Mixed	Numeracy and literacy
2014	Gutiérrez and Rodrigo (2014)	Academic Focus	Mexico	Public secondary schools in Mexico City	Lower secondary	Extra curricular - after school	Quant	Short (<12 weeks)	Large (> 1000)	Low-SES	Positive	Attainment on partial maths tests
2017	Häfner et al. (2017)	Non-academic Focus	Germany	Academic track schools in the German state of Baden-Württemberg, ninth grade students	Lower secondary	Valuing intervention	Quant	Medium (3–12 months)	Large (> 1000)	Low-SES	Positive	Utility Value / Relevance Intervention

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2016	Holmes and Hwang (2016)	Academic Focus; Non-academic Focus	USA	Small Mid-western school district.	Lower secondary	Pedagogy (Project-based Learning)	Mixed methods	Long (≥ 1 year)	Medium (100–1000)	Low-SES	Positive	Academic skill development; Motivated strategies for learning (i.e., cognitive, social, and motivational)
2015	(Jerrim et al., 2015)	Teacher Focus	England	44 schools from London and the South East (year 7)	Lower secondary	Professional development	Mixed methods	Medium (3–12 months)	Large (>1000)	Broad study, analysis controlled for SES	None	Whole school approach - deepen conceptual understanding.
2019	Lokhande and Müller (2019)	Non-academic Focus	Germany	German educational context: Integrated Secondary School.	Lower secondary	Valuing intervention: self-affirmation	Quant	Short (<12 weeks)	Medium (100–1000)	Ethnic minority and Gender	Mixed	Self-affirmation

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2022	Louie et al. (2022)	Academic focus; non-academic focus; teacher focus	USA	Public High schools across 6 cities	Upper secondary	Contextualising learning through data analysis module	Mixed methods	Long (≥ 1 year)	Medium (100–1000)	Low-SES, minority groups	Positive	Contextualising learning
2017	Lynch and Kim (2017)	Academic Focus	USA	High-poverty urban public school district	Lower secondary	Extra Curricular -Summer	Quant	Short (< 12 weeks)	Medium (100–1000)	Low-SES, minority groups	Mixed	Increasing engagement with mathematics to reduce learning loss
2022	Morris and Barton (2022)	Academic Focus; Non-academic Focus	USA	Rural, high poverty junior high school in South-eastern U.S.	Lower secondary	Assessment	Mixed methods	Short (< 12 weeks)	Small (10–100)	Low-SES	Mixed	Implementation of specific strategies grading to boost students' motivation by offering greater agency

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2021	Ni Shuilleabhain et al. (2021)	Non-academic Focus	Ireland	After school workshops in a university - students from Urban, SED schools.	Upper secondary	Extra curricular - after school	Mixed methods	Short (<12 weeks)	Small (10–100)	Low-SES	Positive	increasing engagement and attitudes towards maths through problem solving
2014	Rose and Akos (2014)	Non-academic Focus	USA	Grade 8 in 14 “eligible” schools.	Lower secondary	Pedagogy (Career Relevant Instruction)	Quant	Long (≥1 year)	Large (>1000)	Low-SES	Mixed	Supports for teachers, including lesson content designed to increase use of CRI practices in classroom. Measured the increase of school valuing.
2016	Rubel et al. (2016)	Academic Focus	USA	Remedial class in a low-income neighborhood in a large city in the northeastern United States.	Upper secondary	Pedagogy (pedagogy of place)	Mixed methods	Short (<12 weeks)	Small (10–100)	Low-SES, minority groups	Positive	Statistics and probability (Local Lotto) - the lottery as a critical spatial phenomenon

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2014	Sibieta et al. (2014)	Academic Focus; Non-academic Focus	England	Relatively deprived secondary schools across England, determined by the average neighbourhood deprivation of their pupils	Lower secondary	Incentives	Quant	Medium (3–12 months)	Large (> 1000)	Low-SES	Mixed	Attainment in GCSE exam Student effort
2023	Silverman et al. (2023)	Non-academic Focus	USA	Four high schools in the United States.	Upper secondary	Valuing intervention	Quant	Short (< 12 weeks)	Large (> 1000)	Low-SES	Positive	Math grades and future interest in maths
2022	Wang et al. (2022)	Academic Focus	China	First-year students in high school in a disadvantaged area: Jianzha County, a city in northwestern China, Qinghai Province.	Upper secondary	Digital support tool	Mixed methods	Short (< 12 weeks)	Very Small (< 10)	Low-SES	Positive	improve learning strategies

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2022	Weidinger et al. (2022)	Non-academic Focus	Germany	Academic Track School - Gymnasium.	Lower secondary	Valuing intervention	Quant	Long (≥ 1 year)	Medium (100–1000)	Ethnic minorities	Positive	If utility-value interventions can promote students' academic motivation and achievement, for ethnic minority students and first-generation students at college

Table 3 (continued)

Year	Citation	Study foci	Country	Setting	Secondary group	Intervention type	Quant/Qual/Mixed	Duration	Sample	Specific inclusion for SLR	Result (positive, mixed, none)	Specific topic of focus
2019	Wilson and Grigorian (2019)	Non-academic Focus	USA	High School with predominantly (>99%) Hispanic students	Upper secondary	Extra curricular - mentoring	Mixed methods	Unclear	Medium (100–1000)	Low-SES, minority groups	Mixed	The potential to interrupt high school students' day-to-day mathematics learning in the classroom with a novel informal experience that depends on near-peer interactions.

Authors' contributions Aibh  n Bray had the idea for the article. Aibh  n Bray and Emma Berry contributed to development of search terms. Database searches were performed by Aibh  n Bray and Emma Berry. Selection of articles and data extraction was performed by Aibh  n Bray, Emma Berry and Anette Bagger. The submitted draft of the manuscript was written by Aibh  n Bray and Anette Bagger. All authors commented on previous versions of the manuscript and all authors read and approved the final manuscript.

Funding Open Access funding provided by the IReL Consortium. The Access Maths in STEM (AMiS) project is co-funded by the Erasmus+ programme of the European Union. This project has been funded with support from the European Commission. Grant number: KA220 - 2023-1-IE01-KA220-SCH-000157731.

Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Ethics approval Given the non-empirical nature of this work (SLR), it was not bound by the ethical considerations associated with empirical studies involving human participants, such as voluntary participation, informed consent, anonymity, confidentiality, potential for harm, and results communication. The work was however, bound by the ethical responsibility to conduct rigorous, academic research.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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