EduHome: Leveraging LLMs for Human Behavioural Insights and Strategy Development through Parent–Child Homework Conversations

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Negative family education practices, particularly in parents' homework involvement, have harmful effects on both children and parents. Traditional methods for improving parenting strategies (e.g., books, workshops, counseling) are often overgeneralized, rely on subjective self-reports, and are costly, limiting effectiveness. In this work, we aim to improve parents' educational strategies in homework involvement. To achieve this, we conducted a formative study with 4 parents and 2 educational experts to identify key design principles regarding motivations, pain points, and expectations. Based on these insights, we introduce EduHome, a large language model (LLM) powered system that analyzes real-world audio recordings to support parents. Through a predefined workflow, EduHome provides personalized behavioral insights and scientifically grounded actionable strategies. In a 4-week field experiment involving 20 parents and 3 educational experts, both groups expressed high satisfaction, particularly in observed behavioural changes and anticipated outcomes. Findings provide strong evidence that EduHome can meaningfully improve the family education practices.

CCS Concepts: • **Human-centered computing** → **Empirical studies in ubiquitous and mobile computing**; • **Applied computing**; • **User studies**;

Additional Key Words and Phrases: Family Education, Human Behavioural Modelling, Large Language Models, Parental Homework Involvement

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1 Introduction

"Tell me and I forget. Teach me and I remember. Involve me and I learn" - Benjamin Franklin[51]

Family education is foundational to individual development and social progress, shaping values, social emotional competence, and lifelong learning habits. Within this context, parental involvement in homework is a critical practice associated with children's academic achievement, motivation, and well-being [7, 16, 40]. In many East Asian contexts (e.g. China), this practice is both ubiquitous and a frequent source of everyday family conflict. Driven by a strong cultural emphasis on education, families increasingly treat after-school homework guidance as a core parental responsibility, often investing substantial time. Survey data indicate that 91% of parents have assisted with homework and 78% provide daily guidance; average daily tutoring time rose from 3.67 hours in 2010 to 5.88 hours in 2018—approximately three times the global average [1, 49, 53].

Parental homework involvement benefits children's achievement and helps sustain parent–child connection, yet homework is also a common site of conflict. Evidence indicates that conflicts often stem from inappropriate parental tutoring strategies—such as insufficient positive feedback, over-assistance, and inflated expectations—rather than from

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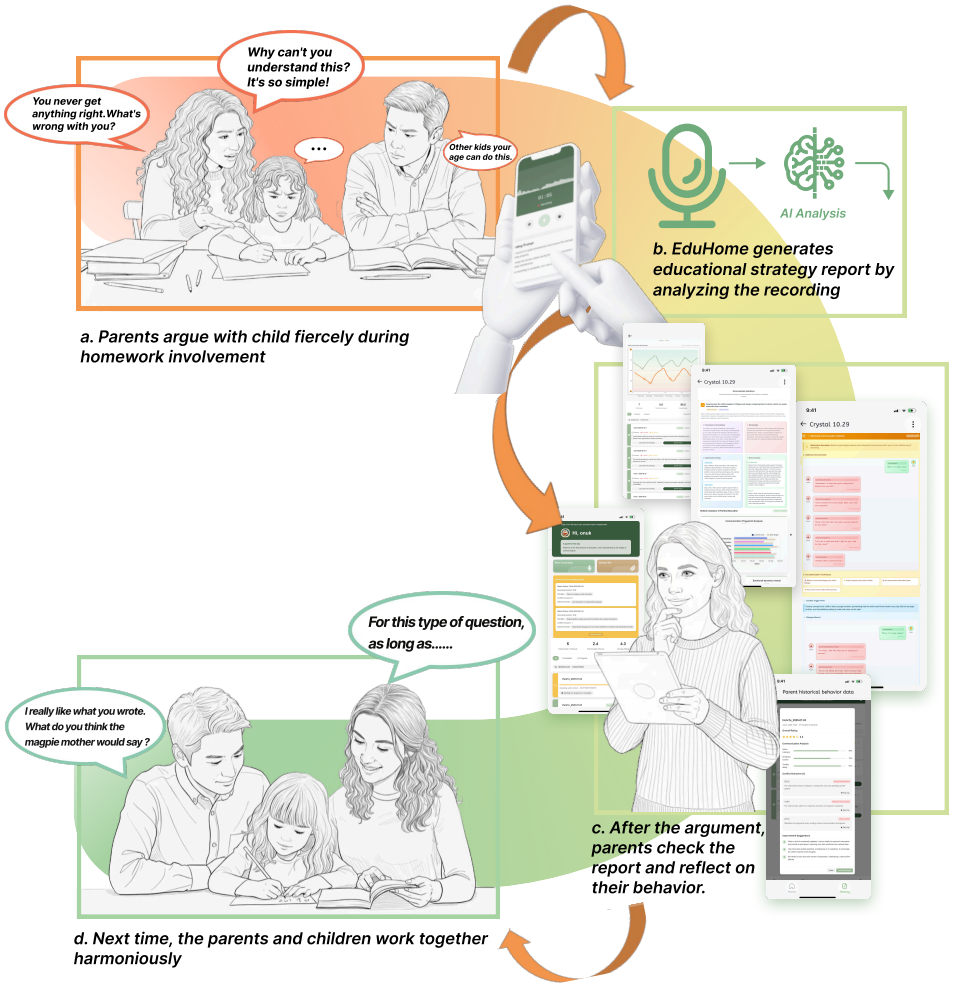


Fig. 1. An overview of the EduHome system for improving parent-child strategies during homework. EduHome transforms tense conflicts into constructive learning experiences through a reflective loop: (a) Parents and child engage in a heated argument during a typical homework session (b) The conversation is recorded, and EduHome's AI analyzes the interaction to generate a personalized educational strategy report. (c) After the argument, the parent reviews the report to reflect on their behavior. (d) By applying the system's guidance, the family achieves a harmonious and supportive dynamic in their next session.

parental involvement itself [22, 40, 42]. Parents' behaviours further affect children's homework emotions through self-confidence: positive parental affect has adaptive effects, whereas negative affect is transmitted as stress and resistance [34]. These dynamics carry real costs. Problematic strategies are linked to lower interest, reduced self-confidence, and strained parent–child relationships, and they can also harm parents' mental and physical health [21]. As one parent remarked, *"I feel like I could have a heart attack when tutoring my daughter."* Consistent with this, a survey of over 20,000 Chinese parents reported that nine in ten experienced emotional breakdowns during homework help and four in ten reported loss of control behaviors (e.g. , scolding or hitting); The media has also reported that in extreme cases, stress

from homework has been linked to serious health issues, like heart problems [1, 27, 37]. Repeated negative episodes can culminate in burnout for both parties and lasting damage to family well-being.

Improving parental education strategies is challenging despite their best intentions. Parents often find themselves in a predicament, striving to control their emotions yet struggling to avoid negative outbursts [28]. Waters et al. [55] found that emotion suppression by parents does not improve interactions with their children and may even have the opposite effect. Traditional methods for enhancing family education include counseling, reading books, attending workshops, taking online courses, joining support groups, and consulting with educators. Group-based methods like workshops and support groups, while more affordable, often provide general advice that may not be personalized to each family's unique situation. Individual-based methods, such as one-on-one counselling, offer specific suggestions but are typically more expensive and rely heavily on subjective self-reports from parents. Additionally, these traditional methods primarily serve parents who actively seek help, potentially missing those unaware of their need for assistance.

