MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(12), em2971
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/19994

Parents' perspectives on their involvement in flipped mathematics pre-class tasks at the senior secondary level

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Received 20 June 2026 ▪ Accepted 12 November 2026

Abstract

As flipped learning shifts instruction beyond the classroom, parents may become partners in pre-class learning. This study examined parents' perspectives on supporting senior secondary flipped mathematics tasks, adopting an explanatory sequential mixed-method design. Questionnaire responses from 198 parents in four schools were analyzed, followed by semi-structured interviews with eight purposively selected parents. The study was informed by the unified theory of acceptance and use of technology and the Epstein's framework of parental involvement. Quantitative analyses were performed using a 28-item parental-involvement composite, while socioeconomic status (SES) was assessed through an eight-indicator index. Parental involvement differed significantly between high- and low-SES groups, $t(196) = 13.31$, $p < .001$, $d = 1.92$, but not across schools as indicated by Welch's one-way analysis of variance, $F(3, 106.36) = 2.11$, $p = .103$, $\omega^2 = .015$. A sensitivity analysis found a positive association when the original 0-8 SES score was analyzed. Interviews identified technological access, time, mathematics confidence, learning expectations, home conditions, and student motivation as influential factors. The findings highlight context-sensitive approaches to parental involvement, supported by clear communication, appropriate orientation, and accessible resources.

Keywords: perspectives on parental involvement, flipped mathematics learning, pre-class tasks, senior secondary education, socioeconomic status, school context

INTRODUCTION

Flipped learning has gained considerable attention in mathematics education as schools respond to evolving curriculum requirements, technological development, and growing demands for student-centered pedagogies. In a flipped classroom, initial content delivery is transferred from the classroom to out-of-school settings, often through digital or video-based resources, allowing classroom time to accommodate interactive activities such as peer discussion, collaborative problem-solving, and formative feedback (Bergmann & Sams, 2012; Esperanza et al., 2023). Purposefully adopted flipped mathematics instruction can strengthen student engagement, self-regulation, and conceptual understanding (Hardison, 2022; Maimaiti et al., 2025). However, inequitable access to digital resources and differences in home learning conditions may affect the consistency and quality of implementation (Banamtuan et al., 2025; Cevikbas & Kaiser, 2023; Kissi et al., 2018).

As learning increasingly extends into home environments, parents' roles in supporting students' academic engagement remain consequential, even at the senior secondary level. Although adolescents are expected to demonstrate greater independence, parental monitoring, encouragement, and provision of resources continue to influence learning behavior and persistence (Đurišić & Bunijevac, 2017; Erdener & Knoeppel, 2018). In technology-mediated contexts, parental involvement may also entail facilitating access to digital tools, assisting with time management, and communicating with schools about learning expectations (Fitriani & Sari, 2023; Garen et al., 2021). Such involvement is shaped by socioeconomic status (SES) and school practices, which may enable or constrain parents' capacity to support learning at home (Chen et al., 2025; Coşkun & Katıtaş, 2021).

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Contribution to the literature

- This study broadens flipped learning research by examining parents' perspectives on supporting senior secondary students' engagement with flipped mathematics pre-class tasks, an area often accorded comparatively limited scholarly attention.
- It enriches existing research on parental involvement by providing empirical insights into how parents perceive their roles, responsibilities, challenges, and support needs within flipped mathematics learning environments.
- By situating the inquiry within a developing African setting such as Nigeria, it offers contextually grounded evidence on the influence of socioeconomic and technological realities on parental involvement, thereby informing a more inclusive and context-responsive approaches to flipped learning.

Previous research initiatives in a local government area of Oyo State, Nigeria, examined student and teacher experiences of flipped mathematics instruction in senior secondary schools (Omoniyi et al., 2025a, 2025b). These studies highlighted students' appreciation of the autonomy and flexibility afforded by flipped learning, alongside challenges involving time management, resource availability, and understanding pre-class tasks. They also emphasized the need for parental support in helping students manage these activities, with the nature of such support varying across schools and socioeconomic contexts. These observations align with findings that position parents as essential collaborators in student learning (Bacskai et al., 2024; Batool et al., 2025).

Despite growing scholarly interest in parental involvement and flipped classroom implementation, limited research has examined how parents perceive their roles in supporting students' engagement with flipped learning, particularly in mathematics education. Existing studies have largely focused on classroom implementation, student experiences, teacher perspectives, instructional outcomes, and parental participation in general online learning environments (Esperanza et al., 2023; Fitriani & Sari, 2023; Omoniyi et al., 2025a). Although some studies have investigated parents' perceptions of flipped classroom practices (Kainat & Sultan, 2020; Khasawneh & Aljarrah, 2022; Loizou, 2020, 2022; Medone, 2019; Shraideh & Abdelrahman, 2020), understanding remains limited regarding how parents experience and facilitate students' completion of flipped mathematics pre-class activities. This gap is particularly relevant in developing-country secondary school settings, where infrastructural and socioeconomic conditions may shape parental involvement.

In Nigeria, efforts to integrate digital technologies into instruction continue amid disparities in internet connectivity, access to digital devices, and the availability of conducive home learning environments. These conditions may affect students' opportunities to engage with instructional materials outside the classroom, a central requirement of flipped learning (Kissi et al., 2018; Yang, 2020). Thus, parental involvement remains important, encompassing the provision of learning resources, supervision, encouragement, and technological support (Epstein, 2001; Epstein & Sheldon, 2022; Goodall & Montgomery, 2014).

Against this background, the present study explored parents' perspectives on their involvement in supporting senior secondary students' engagement with flipped mathematics pre-class activities. Specifically, it investigated whether perceived parental involvement differed by SES and school context and explored the factors parents considered to enable or constrain their engagement. The study sought to generate evidence that could guide teachers, school managers, and policymakers in strengthening home-school collaboration and developing more inclusive, context-aware flipped mathematics practices. To accomplish this aim, the study raised the following three research questions (RQs):

RQ1: Does parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks differ significantly between low-SES and high-SES parents?

RQ2: Are there any significant differences in parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks across the selected schools?

RQ3: What factors do parents perceive as enabling or constraining their involvement in supporting senior secondary flipped mathematics pre-class tasks?

Accordingly, the study tested the following null hypotheses:

$H_0$1: There is no significant difference in parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks between low-SES and high-SES parents.

$H_0$2: There are no significant differences in parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks across the selected schools.

LITERATURE REVIEW

Flipped learning has been widely recognized in mathematics education as an instructional approach that reallocates initial content delivery to out-of-class contexts while reserving classroom time for active learning. The seminal work by Bergmann and Sams (2012) established the flipped classroom as a means of promoting student engagement through problem-solving, discussion, and feedback. Studies in secondary mathematics have reported benefits for engagement, self-efficacy, and conceptual understanding, although outcomes depend on purposeful implementation (Cevikbas & Kaiser, 2023; Kissi et al., 2018; Loizou, 2022). Pre-class tasks, including videos and worked examples, provide initial exposure to content on which subsequent classroom activities build (Esperanza et al., 2023; Yang, 2020).

Successful participation in flipped learning therefore depends on students' engagement with learning activities beyond the classroom (Zhou, 2023). However, students' completion of pre-class tasks varies with access to technology, self-regulatory skills, and support in the home environment (Fung, 2022). At the senior secondary level, parents support academic engagement by monitoring schoolwork, encouraging persistence, and providing resources, despite adolescents' growing independence (Benner et al., 2016; Erdener & Knoeppel, 2018). In technology-mediated settings, this support may also involve facilitating digital access, helping students manage time, and offering emotional encouragement (Fitriani & Sari, 2023; Garen et al., 2021).