Unlike most studies that simply mimic educational expert consultants, are prone to subjectivity, recall bias, and gaps in information, as parents' self-reports are often incomplete and they may be unaware of their own problematic behaviors [6, 20, 46], we innovatively envision placing an intelligent educational expert within the home environment to objectively observe parent-child interactions. By utilizing large language models to analyze these interactions, we aim to formulate precise and customized family education strategies that reflect the actual dynamics and needs of the family, **without requiring additional effort from parents**. Our system was based on the following assumptions: *1. Obtaining objective, informative data from real-world scenarios helps develop effective education strategies, compared to subjective descriptions which may be prone to recall bias and incomplete information. 2. Audio recordings from real-world scenarios can be used to reconstruct what happens between parents and children.* Therefore, our research questions are as below: **RQ1:** From the perspectives of parents and experts, what educational strategies can help improve parents' mindsets and behaviors? **RQ2:** Based on our initial assumptions, how can we design this system?

In this research, we conducted a formative study with 4 parents to understand their motivations, needs, and expectations in improving their homework-related education practices with the *EduHome* system, and with 2 education experts to discuss their envision and thoughts about it. Informed by key findings from this study, we designed and implemented EduHome, an LLM-powered multi-agent system that analyzes audio recordings of homework interactions to provide parents with personalized, actionable strategies. To evaluate the accuracy and effectiveness of our system, we conducted a 4-week field study and recruited 20 parents to use this system. We observed their behaviour changes with the use of system. Then we conduct semi-structured interviews with three education experts and five parents. Additionally, we collected self-reports from 20 parents to assess the overall and per-module performance of the proposed strategies. Our work's contributions are as follows:

- We conducted a user study with *4* parents and *2* educational experts to elicit and delineate recurrent dilemmas in parent homework involvement. Building on the formative study, we have summarized six design guidelines for our system.
- We developed *EduHome*, a LLM-based multi-agent system that analyze in-situ parent homework involvement audio recordings to generates per-session multi-dimensional analytics and personalized, evidence-informed educational strategy.
- We conducted a field experiment with *20* parents *3* educational experts over *4 weeks* that evaluated our system. Participant feedback and usage outcomes provide direct evidence supporting the system's effectiveness in authentic parent homework involvement contexts.

2 Related Works

2.1 Chinese parental homework involvement

Parental homework involvement refers to parents' monitoring, supervision, and participation in their children's schoolwork and academic performance [41, 43]. This involvement is pervasive in China and tied to children's academic outcomes. Studies show that Chinese parents widely engage in homework supervision, with measurable impacts on student achievement [8, 9]. However, this influence is double-edged: supportive, autonomy-promoting help benefits children, while intrusive or misaligned assistance can impede performance and heighten parental stress. For instance, recent evidence finds that when parents provide constructive, autonomy-supportive homework help, children's motivation and grades improve, but over-control or unsolicited help predicts poorer achievement and increased anxiety for both generations [11, 57].

In seeking to assist their children, Chinese parents try different ways. Typically, they rely on broad, group-based guidance—e.g. , school lectures, teacher meetings, community parenting talks—which offer general advice but lack individualized targeting [26, 61]. Others pursue one-on-one solutions such as family education consultants or online forums, yet these avenues often yield subjective, anecdotal advice, incur high costs, and have limited generalizability across families [13, 60]. These shortcomings motivate our approach: by using recordings of real parent–child tutoring interactions, we can objectively reconstruct problematic homework-help dynamics and analyze patterns, answering calls for more direct evidence on how parental involvement unfolds and impacts learning [57].

2.2 Improving Family Education Strategy in Human-Computer Interaction

Researchers in HCI have explored diverse approaches to support and improve family education strategies. A variety of technological interventions have been designed to enhance parent–child learning experiences, including playful tangible systems and AI-driven tools. For example, prior work introduced image-based generative AI to facilitate family expressive arts therapy sessions [25], tangible interfaces to help children with special learning needs [2], and AI storytelling applications that flexibly involve parents in educational activities [59, 62]. Other efforts focused on aligning parental involvement with formal education: early studies examined tablet-based platforms and home–school technologies that help parents understand classroom teaching methods and stay coordinated with instruction [18, 47, 54], while recent innovations like EduChat demonstrated how an LLM-powered chatbot can offer personalized tutoring support for parents and children at home [6]. In addition, qualitative investigations have produced conceptual frameworks to guide effective parent mediation in children's use of educational media [54]. These frameworks identify key dimensions (e.g. , creative design of learning activities, preparative curation of resources, and administrative management of learning routines) that parents can play to foster learning with technology [54]. However, despite these advances, the specific context of parents assisting children with homework remains underexplored in HCI [58]. Only a few systems explicitly tackle real-time challenges of homework tutoring (e.g. a homework companion robot), leaving a notable gap in supporting this crucial aspect of family education [4, 52].

2.3 Persuasion for user behaviour change using LLMs

Persuasion is a psychological strategy aimed at influencing people's attitudes, beliefs, or behaviors, and language is a primary medium through which persuasive effects are achieved [14]. Persuasive approaches have proved effective across many domains—for instance, tailored messages in everyday contexts (e.g. , reducing unhealthy snacking) and mental health–related behavior change [17, 35]. In digital interventions, persuasion often takes the form of timely prompts

or reminders; applications commonly employ strategies such as feedback on one's usage behavior or context-aware notifications to nudge users toward desired actions [5, 24, 31]. Prior studies show that tailoring persuasive content to an individual's situation can significantly improve impact, and that just-in-time adaptive interventions (JITAIs) that vary message timing/content outperform static one-size-fits-all approaches over time [5, 17, 36].

The emergence of large language models (LLMs) such as ChatGPT and PaLM opens new possibilities for generating personalized, context-aware content at scale. Recent research in HCI and health has leveraged LLMs for a range of applications, including health information seeking, mental health support, personal health coaching, health education, and even public-health–oriented interventions [23, 45]. However, very little prior work has applied LLMs to just-in-time, context-sensitive interventions for behavior change in parenting scenarios [3, 52]. Our approach builds on this progress by using LLMs to generate timely and personalized persuasive messages that help parents adopt better educational practices with their children, providing adaptive support exactly when guidance is needed.

3 Co-Designing Educational Guidance: Insights from Experts and Parents

To determine the support forms and core functions that our system should provide in the context of parental homework involvement, we conducted semi-structured interviews with parents and educational experts. We hope to understand 1) Parents' behavioral drivers and inner states during homework tutoring, and how these precipitate educational conflict. 2) The essential components of an effective educational strategy—methods, timing, empathetic expression 3) The conditions and product form factors that enable parental behavior change and sustained use

3.1 Semi-structured Interviews

We purposefully recruited *four parents* and *two educational experts* (see Table 1) who are closely involved in homework tutoring and family education practice. Each participant was interviewed individually by a researcher for about 45–60 minutes via online audio/video conferencing.