While research on flipped classrooms and parental involvement has expanded, their intersection in senior secondary mathematics remains underexplored. Flipped-learning studies largely emphasize instructional effectiveness, student performance, and teacher experiences, with less attention to parents' contribution to pre-class learning (Algarni & Lortie-Forgues, 2023; Cevikbas & Kaiser, 2023; Esperanza et al., 2023). Research on parental involvement tends to focus on early childhood and primary education, leaving secondary settings less represented (Loizou, 2020; Tambunan et al., 2022). Limited empirical attention has also been given to whether involvement varies across socioeconomic groups and schools, despite the relevance of resource access and school practices (Coşkun & Katıtaş, 2021; Kissi et al., 2018).

SES may shape parents' access to educational resources, technological confidence, and flexibility to support learning at home (Ahmed et al., 2024; Taniguchi, 2023). School expectations, communication practices, and technological provision may also influence parental engagement. Beyond these structural conditions, parents' perceived competence, available time, clarity about learning expectations, and access to technological support may enable or constrain their involvement (Fitriani & Sari, 2023). Yet parents' own accounts of these factors in relation to flipped mathematics pre-class tasks have received little empirical examination. The present study addresses this gap by examining perceived involvement across SES groups and schools and exploring the factors shaping parents' participation.

Theoretical Framework

This study was guided by an integrated theoretical framework comprising the unified theory of acceptance and use of technology (UTAUT) and Epstein's framework of parental involvement.

Unified Theory of Acceptance and Use of Technology

UTAUT provides a theoretical perspective for understanding individuals' acceptance and engagement with technology (Venkatesh et al., 2003). It identifies four core constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. Performance expectancy concerns the perceived usefulness of technology, while effort expectancy relates to its perceived ease of use. Social influence refers to the expectations or encouragement of significant others, whereas facilitating conditions encompass the technical, organizational, and material resources supporting technology use.

In this study, these constructs informed the interpretation of parents' engagement with the technological aspects of flipped mathematics, including perceptions of usefulness and ease of use, expectations surrounding participation, and access to devices, connectivity, data, and technical support. This application aligns with research on technology-mediated and flipped-learning contexts (Pan & He, 2024). UTAUT served as an interpretive lens rather than a set of constructs directly measured by the questionnaire.

Epstein's Framework of Parental Involvement

Epstein's framework conceptualizes family engagement through six types of involvement: parenting, communicating, volunteering, learning at home, decision making, and collaborating with the community. It emphasizes partnerships among families, schools, and communities in supporting students' educational development (Epstein, 2001; Epstein & Sheldon, 2022). In this study, parenting, communicating, and learning at home were particularly relevant to parental support for flipped mathematics pre-class tasks. These dimensions helped interpret parents' monitoring, provision of assistance and resources, support for home learning conditions, and communication with schools. The other dimensions were retained within the broader framework but were not assumed to be equally represented in the empirical findings.

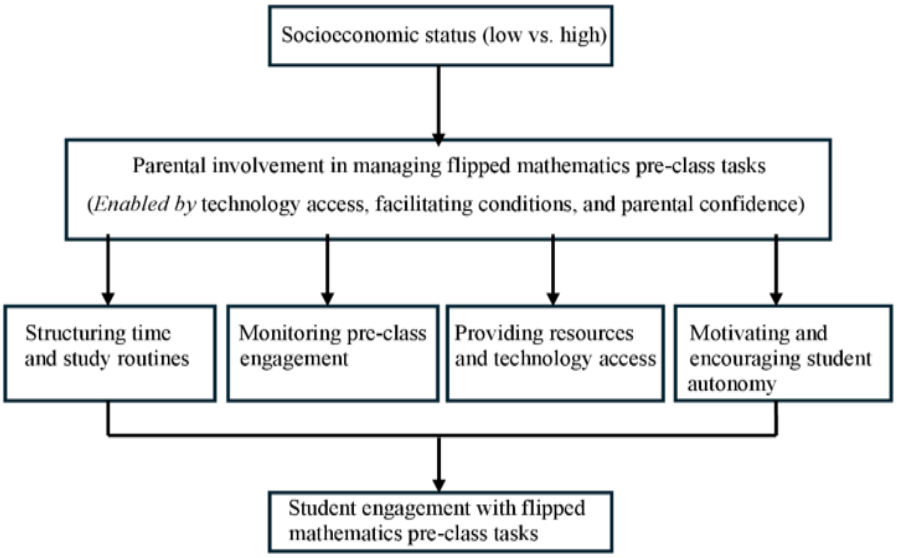


Figure 1. Conceptual framework linking socioeconomic status to parental involvement in flipped mathematics pre-class task management (Omoniyi et al., 2026)

Integration of Unified Theory of Acceptance and Use of Technology and Epstein's Frameworks

The frameworks were integrated to address the technological and educational dimensions of parental involvement in flipped mathematics. UTAUT informed the interpretation of technological conditions, including perceived usefulness, ease of use, and facilitating conditions, while Epstein's framework guided understanding of parental involvement, particularly parenting, communicating, and learning at home.

The integrated framework (**Figure 1**) informed the study's development and interpretation without imposing predetermined coding categories. While guiding the interpretation of technological access and competence, parental monitoring and support, home learning conditions, and school-parent communication, it also allowed additional factors, such as mathematics content confidence and competing parental responsibilities, to emerge from participants' accounts. Initial codes were generated from the interview data and grouped into broader themes, allowing findings beyond the constructs of either framework to be recognized.

METHODOLOGY

Research Design

The study employed an explanatory sequential mixed-method design, collecting and analyzing its quantitative data first before the qualitative phase designed to clarify, contextualize, and elaborate on the quantitative findings (Creswell & Plano Clark, 2018). This design is suitable for situations where initial statistical results demand further contextual interpretation, particularly when determining group differences and underlying perceptions. This study, therefore, utilized quantitative survey data to identify differences in parents' perceived involvement across SES and school context. The qualitative phase provided insight into parents' perceived enablers and constraints shaping their involvement in supporting flipped mathematics pre-class tasks. Integration occurred at the interpretation stage, allowing qualitative findings to contextualize and explain quantitative patterns.

Research Context and Participants

The study was conducted in four senior secondary schools, comprising two urban and two rural schools, selected to reflect variation in geographic location and socioeconomic context. The schools offered mathematics instruction using a flipped learning approach that required students to engage with pre-class tasks outside school. Participants comprised 198 parents or guardians of senior secondary students enrolled in mathematics classes in the four schools. Eligibility criteria required a participant to be a parent, guardian or primary caregiver of a senior secondary student, and to have awareness of, or involvement in, the student's engagement with flipped mathematics pre-class tasks. This selection ensured that participants were positioned to provide informed responses regarding parental involvement.

Data Collection and Analysis

Data were collected and analyzed in accordance with the explanatory sequential mixed-method design. Quantitative data were collected using a five-point Likert-type questionnaire (**Appendix 3**), followed by qualitative data collection using a semi-structured interview guide (**Appendix 4**). The procedures for the collection and analysis of the quantitative data are presented first, followed by those used for the collection and analysis of the qualitative data.

Procedures for Gathering and Analyzing Quantitative Data

The quantitative phase involved a series of procedures covering questionnaire development, psychometric evaluation, administration, retrieval, and data screening in preparation for data analysis. These procedures are presented below in the sequence in which they were undertaken.

Questionnaire Development

A researcher-developed questionnaire was utilized to assess parents' perceived involvement in supporting senior secondary students' flipped mathematics pre-class tasks. The questionnaire was developed specifically for the present study and was informed by a dual-theoretical framework integrating the UTAUT (Venkatesh et al., 2003) and Epstein's framework of parental involvement (Epstein, 2001; Epstein & Sheldon, 2022). The instrument was designed to capture parental involvement in technology-mediated pre-class mathematics learning rather than being presented as an adaptation of an established parental-involvement scale. Two mathematics education researchers and one educational measurement specialist reviewed the draft questionnaire for clarity, alignment with the study constructs, and contextual applicability. Feedback from these experts informed item refinement and finalization.

The questionnaire comprised 40 five-point Likert-type items, coded from 1 = strongly disagree to 5 = strongly agree. The items were organized into eight theoretically specified areas. The first six areas represented parental involvement:

(1) parental communication and monitoring (items 1-5),

(2) parental assistance and support (items 6-10),

(3) parental resource provision (items 11-15),

(4) encouragement and motivation (items 16-20),

(5) parental involvement in the learning environment (items 21-25), and

(6) parental collaboration with the school (items 26-30).

The remaining items addressed

(7) challenges experienced by parents (items 31-35) and

(8) suggested strategies for enhancing parental participation (items 36-40).

Thus, the questionnaire distinguished core parental-involvement items 1-30 from the items addressing contextual challenges and possible strategies.

Questionnaire Administration and Data Collection

Questionnaires were distributed to parents through school-mediated distribution channels, with both physical and electronic formats utilized where appropriate to facilitate flexible access and completion. Participants were provided with information sheets explaining the study's purpose and assurances of confidentiality, and informed consent was obtained prior to participation. They were given a two-week period to complete and return the questionnaires to allow sufficient time for thoughtful responses and to maximize response rates across participating schools.

Psychometric Evaluation of the Questionnaire

Being researcher-developed, the psychometric properties of the questionnaire were assessed using the item-level data obtained from the 198 valid responses. Internal consistency was measured using Cronbach's alpha. The 30 theoretically specified parental-involvement items initially produced an overall alpha coefficient of .876. However, reliability varied across the six theoretically specified domains, with coefficients ranging from .315 to .773. These results indicated that the domains did not all demonstrate adequate internal consistency and, therefore, were not treated as independently validated subscales. Instead, they were retained as theoretically specified content areas representing different aspects of parental involvement.

The factorability of the 30 core parental-involvement items was also determined. The Kaiser-Meyer-Olkin measure was .865, demonstrating adequate sampling adequacy, while Bartlett's test of sphericity was statistically significant, $\chi^2(435) = 1854.28$, $p < .001$. Exploratory factor analysis using principal-axis factoring was conducted to investigate the underlying structure of the items. Parallel analysis produced a dominant general factor: the first observed eigenvalue was 7.890, whereas the second observed eigenvalue was 1.691 and was below the corresponding 95th-percentile random eigenvalue of 1.774. The one-factor solution therefore provided evidence of a dominant common dimension across the core parental-involvement items, although this finding was treated as exploratory rather than as definitive validation of a unidimensional scale.

Inspection of the item-level results identified two items with problematic associations with the overall parental-involvement measure. Item 13, concerning parents' ability to resolve technical problems, showed a negative item-total association and a negative factor loading, whereas item 17, concerning frequent praise for a child's effort, yielded an essentially zero item-total association and a near-zero factor loading. Their removal increased the overall internal consistency coefficient to approximately .893. Accordingly, items 13 and 17 were excluded from the quantitative parental-involvement composite. The resulting 28-item measure was used consistently in the subsequent quantitative analyses. **Table 1** summarizes the psychometric results to establish the basis for decisions concerning item retention and the subsequent operationalization of parental involvement.

Table 1. Internal consistency and factorability of the researcher-developed questionnaire

Measure	Items	*a*
Parental communication and monitoring	1-5	.773
Parental assistance and support	6-10	.563
Parental resource provision	11-15	.478
Encouragement and motivation	16-20	.397
Learning environment	21-25	.448
Collaboration with school	26-30	.315
Core parental involvement	1-30	.876
Revised parental involvement	1-12, 14-16, 18-30	.893

Note. *a*: Cronbach's alpha; Items 31-35 assessed challenges and items 36-40 examined suggested strategies and were not included in the parental-involvement reliability analysis; Items 13 and 17 were excluded from the revised composite following examination of their item-level performance.

Scoring and Operationalization of Parental Involvement

For the quantitative analyses, parental involvement was operationalized using the resulting 28 parental-involvement items in the questionnaire. Items 1-30 were initially designated as the parental-involvement items, whereas items 31-35 assessed challenges experienced by parents and items 36-40 addressed suggested strategies for enhancing parental participation. Consequently, the two sections (items 31-35 and 36-40) were excluded from the parental-involvement composite and treated as separate questionnaire components. Responses to these separated items were summarized descriptively and reported in the study's results to indicate the challenges experienced by parents and the strategies they considered relevant to enhancing parental participation. The qualitative findings subsequently contextualized and elaborated on these descriptive patterns by providing insight into the circumstances underlying the reported challenges and support needs. Following assessment of the item-level psychometric results, items 13 and 17 were also excluded from the composite measure. The final parental-involvement measure comprised items 1-12, 14-16, and 18-30, yielding 28 retained items. For each participant, responses to these 28 five-point Likert-type items were summed to produce a total parental-involvement score. Higher scores indicated greater perceived parental involvement in supporting senior secondary students' flipped mathematics pre-class tasks. The 28-item total score served as the primary metric in the subsequent quantitative analyses.

Although individual Likert-type responses are ordinal, composite scores derived from multiple items may be analyzed using parametric procedures when their distribution and other relevant assumptions are reasonably satisfied (Boone & Boone, 2012; Carifio & Perla, 2008; Norman, 2010; Sullivan & Artino, 2013). Accordingly, means and standard deviations summarized the 28-item parental-involvement scores, while frequencies and percentages described categorical variables and group distributions. For the socioeconomic-status comparison, an independent-samples *t*-test determined whether perceived parental involvement differed between the high-SES and low-SES groups. To determine whether the observed SES-parental-involvement association was dependent on the dichotomization of SES, a sensitivity analysis was conducted with the actual eight-indicator composite as a 0-8 score. Its association with the 28-item parental-involvement score was examined using Pearson's correlation, with Spearman's rank-order correlation calculated to assess the robustness of the finding.

For the school-level comparison, Welch's one-way analysis of variance (ANOVA) tested for differences in perceived parental involvement across the four participating schools because the assumption of homogeneity of variances was violated. Cohen's *d* quantified the magnitude of the SES-group difference, while omega squared (ω^2) estimated the magnitude of the school-group effect (Cohen, 1988; Field, 2018). The resulting 28-item total-score metric was retained across these analyses to ensure consistency in the operational definition of parental involvement and the subsequent descriptive and inferential results.

Socioeconomic Status Classification

A composite approach to SES classification was adopted, consistent with the multidimensional conceptualization of SES and the use of composite indicators in previous research (Sacre et al., 2023). Participants were classified into high-SES and low-SES groups based on a composite SES measure consisting of eight indicators in section A of the questionnaire. These indicators are educational attainment, occupation, household income, housing status, income stability, motor-vehicle ownership, access to digital devices, and availability of a quiet study space (see **Appendix 3**). Each of the eight SES indicators was coded dichotomously (0 or 1), with higher scores indicating greater socioeconomic advantage. The individual indicator scores were then summed to obtain a composite SES score ranging from 0 to 8.