The procedures of interviewing experts are as follows: We first introduce the purpose of this interview to the experts, and then demonstrate the early prototype of *EduHome* to them, eliciting the main research objects, so that the experts can have a more complete understanding. Then we proceed to a quantitative evaluation discussion (discussing experts' views on quantitative evaluation tools and methods) and a qualitative evaluation discussion (exploring experts' opinions and suggestions on qualitative evaluation). As for the parents who were invited to interview, some of them were selected from the subjects, and we showed them a systemically generated report on home education strategies for their respective families. While other parents were recruited, but we didn't provide them with an exclusive report. We just showed them samples. Both parents were asked questions about the effectiveness of the model, whether the system was helpful, what they liked or disliked, and so on. Since parents are the main users of our system, we pay special attention to the user experience of parents. The full semi-structured interview protocol is detailed in Appendix 5. Questions posted in interviews were included, but were not limited to:

(1) How do experts and parents view the use of parental homework involvement recordings to develop family education strategies? (Model Usability)
(2) What designs, functions, and considerations should be taken into account for such a system? (System Design)
(3) What elements should an effective education strategy include and exclude to improve parental education strategies and actions? (Strategy Design)

Table 1. Participant Information

ID	Role	Age	Gender	Occupation	Education	Child	Work Years	Discipline
P1	Parent	47	Female	Community worker	Bachelor	Boy, Grade 2 (8)	—	—
P2	Parent	37	Female	Business owner	Bachelor	Boy, Grade 3	—	—
P3	Parent	36	Female	Employee	Master+	Boy, Grade 1	—	—
P4	Parent	38	Female	Employee	High school	Girl, Grade 3	—	—
E1	Expert	28	Female	Research staff	—	—	5	Family education
E2	Expert	47	Female	School teacher	—	—	28	Mental health education

Table 2. Some interesting ideas about co-designing with parents and experts . We used open coding to deduce the themes.

Role	Participants' Ideas	Theme
Expert	This approach is more convenient than questionnaires or interviews and offers greater ecological validity.	Model Usability
Parent	Easier than consulting teachers or experts; less pressure and a more relaxed atmosphere.	Model Usability
Parent	Provides a clear path for reflection immediately after tutoring.	Model Usability
Expert	Beyond a single "solution", parents need empathy—to feel not alone and to see hope for their child.	Strategy Design
Expert	The goal is not to turn parents into teachers but to reduce conflict and anxiety; respond calmly when the child struggles.	Strategy Design
Parent	Generate personalized guidance tailored to each family's characteristics.	Strategy Design
Expert	Ground content in professional theory but avoid jargon that hinders readability.	System Design
Parent	Text-only output is dull; add AI voice and images to ease comprehension.	System Design
Parent	Add check-ins and sharing features to encourage continued use.	System Design

We followed up with additional questions based on participants' answers and, when applicable, asked them to share example materials (e.g. , prior strategy handouts, school guidelines, or screenshots of tools they use) to ground the discussion.

With consent, all interviews were audio-recorded and fully anonymized. Two researchers performed open coding and thematic analysis on transcripts. They first coded independently and then reconciled disagreements through discussion. We synthesized recurring themes about (i) the perceived *model* and its *usability*, (ii) the *system* functions and presentation that facilitate sustained use, and (iii) the *strategy* content and tone that make guidance actionable for parents. Representative quotes are labeled as P^* (parents) and E^* (experts). To ensure coding accuracy, they went through all transcriptions one more time.

3.2 Design Findings

Our semi-structured interviews informed three layers of design logic for *EduHome* (see Table 2 for representative quotes and themes). First, *System Design* distilled two principles from parent/expert needs—professionalism and readability (F1, F2). Second, *Model Usability* validated the recording-based modality and shaped the end-to-end workflow (F3). Third, *Strategy Design* translated these into actionable outputs—balancing empathy with guidance, returning to authentic dialogue, and personalizing profiles (F4–F6).

3.2.1 *System Design: Readability & Professionalism.*

F1. Use multimodal outputs to reduce reading burden. Heavy text creates cognitive load; parents preferred voice narration, pictorial cards, and lightweight formats to accelerate comprehension and execution (P2). Interventions should span text, images, video, and voice/phone counseling, and can include relaxation content and counseling tips to aid emotional reset (P1). Moderate theory helps, but jargon-dense content overwhelms. Timing is crucial—micro-prompts are most useful just before conflict escalates (P2).

F2. Build a professional knowledge base and a clear coding/evaluation system, and track interaction behaviors. Converting real-world errors into reusable knowledge requires a transparent taxonomy of educational problems, a dialogue behavior codebook, and an interpretable evaluation rubric (E1). Experts advised mechanism-first staging (motivation, emotion regulation, communicative structure) with iterative calibration, avoiding distraction by minutiae (E2). Participants noted current limits (recordings-only analysis; insufficient theory) and expected concise "reflection points" plus behavior trajectories and change curves to foster long-term self-efficacy (P1, P3).

3.2.2 *Model Usability.*

F3. Recording-based strategy generation is perceived as more situated and low-friction. Parents viewed homework-tutoring recordings as better reflecting everyday contexts than surveys or recall-based self-reports, with lower cost and entry barriers that support sustained use (P1, P2). Triangulation with expert counseling, homeroom teachers, and popular accounts/books suggested one-to-one specificity, low time/financial cost, and strong structure—substituting for help that is hard to ask for or access (P2, P3). Experts noted the "recordings-to-strategies" pipeline is smoother than questionnaires or single interviews and better captures daily ecology (E1). Parents also mentioned potential defensiveness during recording and limited coverage (P1, E1), motivating modality/scope refinements.

3.2.3 *Strategy Design: Effective, Empathic, and Personalized.*

F4. Balance empathy with guidance. Interventions should help parents feel seen and understood before delivering precise, executable guidance. The report felt "affirming yet emotionally cold"; adding reassurance and contextualization may reduce isolation, anxiety, and conflict intensity (E1). Experts recommended staged presentation, focusing on the most severe issues and attending to children's emotions rather than behaviors alone (E2). Parents wanted just-in-time prompts at incipient inflection points and more granular, plain-language strategies (P2), while cautioning against overly long empathic sections (P3).

F5. Return to the dialogue itself. Compared with abstract advice, analysis and rewrites grounded in authentic dialogue segments were more persuasive and learnable. Experts suggested replaying parent utterances and offering case trajectories/turning points with causal explanations (e.g. , the "curse of knowledge") (E1). Parents found the generated dialogue guidance effective (P4), while noting the need to broaden the repertoire of recognized behaviors and conflicts (P1).

F6. Construct personalized family profiles. Parents judged current strategies too generic (P1, P4) and stressed profiling both parents and children—their personalities and interaction patterns (P2, P4). Experts expected increasingly precise profiles as more recordings accumulate (E2), motivating memory-based personalization for strategy content and timing.