For the present study, the composite SES score was dichotomized to facilitate comparison of parents categorized as having relatively higher versus lower socioeconomic advantage. This classification was adopted for the purposes of the study's group comparison and does not imply that SES is inherently binary. Of the 198 valid participants, 116 (58.6%) were classified as high-SES and 82 (41.4%) as low-SES. Across the four participating schools, the high- and low-SES distributions were 27 and 22 in school Q, 18 and 21 in school R, 39 and 19 in school S, and 32 and 20 in school T, respectively. This grouping (outlined in **Appendix 2**)

facilitated the comparison of parents' perceived involvement between the two SES groups.

Procedures for Gathering and Analyzing Qualitative Data

The qualitative phase was the second stage of the explanatory sequential mixed-method design. Its purpose was to obtain more detailed accounts of parents' experiences of supporting senior secondary students' flipped mathematics pre-class tasks and to illuminate patterns identified during the quantitative phase. The qualitative component specifically explored the conditions shaping parental involvement and how parents adapted support to household circumstances. The phase comprised procedures for developing the interview guide, addressing the trustworthiness of the qualitative process, selecting participants, collecting and transcribing interview data, and conducting thematic analysis.

Development of the Interview Guide

The semi-structured interview guide was developed to gain deeper insight into parents' experiences and the contextual conditions surrounding their involvement in supporting senior secondary students' flipped mathematics pre-class tasks. The development of the guide was informed by the study's integrated theoretical framework comprising the UTAUT and Epstein's framework of parental involvement, while remaining sufficiently open to allow issues not directly represented within the frameworks to emerge from participants' accounts. The interview questions addressed parents' experiences of communication and monitoring, assistance and support, resource provision, encouragement and motivation, home learning conditions, and collaboration with the school. Questions were phrased in an open-ended manner to encourage participants to describe their experiences, practices, perceptions, and challenges in their own words, while allowing the interviewer to use probes and follow-up questions to clarify or elaborate on responses (Creswell & Plano Clark, 2018; Kallio et al., 2016). The interview guide was designed in clear and accessible language appropriate for the participating parents and the study context.

Selection of the Interview Participants

Eight parents were purposively selected from the 198 participants who had provided valid questionnaire responses and indicated their willingness to take part in follow-up interviews. Two parents were chosen from each of the four participating schools, consisting of one high-SES and one low-SES participant per school. This sampling strategy ensured representation across all four schools and both SES classifications included in the quantitative phase.

Selection was guided by the need to capture variation relevant to the quantitative findings and to obtain more detailed accounts of parents' experiences of supporting flipped mathematics pre-class tasks. Consequently, participants represented different school contexts and SES classifications and included parents whose questionnaire responses provided scope for further exploration of their experiences.

The qualitative sample was determined purposively for explanatory depth and variation rather than through a formal saturation calculation. Accordingly, the study does not claim that saturation was formally established. The eight participants were considered appropriate for the focused explanatory purpose of the qualitative phase, which was to obtain contextual accounts that could be integrated with the quantitative findings rather than to produce statistically generalizable estimates. In keeping with ethical standards, interviewees were assigned the anonymized identifiers P1 to P8 and their schools Q, R, S, and T.

Conduct of the Interviews

Qualitative data were gathered through individual, face-to-face semi-structured interviews conducted once with each of the eight selected parents at mutually convenient times. Each interview lasted approximately thirty minutes. With participants' consent, the interviews were audio-recorded and subsequently transcribed verbatim. An open-ended interview protocol encouraged participants to describe their experiences in their own words while maintaining consistency across interviews. The questions addressed six broad areas: communication and monitoring, assistance and support, resource provision, encouragement and motivation, the home learning environment, and collaboration with the school.

The protocol explored how parents found out about pre-class tasks, how they monitored and supported completion, the types of assistance and resources they provided, challenges they experienced, and the support or communication they received from schools. The interviews were conducted as individual conversations rather than group interviews, enabling participants to provide detailed accounts of their experiences. Furthermore, the use of open-ended questions allowed issues that were not explicitly anticipated in the interview protocol to emerge from participants' responses.

Process of Analyzing Qualitative Data

The qualitative data underwent thematic analysis following the six-step process recommended by Braun and Clarke (2006). Analysis commenced after the interviews had been transcribed and the research team had become familiar with the interview data. The three-member research team independently reviewed and

coded the transcripts, generating initial codes from participants' responses. The codes were then compared, discussed, and progressively refined. Ten initial codes were developed from the interview data. These included technological access and competence, time availability and competing duties, mathematics content knowledge and confidence, understanding of flipped-learning expectations, socioeconomic and material resources, the home learning environment, student motivation and self-regulation, parental beliefs and attitudes, school communication and institutional support, and cultural or contextual expectations.

A qualitative codebook (**Appendix 31**) was developed to document the definitions, inclusion and exclusion criteria, and illustrative excerpts associated with these initial codes. The codebook was used iteratively during coding and refined as the analysis progressed. Related codes were subsequently clustered into broader categories and higher-order themes. This process resulted in six final themes: technological access and competence; time availability and competing responsibilities; mathematics content knowledge and confidence; understanding of flipped-learning expectations; home learning environment, and finally, student motivation, parental beliefs, and cultural expectations. The clustering of the initial codes into the final themes, together with the rationale for grouping related codes, is documented by **Appendix 32**.

The analysis was not structured as a direct mapping of interview questions onto themes. Instead, initial codes were generated from the interview data, compared across transcripts, and subsequently synthesized into broader themes where they reflected related or mutually reinforcing patterns of meaning. For example, technological access and socioeconomic/material resources were brought together in developing the technological-access theme, while understanding of flipped-learning expectations was considered alongside school communication and institutional support. Student motivation, parental beliefs, and cultural expectations were similarly synthesized into a broader theme.

The three researchers independently coded the transcripts and subsequently compared their coding decisions. They discussed their interpretations and worked together to reconcile any differences. Thus, the analysis relied on independent coding followed by collaborative comparison and consensus, rather than on the calculation of an intercoder reliability coefficient. The final themes were then interpreted in relation to the study's RQs and theoretical framework. UTAUT and Epstein's framework of parental involvement were treated as complementary interpretive lenses rather than as rigid predetermined coding categories. This allowed theoretically relevant patterns concerning technological conditions, school-family communication, and learning at home to be identified while also permitting contextual factors such as mathematics confidence and competing parental responsibilities to emerge from the data. The qualitative findings consequently offered contextual insight into the quantitative results and contributed to the subsequent mixed-method integration.

Establishing the Trustworthiness of the Interview Process

In accordance with established qualitative research criteria (Adler, 2022; Lincoln & Guba, 1985), procedures addressing credibility, dependability, confirmability, and transferability were applied to enhance the study's trustworthiness. Credibility was supported by aligning the interview questions with the RQs and theoretical framework, while retaining open-ended wording and using probing and clarification during interviews to capture participants' experiences in greater depth. Dependability was strengthened by following a common semi-structured interview guide across participants and systematic documentation of the qualitative analytic procedures. Confirmability was supported by transcribing interviews verbatim and comparing developing interpretations against the original interview data throughout the analysis.