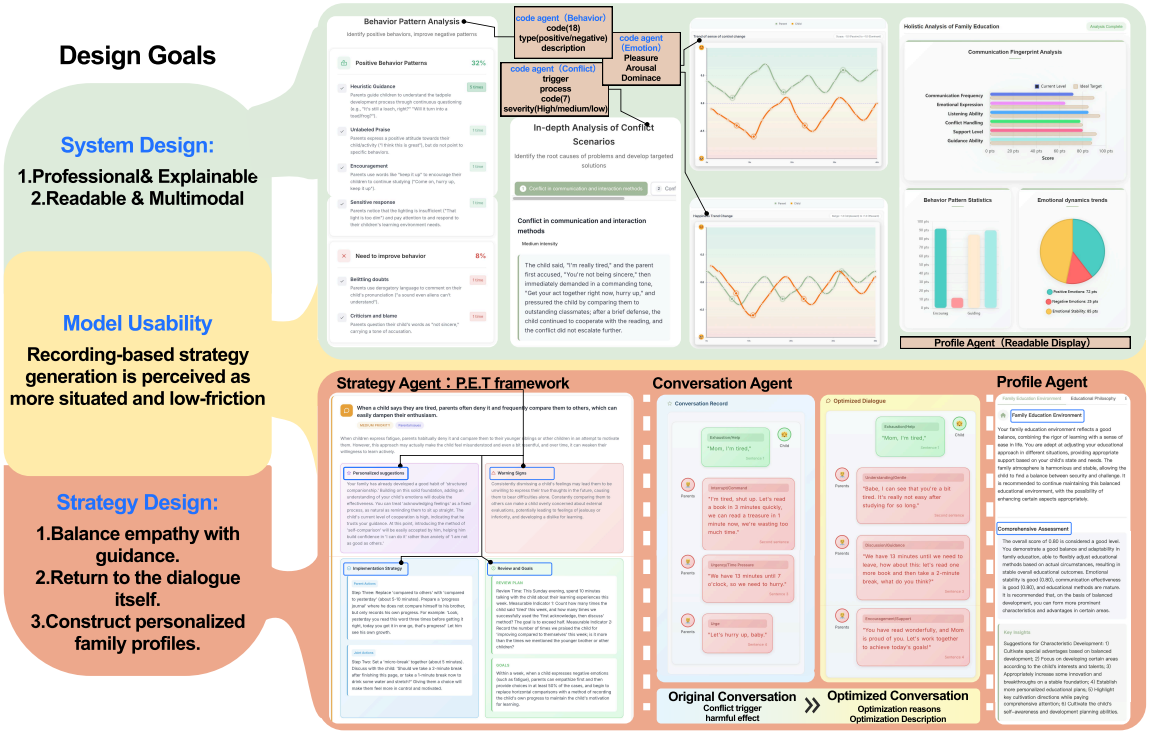


Fig. 2. The design of *EduHome* inspired by key findings, including four agents and their presentation forms: (1) **Code Agent** panels visualize conflict codes, behavior codes, and emotion(Pleasure,Arousal,Dominance); (2) **Conversation Agent** panels show contrastive dialogue rewrites, prompts, and turn-taking cues; (3) **Profile Agent** panels present personalized family profiles with short-/long-term signals; (4) **Strategy Agent** panels deliver tailored, actionable plans with stepwise guidance.

4 EduHome: Design and Implementation

Grounded in the strong evidence that parents' homework involvements profiling the family education environments, and informed by key findings from our formative study, we implement *EduHome* as an LLM-powered multi-agent system. As shown in Fig. 3, we first derive the end-to-end interaction flow following the "recordings-to-strategies" model (F3), Building on these findings, we architect four collaborating agents, and Fig. 2 depicts the overall system design and the presentation of each module.

We then instantiate four core agents: **Code Agent** (F1, F2). Building on prior work by Nan et al. [10], the Code Agent analyzes recordings to quantify conflict events, interaction behaviors, and affective states, and visualizes parent–child dynamics over time. **Conversation Agent** (F4, F5). Using the analyzed recordings, this agent provides conversational scaffolds, such as contrastive rewrites, prompts, and turn-taking cues, to help parents communicate more effectively with their children. **Profile Agent** (F2, F6). This agent maintains a personalized family profile that integrates short- and long-term signals, enabling situation-aware recommendations and progress tracking. **Strategy Agent** (F2, F4, F6). For each family and each uploaded recording, this agent generates tailored, actionable strategies grounded in context, coupling problem identification with feasible next steps.

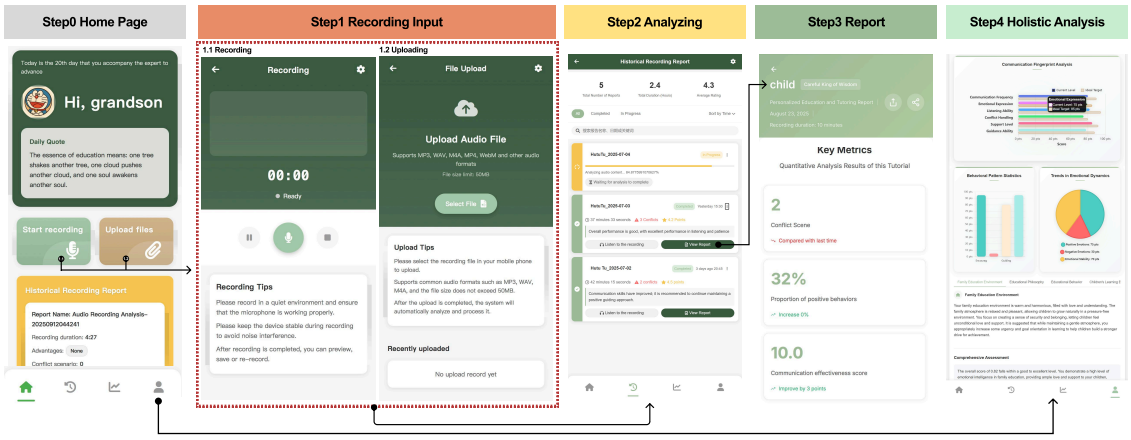


Fig. 3. Interaction Workflow: This figure illustrates the end-to-end user journey within the EduHome system, from data input to receiving analytical feedback. The process begins on the Home Page (Step 0), where a parent can either start a new recording or upload an existing audio file of a homework session (Step 1). After submission, the system displays the progress of analysis (Step 2). Once completed, the parent can review a detailed, session-specific Report (Step 3), which includes different parts. Finally, the Holistic Analysis (Step 4) provides a comprehensive dashboard with visualizations in different domains

4.1 Code Agent: Perception and Quantification

As the system's perception layer, the Code Agent quantifies parent-child interactions during homework tutoring and renders them interpretable for parents. Instead of subjective observation, it operationalizes a structured coding theory to convert interactions into analyzable data. Building on prior coding schemes for homework tutoring by Nan [10], we model three dimensions: conflict, behavior, and emotion. The codebook covers seven conflict types, eighteen behavior codes, and the PAD dimensions .

For conflict, we record the trigger, the content of conflict, and the severity. This event-level decomposition reconstructs the tutoring episode and supports the Conversation Agent in dialogue segmentation for downstream analysis and feedback. For behavior, we group codes into positive, neutral, and negative categories while retaining fine-grained subcodes. For emotion, we adopt PAD: Pleasure (affective valence indicating overall family well-being during tutoring), Arousal (activation level indexing tension vs. relaxation), and Dominance (sense of control used to detect potential overcontrol). The consolidated codebook appears in Table 6, and the placement of the Code Agent within the system is illustrated in Fig. 2.

4.2 Conversation Agent: Analysis of Parent-Child Communication Dialogue

This module converts high-tension homework tutoring dialogue into a reflective workflow that is audible, diagnosable, and rewritable, helping parents identify communication blind spots (e.g. , the "curse of knowledge" where parents repeat explanations without recognizing the child's incomplete understanding). Leveraging conflict segments extracted by the Code Agent, the system segments and annotates the original recording so that parents can relisten to their tone and review interactional details. By analyzing how emotional contagion and conversational structure contribute to escalation, the module then produces improved dialogue: clear rewrites and step-by-step exemplars that teach concrete techniques for more effective communication and a better grasp of the child's needs (see Fig. 2).

Table 3. Four-dimensional dynamic profile: scope, representative signals, and update cadence.

Dimension	Scope	Representative Signals / Update Cadence
Family Environment	Home routines, study setting, stressors	Noise/interruptions, routine stability, support resources; slow drift (LT)
Child Behaviors	Task engagement, self-regulation, help-seeking	On-task ratio, delay/avoidance, repair attempts; session-level (ST), trend (LT)
Parental Beliefs	Expectations, values, efficacy beliefs	Goal alignment, autonomy/discipline stance; slow drift (LT)
Parental Behaviors	Interaction style, scaffolding, emotion work	Behavior-code mix, PAD trajectories, repair moves; session-level (ST)

4.3 Profile Agent: Parent–Child Portrait Modeling

To more accurately capture the personalized characteristics of parent–child interactions, the Profile Agent builds an educational profile for each family that uploads recordings. As shown in Fig. 2 (Profile panel), the profile spans four dimensions: family education environment, child learning behaviors, parental beliefs, and parental behaviors. It fuses current session signals with historical trends to ground personalized strategy generation.

The profile agent operates on a dual-scale memory architecture that integrates long-term "climate" trajectories with short-term session signals (e.g., conflicts, behaviors, emotions). This long-term/short-term (LT/ST) split is visualized in the Profile panel of Fig.2, with a detailed summary of its dimensions provided in Table3. Repeated uploads progressively densify this longitudinal record, enabling week-over-week analyses such as tracking affective shifts and conflict reduction.

Technically, the agent is built upon a Mem0-backed vector database. This memory layer supports atomic storage across diverse data types, including behavioral scenes, emotional summaries, insight logs, and user-profile entries. Text content is embedded using a high-capacity model and retrieved through a similarity search, which is weighted by a recency-aware time-decay function to prioritize recent sessions. This mechanism ensures the profile remains historically grounded while being highly sensitive to the current session.

4.4 Strategy Agent: Generate Professional Education Strategy Based on P.E.T Framework

This module aims to generate actionable and personalized strategies. In contrast to generic, theory-heavy advice, the PET Strategy Agent operationalizes the Parent Effectiveness Training (P.E.T.) framework and integrates three data sources: (i) a RAG/MCP knowledge base grounded in P.E.T., which includes curated strategies and exemplar phrasings, augmented via MCP connectors (Context7, WebResearch) for vetted external knowledge; (ii) long-horizon *history memory* from the Memory Agent; and (iii) the *current context*, including fine-grained analysis of the present session and representative dialogue excerpts.

The agent produces specific, executable, and measurable strategies organized into four parts: **personalized recommendations**, **step-by-step implementation**, **long-term goals**, and **warning signals**, see Fig. 3. Each strategy is decomposed into small, immediately performable steps with observable criteria and progress checkpoints, tailored to the family profile to avoid one-size-fits-all guidance. Grounded in mature P.E.T. mechanisms, the module emphasizes practical utility while maintaining theoretical level.

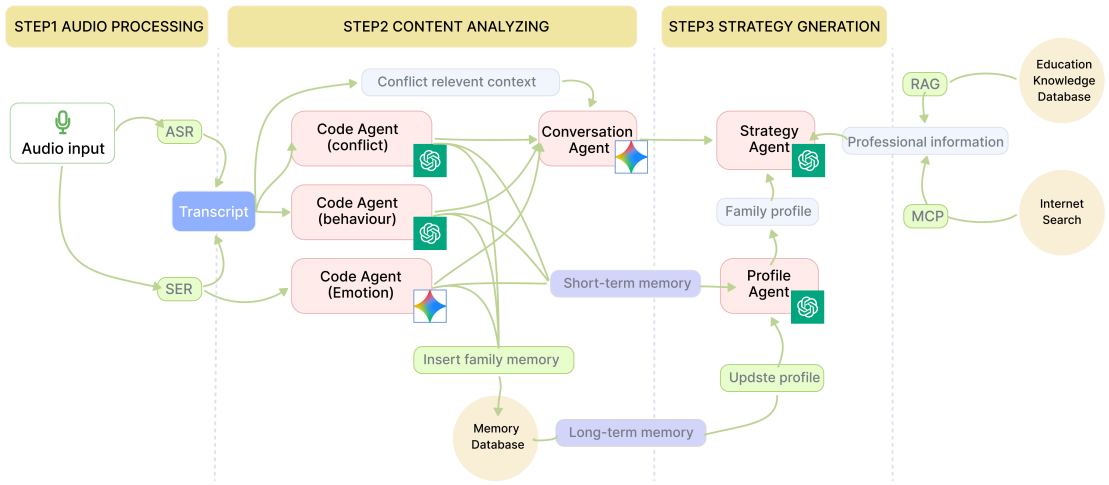


Fig. 4. The multi-agent system implementation of EduHome. This diagram shows the EduHome pipeline, which transforms raw audio of parent-child interactions into personalized strategies. Initially, audio is processed via ASR and SER. The Code and Conversation Agents then analyze the resulting data, updating a family memory store. Based on this memory, the Profile Agent builds a dynamic family profile. Finally, the Strategy Agent synthesizes this profile with professional knowledge, retrieved via RAG/MCP from database, to generate tailored, actionable guidance for parents.

4.5 Implementation

4.5.1 Workflow. EduHome is an LLM-based multi-agent system (as shown in Figure 4). The collaboration pipeline is as follows. First, when a parent uploads a homework-tutoring recording, the backend applies automatic speech recognition (ASR) to obtain a transcript, then performs speaker diarization and role assignment (parent vs. child), filler-word filtering, and other preprocessing to produce a clean, time-stamped, speaker-attributed transcript. Next, in the content analysis stage, the transcript is processed by the Code Agent to code conflicts and behaviors, and—together with the raw audio—runs speech emotion recognition (SER) to estimate pleasure, arousal, and dominance (PAD), yielding three time-series curves. Based on the conflict outputs, the system locates the corresponding segments and hands them to the Conversation Agent, which diagnoses likely causes and rewrites the problematic exchanges into improved alternatives. Before being committed to the family memory store (which maintains both episodic and semantic memories), each analysis is compared against existing entries; any content that duplicates prior memories is filtered so that only novel information is saved. After each analysis, the Profile Agent updates the family profile. Finally, in the strategy generation stage, the Strategy Agent retrieves from the internal professional knowledge base and conducts web search if needed; guided by the Parent Effectiveness Training (P.E.T.) framework and conditioned on the family-specific traits returned by the Profile Agent, it composes actionable strategies.

4.5.2 Client-Side Implementation. EduHome adopts a client–server separation to deliver personalized strategy generation. On the client side, we implement a Progressive Web App (PWA) that can be installed on mobile devices or accessed directly via the browser, offering an app-like experience from a single codebase [30, 33]. Guided by Figma design specifications, the front end realizes the core interactions introduced earlier, including recording parent–child conversations, uploading audio, viewing analysis reports, and completing daily check-ins. To present multimodal data,

we render interactive visualizations with the HTML Canvas API, enabling responsive, animation-ready charts and timelines suitable for in-situ exploration [29, 56].

4.5.3 Server-Side Implementation. The backend is implemented in Python with FastAPI [44], exposing stateless APIs and background workers. We use Supabase to persist usage logs and artifacts [50]. For core inference, the system integrates OpenAI's GPT-4o API with function-calling to obtain structured outputs [38]. In the Conversation Agent and other long-context scenarios, We employ Google's Gemini 2.5 Pro, leveraging its extended context window and multimodal input capabilities to enhance dialogue analysis and summarization. [12]. The Strategy Agent uses OpenAI's `text-embedding-3-large` to power Retrieval-Augmented Generation (RAG) over our curated knowledge base [19, 39]. The Profile Agent relies on the open-source Mem0 atomic memory store to maintain family-specific profiles [32]. Our knowledge base aggregates authoritative pedagogical resources, including expert-authored books, recorded lectures, and anonymized counseling cases.