In addition, the three-member research team independently coded the transcripts, compared coding decisions, discussed discrepancies, and reached consensus on the interpretation of the data. Transferability was supported by providing contextual detail about the participating schools, the purposive selection of parents across the four schools and two SES classifications, and the circumstances surrounding their involvement in facilitating flipped mathematics pre-class tasks. These contextual descriptions may help assess the extent to which the findings are applicable to comparable educational settings. These procedures promoted transparent development of the qualitative findings and kept interpretations grounded in participants' narratives.

Ethical Considerations

In compliance with established ethical principles (e.g., Bos, 2020; Creswell & Plano Clark, 2018; Demircioğlu, 2024) governing educational research engaging human participants, the investigation strictly observed necessary ethical principles to protect participants' rights and ensure research integrity. Before data collection, ethical approval was secured from the state's Ministry of Education. Participation was voluntary, and informed consent was obtained from all parents after clearly explaining the study's purpose, procedures, and expected time commitment to them. Participants were guaranteed anonymity and confidentiality, with no personally identifiable information gathered or reported. Questionnaire responses and interview data were coded and stored

Table 2. Descriptive statistics of parental involvement by SES

SES group	*n*	*M*	*SD*
High-SES	116	99.19	14.61
Low-SES	82	72	13.50
Total	198	-	-

safely, accessible only to the researchers. Additionally, participants were informed of their right to withdraw from the study at any stage without repercussions until such time as withdrawal was no longer practicable, particularly after the data had been anonymized and incorporated into the analysis. At the qualitative stage, due caution was exercised to carry out interviews respectfully and to prevent participants from experiencing any form of discomfort or coercion.

RESULTS

Reflecting the explanatory sequential mixed-method design, the study's findings are reported in two successive phases, beginning with the quantitative results (to address **RQ1** and **RQ2**) and followed by the qualitative findings (to respond to **RQ3**).

Quantitative Results

The quantitative results are sequentially organized in relation to the RQs. **RQ1** was addressed through descriptive statistics and independent-samples *t*-test comparing parental involvement across the high-SES and low-SES groups. **RQ2** was subsequently examined using descriptive statistics and Welch's one-way ANOVA, which assessed differences in parental involvement across the four selected schools. The quantitative phase commenced with the psychometric findings, which examined the internal consistency and empirical structure of the researcher-developed questionnaire before the substantive quantitative results are presented. Subsequently, for the SES analysis, parents were categorized into high-SES and low-SES groups according to their responses to the indicators contained in section A of the questionnaire.

Descriptive Statistics for Socioeconomic Status Groups

Descriptive statistics were calculated using the data derived from the 28 core questionnaire items (**Appendix 30**) to assess parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks across the high-SES and low-SES groups. High-SES parents (n = 116) had a mean parental-involvement score of 99.19 (SD = 14.61), compared with 72.00 (SD = 13.50) among low-SES parents (n = 82). The observed difference between the group means was 27.19. These descriptive results suggest a substantial difference in the group mean scores, which was subsequently examined using an independent-samples *t*-test. **Table 2** presents the descriptive statistics for the two SES groups. **Table 2** outlines the descriptive statistics across the two SES groups.

To visually depict the distributional characteristics and potential outliers for each SES group, the box plots below (**Figure 2**), generated directly from the raw parental involvement scores, are provided. Numerical quartile values are, however, not reported since the primary analysis is parametric and based on means and standard deviations.

Independent-Samples *t*-Test for Socioeconomic Status Differences

An independent-samples *t*-test was performed on the same data obtained from the 28 core questionnaire items (**Appendix 30**) to investigate whether parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks differed between the high-SES and low-SES groups. The difference between the two groups was statistically significant, $t(196) = 13.31$, p

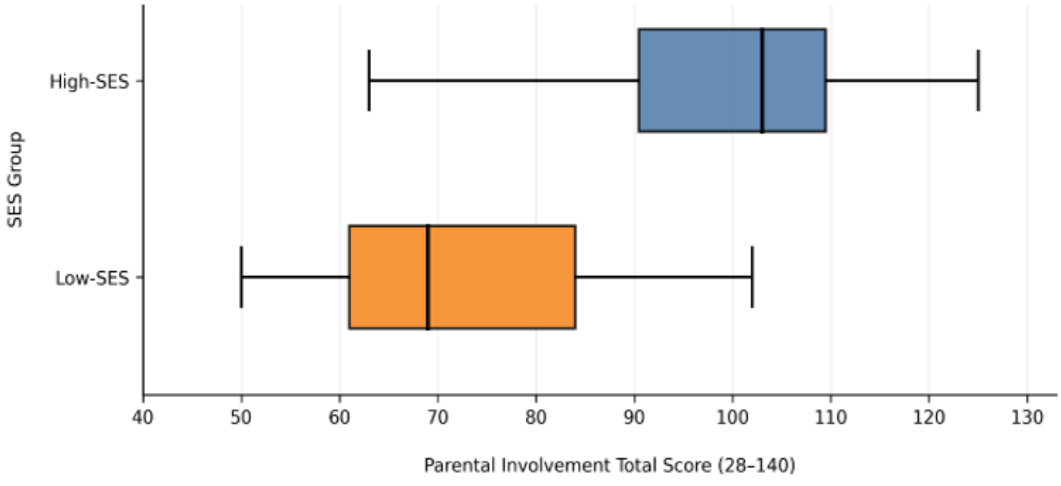


Figure 2. Box plots showing distribution of parents' perceived involvement scores in supporting senior secondary flipped mathematics by socioeconomic status group (created by the authors)

Table 3. Independent-samples *t*-test of parental involvement by socioeconomic status

SES group	*n*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
High-SES	116	99.19	14.61	13.31	196	< .001	1.92
Low-SES	82	72	13.50				

Note. *df*: Degrees of freedom = *n*1 + *n*2 - 2 = 116 + 82 - 2 = 196; Effect size interpreted according to conventional benchmarks (Cohen, 1988)

Table 4. Descriptive statistics of parental involvement across schools

School	Location	*n*	*M*	*SD*
Rural school Q	Rural	49	82.76	15.85
Rural school R	Rural	39	86.87	13.80
Urban school S	Urban	58	89.72	19.72
Urban school T	Urban	52	91.60	24.71
Total		198		

< .001, with a mean difference of 27.19. The pooled-standard-deviation effect size was Cohen's d = 1.92. Thus, within this sample, SES-group membership was considered as a statistically significant difference in parents' reported involvement. The *t*-test result (**Table 3**) should be interpreted as a group difference in the observed sample, rather than as evidence that SES causes differences in parental involvement.

A sensitivity analysis was conducted to assess whether the relationship between SES and parental involvement remained evident when the original composite score was analyzed without dichotomization. The 0-8 SES composite was positively correlated with the 28-item parental-involvement score, Pearson's r = .534, p < .001, N = 198, 95% CI [.426, .626]. This finding was supported by Spearman's rank-order correlation, which also indicated a significant positive association (ρ = .572, p < .001).

The consistency in the direction and statistical significance of the two correlation results strengthens the evidence that the SES-parental-involvement association was not solely dependent on the high-/low-SES classification.

Descriptive Statistics of Parental Involvement Across Schools

Descriptive statistics were calculated from responses to the 28 core questionnaire items (**Appendix 22-Appendix 29**) to describe variation in parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks across the four participating schools. The mean parental-involvement scores ranged from 82.76 (*SD* = 15.85) in school Q to 91.60 (*SD* = 24.71) in school T. School R had a mean of 86.87 (*SD* = 13.80), while school S had a mean of 89.72 (*SD* = 19.72). These descriptive results reveal some variations in the observed mean scores across the four schools. Nevertheless, differences in descriptive means should not be interpreted as statistically significant without considering the inferential test. **Table 4** presents a summary of the descriptive statistics across the schools.