5 User Study

We conducted a user study to evaluate EduHome's effectiveness and usability in supporting parents in read-world situations. This user study focused on the following three questions to evaluate our system:

(1) **EQ1:** Does EduHome improve parents' behaviors during homework involvement? (Section6.1)
(2) **EQ2:** In what ways is EduHome helpful to parents? (Section6.2)
(3) **EQ3:** How do parents perceive EduHome? (Section6.3)

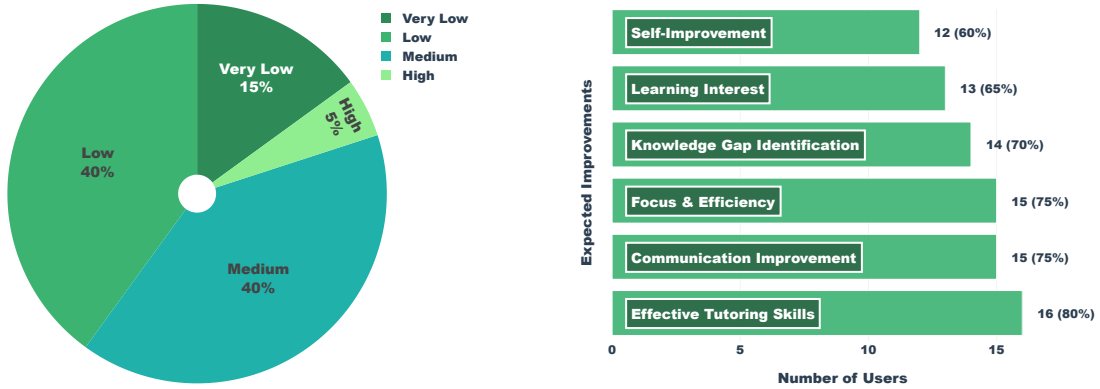
Over one month, parents from 20 distinct families and 3 educational experts participated. We assessed real-world use through questionnaires, semi-structured interviews, in-app feedback, and backend telemetry. The Human Research Ethics Committee at our University has approved the study, and all the procedures strictly follow the ethical codes. Besides, we anonymized all the participants to protect their privacy.

5.1 Participants

We disseminated recruitment materials via social media and parent group chats, and administered a questionnaire to identify parents who regularly tutor their children's homework and are motivated to improve their tutoring behaviors. In addition to basic demographics, the survey collected family's basic condition and parents' attitude toward homework involvement; we excluded parents who (1) reported fewer than three homework-tutoring sessions per week, or (2) had children outside grades 1–3, or (3) expressed no intention to improve tutoring behaviors. We adopted a rolling deployment [15] and formed two cohorts (7 and 20 parents), each using the system for two weeks. In the first pilot cohort, 5 of 7 parents met the usage threshold, with one reporting no tutoring due to time constraints and another having sessions too short to yield usable recordings; in the second cohort, 20 parents were enrolled and 15 actively used the system. Parents who met inclusion criteria and completed the feedback questionnaire received a $15 stipend, and those who participated in the exit interview received an additional $15/hour; we also recruited three educational experts (one professional researcher and two primary school teachers) to provide professional assessments.

5.2 Procedure

We evaluate the EduHome from two key perspectives: (1) the parent perspective, which assesses the accuracy, effectiveness, and overall satisfaction with each module and dimension of the system. and (2) the expert perspective, which



(a) Emotional State During Tutoring (N=20)

(b) User Expectations

Fig. 5. Emotional states and user expectations during tutoring.

focuses on ensuring that the report content is scientifically rigorous, aligns with educational theories, is suitable for parents to understand and implement, and contains no inappropriate or risky content;

For parent, each participation began with a pre-study questionnaire to assess their current homework-tutoring practices. This was followed by a two-week usage period, during which parents were required to upload at least three tutoring recordings (10-60 minutes each) and rate the system's generated report included four modules after every session. To ensure system quality, we implemented a rolling deployment schedule [15], using feedback from the first cohort to stabilize and improve the system for the second, who followed the identical experimental protocol. At the end of the two weeks, parents completed a final evaluation questionnaire, and those with more than five recordings were invited to a semi-structured exit interview, with five participating.

For experts, we engaged three educational experts to evaluate the generated education strategies. Given the large number of reports, we randomly selected five reports and their corresponding audio recordings for each expert. The experts were asked to listen to the original audio and review the generated reports. Following this, we conducted semi-structured interviews with the experts to gather their insights.

5.3 Evaluation Metrics

5.3.1 Questionnaires. To establish a baseline prior to the study, we first surveyed parents about their homework-tutoring practices, including tutoring frequency, satisfaction with the process and outcomes(Figure 6), their typical emotional state during tutoring (angry to pleased), and the kinds of support they expected from the system(Figure 5).

After the user studies, we invited parents to provide feedback on the system. The questionnaire was designed using the *Kirkpatrick Model* [48], a widely recognized framework for evaluating the effectiveness of educational programs. The questions were structured around the model's four levels: *Reaction*, *Learning*, *Behavior*, and *Results*. *Reaction* gauged parents' overall feelings about the strategies, while *Learning* assessed what they gained, particularly in educational methods and family interaction skills. *Behavior* evaluated the application of strategies in daily life and their impact, using predictive questions to explore potential changes and expectations. Finally, *Results* examined the anticipated long-term impact on family relationships and the child's academic performance, assessing parents' expectations and confidence in the strategies. The questionnaire is detailed in Table 4. In addition to the overall evaluation, parents were

Fig. 6. Pre-System User Attitudes and Current Tutoring Status (N=20).

asked two specific questions for each of the six modules in the report: 1) *To what extent do you think the [Module Name] accurately reflects your daily interactions with your child? (Likert scale: Completely inaccurate to Completely accurate)* 2) *To what extent do you think the [Module Name] helps improve your involvement and effectiveness in assisting your child with homework? (Likert scale: Not helpful at all to Very helpful).* Overall,20 parents completed the questionnaires.

5.3.2 Semi-structured interviews. To deepen and contextualize the questionnaire findings, we conducted semi-structured interviews with two groups. With educational experts, we focused on content accuracy and scientific validity, the applicability and feasibility of the strategies, sensitivity and ethical considerations, and overall quality and improvement suggestions. The predefined expert interview protocol appears in Appendix A.2. As for parents (five participants), the interviews focused on the following key topics: Understanding and practicality of the report content, Module feedback and experience, Behavioral change and conceptual shift, Impact and results, and Suggestions for report improvement. The predefined interview questions are provided in Appendix A.3.

5.3.3 Usage data and module-level feedback. To triangulate self-reports with behavioral evidence over a one-month deployment, we collected two complementary data streams. First, parents provided module-level ratings along three dimensions using Likert scales: (a) **content authenticity**—the extent to which [Module Name] reflects daily parent–child interactions (Completely inaccurate → Completely accurate); (b) **content comprehensibility**—the extent to which the content of [Module Name] is fully understood (Fully understand → Do not understand at all); and (c) **module usefulness**—the extent to which [Module Name] helps improve parental involvement and effectiveness in homework assistance (Not helpful at all → Very helpful). Second, the backend logged system-derived indicators from each recording: (a) conflict metrics (e.g. , total counts by conflict category based on coding), and (b) key behavioral metrics (e.g. , frequencies of positive and negative tutoring behaviors identified through coding). A reference schema is shown in Table 6.

6 Results

We present findings from our mixed-method evaluation, organized around our three evaluation questions (EQ1–EQ3). Results are based on coded behavioral data ($N = 649$), conflict episodes ($N = 341$), longitudinal reports from parents, post-system surveys ($N = 20$), and expert reviews.