For a clearer comparison beyond what is readily observable from numerical data in **Table 4** alone, **Figure 3** visually represents the variation in parents' perceived involvement in supporting flipped mathematics pre-class tasks across schools Q, R, S, and T.

Welch's One-Way ANOVA of the School-Level Differences in Parental Involvement

A Welch's one-way ANOVA helped test whether parents' perceived involvement in supporting senior secondary flipped mathematics pre-class tasks differed across schools Q, R, S, and T. Before the inferential analysis, the assumptions underlying the conventional ANOVA were examined.

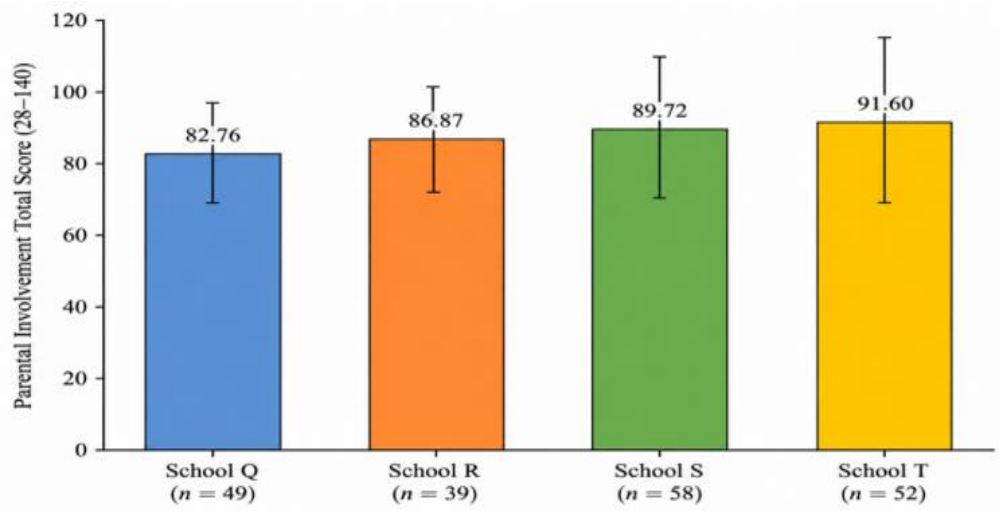


Figure 3. Mean parents' perceived involvement scores in senior secondary flipped mathematics by school group (Error bars represent group standard deviations calculated from the group sum of squares and sample sizes) (created by the authors)

Table 5. Welch's ANOVA for differences in parental involvement across school groups

Effect	Welch's F	df_1	df_2	p	Effect size
School group	2.11	3	106.36	.103	ω^2 = .015

Note. Welch's ANOVA: $F(3, 106.36) = 2.11$; $p = .103$; $\omega^2 = .015$

The homogeneity-of-variance assumption was not satisfied, as indicated by Levene's test, $F(3, 194) = 8.02$, $p < .001$. The residual normality assessment also indicated some departure from normality (Shapiro-Wilk $W = .951$, $p < .001$).

Since the homogeneity-of-variance assumption was violated, Welch's one-way ANOVA was considered as a robust alternative to the conventional one-way ANOVA. Based on the data presented in **Appendix 22**-**Appendix 29**, Welch's test demonstrated that the differences in parental-involvement scores across the four schools were not statistically significant, $F(3, 106.36) = 2.11$, $p = .103$. The observed school mean scores ranged from 82.76 to 91.60, but these differences did not represent sufficient statistical evidence of a school-level difference in perceived parental involvement. The corresponding effect was small, with $\omega^2 = .015$. **Table 5** depicts the Welch's one-way ANOVA results.

As illustrated by **Table 5**, the Welch's one-way ANOVA result revealed that parents' perceived involvement in facilitating senior secondary flipped mathematics pre-class tasks did not differ significantly across the four participating schools, $F(3, 106.36) = 2.11$, $p = .103$. Although the school-level descriptive mean scores varied from 82.76 to 91.60, the observed differences were not statistically significant. The associated effect was small ($\omega^2 = .015$).

Descriptive Findings from Items 31-40: Parents' Challenges and Suggested Strategies

Items 31-40 were not included among the core items for operationalizing parental involvement and were therefore summarized descriptively. Items 31-35, which concerned challenges experienced by parents, yielded mean scores ranging from 85.96 to 98.84. The more prominent reported challenges included limited access to reliable technological devices and internet connectivity (item 32: $M = 98.84$, $SD = 36.96$), difficulty understanding mathematics concepts (item 31: $M = 98.28$, $SD = 38.36$), and time constraints (item 34: $M = 97.72$, $SD = 40.6$). The five items focusing on challenges had an overall mean score of 3.36.

Items 36-40, which covered suggested strategies for enhancing parental participation, produced mean scores ranging from 88.76 to 101.36. The most strongly endorsed strategies were a parent-teacher feedback system (item 40: $M = 101.36$, $SD = 36.96$) and regular teacher communication about flipped-learning expectations (item 37: $M = 100.24$, $SD = 39.76$), recording a combined mean score of 94.92 across the five items centered on strategies. These findings from items 31-40 complement the principal quantitative results by highlighting the challenges parents experienced and the strategies they considered relevant to strengthening their participation. These descriptive patterns provided a basis for the subsequent qualitative phase, which explored the circumstances underlying the reported experiences in greater depth.

Qualitative Findings

The qualitative analysis generated six themes describing the conditions that shaped parents' involvement in supporting senior secondary students' flipped mathematics pre-class tasks. Ten initial codes were developed from the interview data (**Appendix 31**) and subsequently clustered into six higher-order themes through comparison and synthesis across participants (**Appendix 32**). The qualitative phase added contextual depth to the descriptive findings on challenges experienced by parents (items 31-35) and strategies proposed to enhance participation (items 36-40). The themes were not direct equivalents of these questionnaire items or the thematic areas covered by the interview guide. Instead, they captured interconnected patterns in parents' accounts and provided deeper insight into the technological, academic, temporal, household, and school-related circumstances underlying the reported challenges and support needs.

Theme 1. Technological access and competence

Parents' descriptions of their experiences elaborated on the questionnaire finding that limited access to reliable technological devices and internet connectivity constrained their participation. Participants described both material access and technological competence as important conditions affecting their ability to support digital pre-class activities. P1 noted, "At times, the video does not load or takes much time to load because of poor network." P3 explained, "I don't understand how the platform works. Most times, I just ask my child whether she has done the work." Similarly, P6 stated, "When the internet finishes, there is practically nothing I can do," while P8 observed that "Technology makes parental participation easier if one knows how to use it." These responses suggest that technological constraints involved more than simply owning a device. Connectivity, data availability, platform familiarity, and parents' confidence in using digital tools affected the extent to which they could provide direct support. Thus, participants' accounts contextualized the questionnaire finding on technological access by illustrating how technological limitations could shift parents' roles from active assistance towards monitoring their children's task completion.

Theme 2. Time availability and competing responsibilities

Parents' narratives further explained the time-management challenges associated with balancing their own responsibilities and their children's flipped-learning schedules, as previously identified in the questionnaire results. Parents described work schedules, fatigue, household duties, and other family responsibilities as limiting the time available for sustained involvement. P2 commented, "After returning from work, I am usually tired. So, it's not really convenient for me to fully assist my son in his homework." P5 responded, "My job does not allow me to sit and monitor my daughter's pre-class work daily." In contrast, P7 reported, "On days I am free, I check the videos with my child," and P4 said, "Only on some weekends I have time to help." P1 likewise observed, "House chores also take much of my time in the evening," while P8 expressed with concern, "Even when I want to help, there is pressure from other family duties." These reflections reveal that limited parental involvement was not necessarily attributable to a lack of willingness. Rather, parents sometimes had to negotiate their involvement around competing responsibilities. Thus, time availability affected the frequency and intensity of support rather than eliminating parental participation altogether.