Table 4. Questionnaire for collecting parent feedback on the educational strategy report

Level	Dimension	Questions	Likert scale
Reaction	Overall Satisfaction	How satisfied are you with the overall educational strategies in the report?	Very dissatisfied to Very satisfied
	Report Accuracy	Does the report's analysis accurately reflect your interaction with your child?	Very inaccurate to Very accurate
	Strategy Relevance	Are these strategies relevant to your and your child's actual situation?	Very irrelevant to Very relevant
Learning	Self-Efficacy	How confident are you in implementing the suggested educational strategies?	Not confident at all to Very confident
	Learning Effectiveness	Did you learn new educational methods or techniques from the report?	Learned nothing new to Learned a lot
	Knowledge Growth	Did the knowledge or strategies change your views on family education?	No change at all to Significant change
Behavior	Feasibility	How easy do you think it is to integrate these strategies into your daily life?	Very difficult to Very easy
	Behavioral Change	Will these suggestions help you change how you assist your child with homework?	Not helpful at all to Very helpful
		How do you plan to apply these strategies in the next few weeks?	N/A (Open-ended question)
		What behavioural changes do you expect if you strictly follow the strategies?	N/A (Open-ended question)
Results	Educational Beliefs	How much will these strategies help change your beliefs about family education?	Not helpful at all to Very helpful
	Academic Performance	How much do you expect these strategies to improve child's academic performance?	No impact at all to Very impactful
	Family Relationship	How much do you expect these strategies to improve your family relationships?	No impact at all to Very impactful
	Parent-Child Commun.	How much will these strategies help improve communication with your child?	Not helpful at all to Very helpful
	Others	After applying these strategies, what specific results do you hope to see?	N/A (Open-ended question)

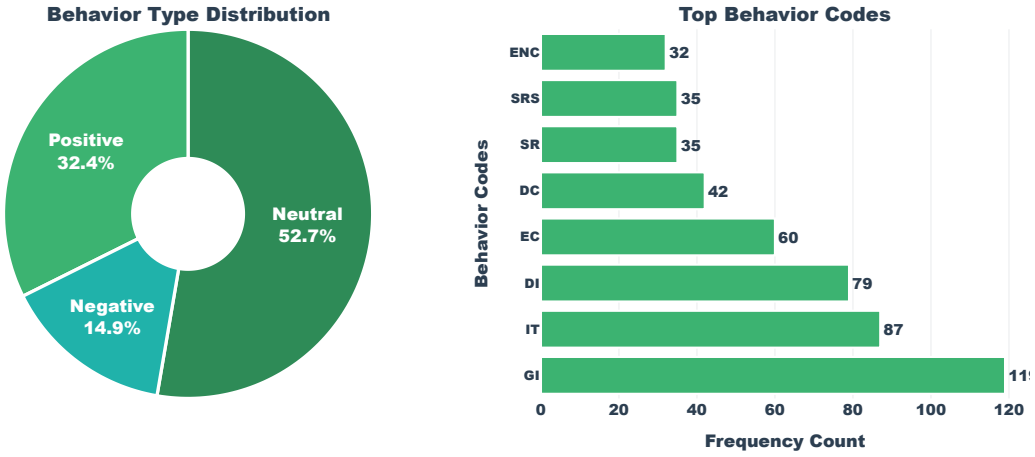


Fig. 7. Distribution of user behavioral patterns and frequencies of specific behavior codes (N=649). Codes: ENC = Encouragement, SRS = Sensitive Response, SR = Setting Rules, DC = Direct Command, EC = Error Correction, DI = Direct Instruction, IT = Information Teaching, GI = Guided Inquiry. The complete code book for behaviors is provided in the Appendix (Section A.4).

6.1 Changes in Parent Behaviors and Conflicts

We first examine whether EduHome influenced parents' tutoring behaviors and parent–child conflicts. As shown in Figure 7, neutral behaviors dominated overall interactions (52.7%), followed by positive (32.4%) and negative behaviors (14.9%). The most frequent strategies included guided inquiry (111 instances), information teaching (87), and direct instruction (79), while emotionally supportive behaviors such as encouragement (32) and sensitive responses (35) were less common. This suggests parents prioritized instructional over affective support.

Conflict analysis revealed that *knowledge gap* conflicts were the most frequent (100 instances), followed by *learning process* (67) and *rules and control* (67), with the latter being the most likely to escalate into high-severity episodes (14 cases) (Figure 8). Communication-related conflicts were less frequent overall but occasionally reached high severity, indicating risks when miscommunication amplified tensions.

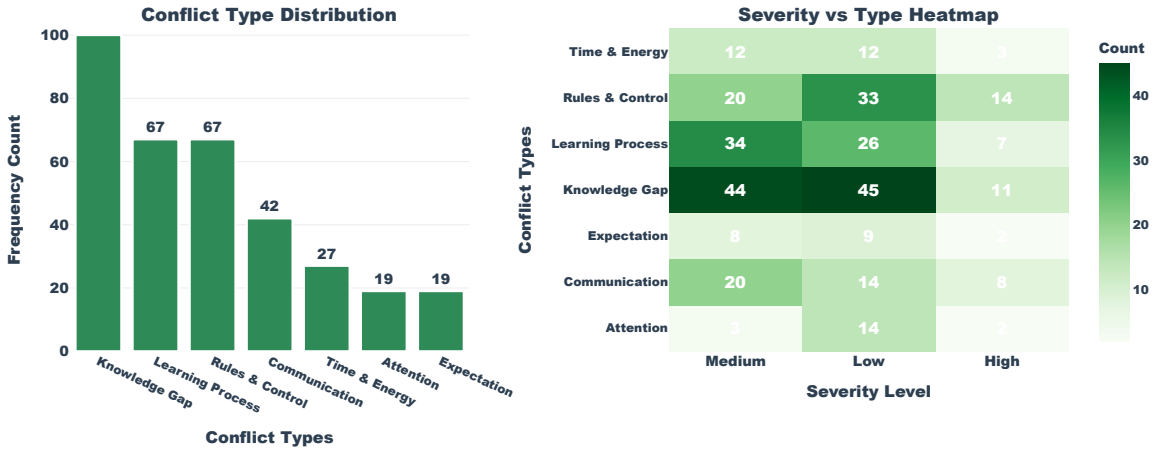


Fig. 8. Distribution of conflict types and their severity levels (N=341). Each conflict type is rated across three severity levels: Low, Medium, and High. The complete code book for conflicts is provided in the Appendix (Section A.4).

Fig. 9. Sankey diagrams of user behavior and conflict flows before and after system use.

Longitudinal analyses further demonstrated reductions in both negative behaviors and conflicts after system use. Figure 9 shows that the proportion of parents ending with negative behaviors decreased from 28 to 13, while those exhibiting neutral or positive behaviors increased. Similarly, high-severity conflicts reduced from 18 to 5. At the individual level, Figure 10 illustrates that 9 out of 14 parents reduced their proportion of negative behaviors, while 11 out of 11 parents with multiple reports experienced decreases in conflict frequency. This indicates that EduHome was particularly effective at mitigating conflicts, although behavioral improvements showed individual variability.