Theme 3. Mathematics content knowledge and confidence

The questionnaire results identified difficulty understanding mathematics concepts as another prominent challenge. The interviews shed light on this finding by showing how parents' confidence in their mathematics knowledge affected the form of assistance they provided. P3 admitted, "The senior secondary mathematics is too advanced for me," Expressing a similar concern, P6 lamented, "I cannot explain the formulas, so I only encourage my daughter to keep pushing." P5 likewise regretted, "I did not study mathematics at that level," and P7 expressed concern about providing incorrect explanations, stating, "I am afraid of confusing my child if I try to explain." Rather than withdrawing completely, some parents responded by moving from direct instructional assistance to monitoring, encouragement, and ensuring task completion. P1 stated, "I just make sure the homework is completed," while P8 explained, "I leave the explanations to the teacher." The qualitative evidence therefore extends the questionnaire finding by demonstrating that limited mathematics confidence did not necessarily mean an absence of parental involvement; instead, it influenced how parents participated.

Theme 4. Understanding of flipped-learning expectations and school communication

The descriptive findings concerning suggested strategies showed relatively strong endorsement of regular teacher communication and parent-teacher feedback. The interviews offer an important explanation for this preference. Parents reported uncertainty about the purpose of flipped learning, the requirements of pre-class tasks, and the role expected of them when school guidance was insufficient. P7 stated, "Once the teacher explained the flipped system, I knew my role," whereas P2 recalled, "At first, I did not know whether it was compulsory." P4 shared a similar sentiment, "Sometimes I am not sure what is expected from me as a parent," while P5 explained, "Clear instructions helped me assist better." P6 added, "When the school provides clear instructions, I feel more confident to support." These responses expand on the questionnaire findings regarding communication and parent-teacher support by showing that parents' requests for clearer communication were related to practical uncertainty about what they should do, how much they should do, and what the school expected of them. Accordingly, school communication emerged as a condition that could make parental participation more purposeful and manageable.

Theme 5. Home learning environment and resources

Parents also identified household conditions that affected the extent to which they could support pre-class learning. Noise, overcrowding, shared spaces, and shared technological resources could interfere with students' ability to follow pre-class schedules. P1 commented, "There are many distractions at home," while P6 observed, "We share one room, so it is noisy." In contrast, P3 stated, "Having a quiet corner helps," whereas P8 noted, "Sharing devices makes it difficult to follow schedules." These experiences extend the questionnaire findings concerning technological and parental support by suggesting that the effectiveness of parental involvement also depended on the environment in which that involvement occurred. Parents could provide encouragement or supervision, for instance, but their efforts were sometimes hampered by insufficient space, competing household routines, and limited access to shared resources.

Theme 6. Student motivation, parental beliefs, and cultural expectations

The final theme concerned the interaction among student motivation, parents' beliefs about their educational responsibilities, and expectations surrounding student independence. Parents emphasized adjusting their involvement according to how independently their children managed pre-class tasks. P5 commented, "When my child is motivated, I do

not have to do much because he takes responsibility for his learning." Conversely, P2 said, "I need to constantly remind my child to do his mathematics tasks because he easily loses focus." Parents also expressed strong beliefs concerning their responsibilities. P4 agreed, "As a parent, I believe it's my duty to make sure that my child takes schoolwork seriously," while P6 explained, "In my family, we really value education. That's why I always encourage girl to complete the homework before class." These perspectives show that parental support was shaped not only by parents' available resources and capabilities but also by perceptions of their responsibilities and their children's level of independence. In this respect, parental support included monitoring, reminders, encouragement, and reinforcement of students' responsibility for completing pre-class work.

Synthesis of the Qualitative Findings

In combination, the six themes clarify, contextualize and elaborate on the descriptive questionnaire findings by highlighting the circumstances in which reported challenges and support needs were experienced. Technological access and competence (theme 1) accounted for the prominence of technology-related challenges; time availability and competing responsibilities (theme 2) demonstrated how work and household demands constrained participation, and mathematics content knowledge and confidence (theme 3) clarified why some parents found direct academic assistance difficult,. At the same time, the findings concerning school communication and understanding flipped learning expectations (theme 4) provided qualitative context for parents' endorsement of clearer guidance, regular communication, and parent-teacher feedback. **Appendix 33** illustrates the distribution of parents' responses that contributed to the development of each of the six higher-order themes.

An important pattern across all identified themes was that parents did not necessarily respond to constraints by withdrawing from their children's learning. Instead, they often adapted the form of their involvement. Parents who could not confidently explain mathematics concepts relied on monitoring and encouragement; those with limited time participated when their schedules permitted, and those experiencing technological difficulties sometimes concentrated on checking task completion rather than providing direct digital assistance. The qualitative findings therefore expand on the quantitative results by demonstrating that parental involvement is not determined solely by its amount but also by the form it takes under different household, technological, academic, and school-related conditions.

This interpretation also helps connect the questionnaire findings on suggested strategies with parents' lived experiences. Requests for clearer instructions, regular school communication, parent-teacher feedback, digital resources, and training can be understood in light of the practical barriers described in the interviews. Accordingly, the qualitative phase clarified the patterns emerging from the descriptive questionnaire results without interpreting the interview findings as a quantitative estimate of the prevalence of those challenges or strategies. For explicit explanation of how the qualitative findings contributed to the interpretation of the quantitative results, **Table 6** captures the principal areas of integration across the two phases.

In summary, the quantitative and qualitative findings addressed the study's RQs. The SES-group comparison showed a statistically significant difference in parents' perceived involvement, whereas the school-group comparison revealed no statistically significant difference. Accordingly, the null hypothesis of no significant difference in perceived parental involvement between low-SES and high-SES parents is rejected, while the null hypothesis of no significant difference across the selected schools is not rejected.

DISCUSSION

The quantitative analysis produced a significant difference in perceived parental involvement between high- and low-SES groups, $t(196) = 13.31$, $p < .001$, Cohen's $d = 1.92$. The sensitivity analysis also indicated a positive association between the original 0-8 SES composite and parental involvement (Pearson's $r = .534$, $p < .001$; Spearman's $\rho = .572$, $p < .001$). Thus, the association was not solely dependent on dichotomizing SES. These findings indicate an association, not a causal effect of SES.

This pattern resonates with research linking parental involvement to family resources and learning materials (Ahmed et al., 2024; Benner et al., 2016). Digital access may be especially relevant in technology-mediated learning (Fitriani & Sari, 2023). Interviews contextualized the SES difference through accounts of internet access, shared devices, household responsibilities, and mathematics confidence. However, the difference should not be interpreted causally.

Welch's one-way ANOVA found no significant difference in parental involvement across schools Q, R, S, and T, $F(3, 106.36) = 2.11$, $p = .103$, $\omega^2 = .015$, suggesting that school membership accounted for little variation in this sample. Nevertheless, parents' accounts highlighted responsibilities, mathematics confidence, home conditions, student motivation, and communication about flipped-learning expectations as factors informing their involvement. Clear explanations of flipped-learning expectations would help parents understand their roles, which included monitoring, encouragement, providing resources, supporting home learning, communicating with schools, and offering academic assistance. These activities were consistent with

Table 6. Joint display of quantitative and qualitative findings on parental involvement in flipped mathematics

Quantitative finding	Qualitative finding	Integrated interpretation	Theoretical framing
SES-group difference: Parents in the high-SES group reported significantly higher perceived involvement than those in the low-SES group.	Theme 1: Technological access and competence; Theme 2: Available time and competing responsibilities; Theme 3: Mathematics content knowledge and confidence; Theme 5: Home learning environment and resources. Parents described limited internet/data, shared devices, competing responsibilities, limited mathematics confidence, noise and inadequate study conditions as constraints on their support.	The qualitative findings contextualize the quantitative SES difference by showing that parents' capacity to participate was experienced within differing technological, material, temporal, academic and home-learning conditions. The qualitative data do not establish a causal pathway between SES and involvement.	UTAUT: facilitating conditions help explain the role of technological/ material access. Epstein's framework: learning at home situates these conditions within parents' home-based involvement.
School-group comparison: Perceived parental involvement did not differ significantly across schools Q, R, S and T.	Themes 2, 3, 5, and 6: Parents described time pressures, mathematics confidence, home conditions, student motivation, parental beliefs and cultural expectations as influences on involvement. These themes concern household and individual circumstances rather than school membership alone.	The qualitative findings clarify and contextualize the non-significant school-group result by drawing attention to factors that may operate across school settings. They do not demonstrate that family factors statistically explain the absence of school differences.	Epstein's framework: Parental involvement is enacted within family and home contexts. UTAUT: Enabling conditions may influence participation irrespective of school membership.
Parental involvement was operationalized as a multi-dimensional construct encompassing communication/ monitoring, assistance/ support, resource provision, encouragement/ motivation, learning environment and school collaboration.	Across the six themes, parents described different ways of adapting their involvement. For example, parents with limited mathematics confidence sometimes shifted from direct academic assistance toward monitoring, encouragement and reliance on teachers. The qualitative analysis further characterized involvement as multi-dimensional and adaptive.	The qualitative findings expand on the quantitative measure by showing that the extent of involvement does not fully capture the different forms that involvement may take under varying parental circumstances.	Epstein's framework: Provides a framework for understanding the different forms of parental involvement. UTAUT: Helps interpret how technological conditions can enable or constrain particular forms of participation.

Epstein's framework (Epstein, 2001; Epstein & Sheldon, 2022). Parents also adapted their involvement to their circumstances; those less confident in mathematics tended to monitor and encourage rather than provide direct instruction (Fitriani & Sari, 2023).

Parents' technological difficulties relate to UTAUT's facilitating conditions and effort expectancy (Venkatesh et al., 2003), constructs also relevant in flipped-learning research (Agyei & Razi, 2022; Pan & He, 2024). UTAUT does not fully explain parental involvement because mathematics confidence, competing responsibilities, home conditions, and student motivation extend beyond its constructs.

Epstein's framework highlights communication and learning at home. Clear explanations, monitoring, encouragement, and resource provision were evident in parents' accounts (Epstein, 2001; Epstein & Sheldon, 2022). Parenting, communication, and learning at home were most prominent; other dimensions were less represented. Time pressures and mathematics confidence also influenced parental support (Coşkun & Katıtaş, 2021). These findings suggest that the combined UTAUT-Epstein framework establishes an important conceptual foundation but does not exhaust the range of contextual conditions affecting parental involvement in flipped mathematics.

Limitations of the Study

The findings should be interpreted in light of several limitations. First, dichotomizing SES facilitated group comparison but reduced variation in the original measure, although the sensitivity analysis also examined the 0-8 score. Second, the 28-item measure remains exploratory because factor analysis, item refinement, and subsequent analyses used the same sample; independent validation is required. Third, the qualitative phase involved eight purposively selected parents and did not formally establish saturation, so its findings provide contextual insight rather than statistical generalization. Digital-device access and a quiet study

space were included in the SES composite and also in the qualitative findings, limiting their interpretation as independent explanations of the SES-group difference. The cross-sectional design also precludes conclusions about change over time or causality.

CONCLUSION

This study investigated parents' perspectives on their involvement in supporting senior secondary students' flipped mathematics pre-class tasks in the Nigerian context using an explanatory sequential mixed-method design. The quantitative results yielded a statistically significant difference in perceived parental involvement between the high- and low-SES groups. This finding was further supported by a sensitivity analysis, which showed that the positive association between SES and perceived parental involvement remained evident when SES was analyzed using the original 0-8 composite score. In contrast, Welch's one-way ANOVA indicated no statistically significant difference in perceived parental involvement across the four participating schools. The qualitative findings provided contextual insights into these patterns, identifying technological access and competence, time availability and competing responsibilities, mathematics content confidence, understanding of flipped-learning expectations, home learning conditions and resources, and student motivation, parental beliefs, and school communication as important dimensions of parents' experiences. Collectively, the findings characterize parental involvement as a multi-dimensional and context-dependent process rather than a uniform approach to homework supervision.

The study further demonstrates that parents' involvement in flipped mathematics extends beyond ensuring that students complete assigned pre-class activities. Parents emphasized adapting their roles according to their technological capabilities, available time, confidence in mathematics content, household learning conditions, and understanding of the expectations associated with flipped learning. Some parents rendered direct assistance, whereas others relied more on monitoring, encouragement, or communication with teachers when direct instructional support was difficult. The integration of UTAUT and Epstein's framework of parental involvement offered complementary perspectives for interpreting these findings. UTAUT helped situate parents' engagement within the technological conditions required for participation, while Epstein's framework illuminated the forms and relational contexts through which parental involvement was enacted. The study therefore extends research on flipped classroom implementation by foregrounding parents' experiences within senior secondary mathematics rather than focusing exclusively on student learning outcomes.

The findings have implications for the implementation of flipped mathematics in Nigerian secondary schools while also offering considerations that may be applicable to similar African contexts. Schools should recognize parents as relevant partners in technology-mediated learning and provide clear, sustained communication about the purpose, expectations, and practical requirements of pre-class activities. Parent orientation and accessible guidance may help families understand how they can support learning without requiring them to assume the role of the mathematics teacher. Schools may also consider offline or low-data learning alternatives and context-sensitive digital support for families with limited technological or material resources. Improving school-home communication can further provide parents with appropriate channels for seeking clarification and support. Future research could adopt longitudinal, comparative, or intervention-based designs to investigate changes in parental involvement over time and assess approaches for strengthening parents' capacity to support flipped learning. Overall, this study contributes an integrated, context-sensitive account of parental involvement in senior secondary flipped mathematics and underscores the importance of considering the family context alongside technological and school-based conditions.

Author contributions: AAO: conceptualization, data curation, formal analysis, investigation, methodology, visualization, writing – original draft, writing – review & editing; **TJ:** supervision, validation, writing – review & editing; **LCJ:** project administration, resources, supervision, validation. All authors agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgments: The authors would like to thank the schools, teachers, students, and particularly the parents who participated in the study and the experts who assisted in validating the research instruments.

Ethical statement: This study was approved by the Ministry of Education Research Ethics Committee on 3 February 2023 with approval number 2023_MoE/OYS-MEREC/215. Written informed consents were also secured from the participants before conducting the study.

AI statement: The authors declare that GenAI was not used in creating the manuscript.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author. **Supplementary Data** is available at Mendeley Data repository: https://doi.org/10.17632/cbzmx432tm.4

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