6.2 Perceived Usefulness of System Modules

We next analyze how parents evaluated the different system modules. As shown in Figure 11, ratings across all modules were generally high (range 4.00–4.74). The *Profile* module scored highest on authenticity (M=4.61) but lowest on usefulness (M=4.13). The *Conversation* module was valued for authenticity (M=4.63) and usefulness (M=4.43), though

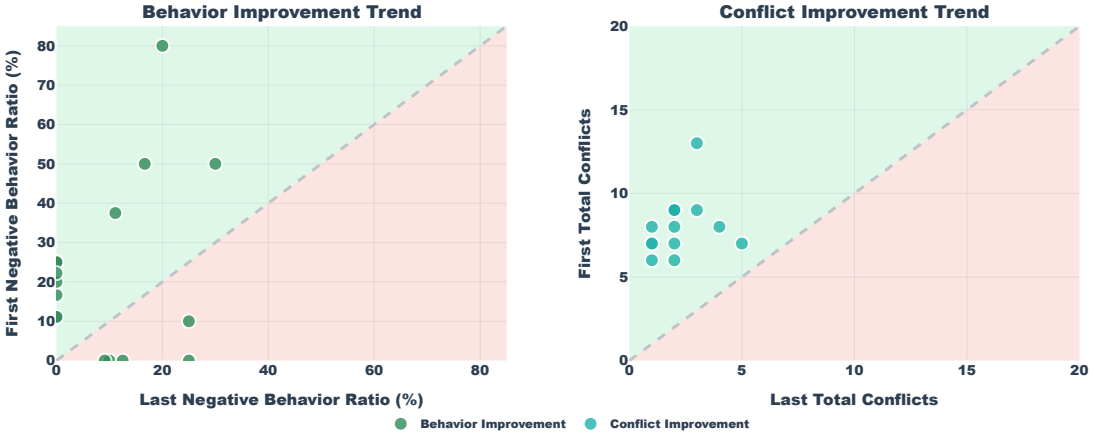


Fig. 10. Improvement trends of user behaviors and conflicts, based on first vs. last reports.

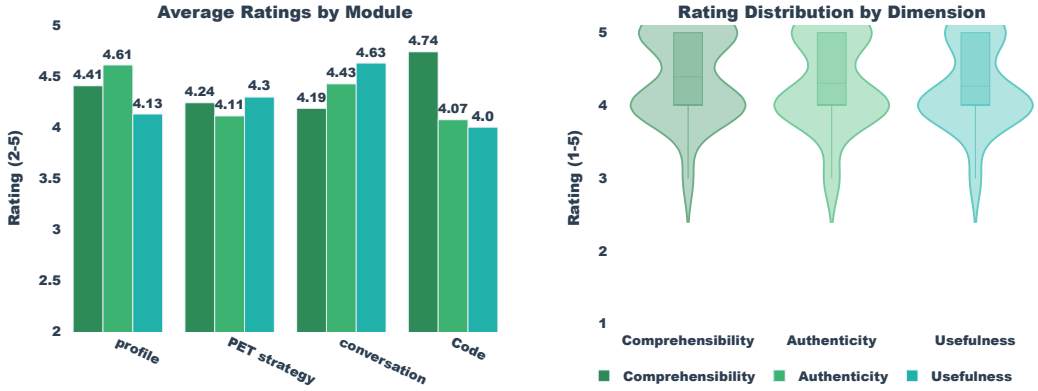


Fig. 11. User ratings of report modules (Profile, PET Strategy, Conversation, Code) across three dimensions: Comprehensibility, Authenticity, and Usefulness.

perceived as slightly harder to comprehend (M=4.19). The *Code* module achieved the highest comprehensibility (M=4.74) but received lower scores for authenticity (M=4.07) and usefulness (M=4.00). The *PET Strategy* module received balanced scores across all dimensions (4.11–4.30). Distributional patterns further show that comprehensibility and authenticity clustered around 4–5, whereas usefulness displayed a wider spread, suggesting room for improvement in practical applicability.

6.3 Overall Satisfaction and Perceived Impact

Finally, we examine parents' post-system evaluations (Q1–Q15; see Appendix 7 for full items). As illustrated in Figure 12, overall satisfaction was high (M=4.18/5). Parents most strongly agreed that the reports helped them learn new methods (Q5, M=4.35), change their tutoring practices (Q8, M=4.35), and improve communication with their children (Q12, M=4.35). Lower ratings were given to shifts in educational beliefs (Q6, M=3.95) and anticipated impacts on academic performance (Q10, M=3.90).

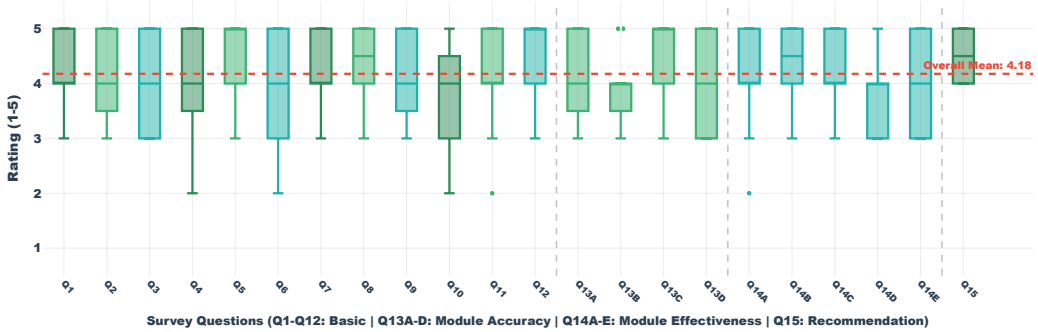


Fig. 12. Post-system satisfaction ratings (Q1–Q15), covering strategy evaluation, perceived impact, module accuracy/effectiveness, and recommendation intention (N=20). The complete questionnaire items are provided in Appendix Table 7.

Module-specific evaluations indicated that *conflict/behavior identification* (Q13C, M=4.40) was perceived as the most accurate reflection of daily interactions, while *family profile* (Q13B) and *PET strategy guidance* (Q13D) scored lower (M=3.95). In terms of effectiveness, the *communication module* (Q14B, M=4.35) and *panoramic overview* (Q14A, M=4.25) were most highly valued, whereas *personalized tips* (Q14D, M=3.85) and *long-term navigation* (Q14E, M=3.95) were perceived as less impactful. Importantly, parents expressed strong willingness to recommend EduHome to others (Q15, M=4.50), underscoring the overall acceptance of the system.

In summary, EduHome effectively reduced conflict frequency and severity while encouraging more constructive parent–child interactions. Parents perceived the system as reliable, comprehensible, and helpful, particularly in improving communication and tutoring practices. However, anticipated academic impacts and the perceived usefulness of certain modules (e.g. , personalized tips, long-term guidance) remain areas for refinement.

7 Discussion

7.1 Understanding Parent–Child Tutoring Dynamics

Our findings shed light on the fine-grained dynamics of parent–child tutoring at home, revealing both the dominant patterns and the underexplored dimensions of everyday interactions. Across coded behaviors and topic modeling, we observed that parents primarily emphasized *task completion* (24.2%) and *inspiring guidance* (21.8%), together accounting for nearly half of all interactions (Figure 13). This indicates that while parents often adopt pragmatic strategies to ensure progress, they also attempt to engage children in exploratory thinking through questions and perspective-taking. Such a dual emphasis highlights that parental tutoring is not purely instructional but integrates elements of scaffolding, aligning with prior work on dialogic learning. However, our data also reveal that explicit *feedback mechanisms* were comparatively rare (15.8%), with limited use of encouragement and constructive error correction. This imbalance suggests a gap between cognitive guidance and affective support, which may hinder children's motivation and resilience.

Linguistic analysis further differentiates interaction styles. Positive behaviors were characterized by terms such as "encourage," "inspire," and "question," underscoring the role of dialogic prompts in sustaining engagement. Neutral behaviors, dominated by words like "complete," "direct," and "explain," reflected a more task-driven and rule-oriented approach with limited emotional tone. Negative behaviors included language such as "disappoint," "criticize," and "impatient," signaling emotionally charged communication that risks escalating tensions. These lexical distinctions, as

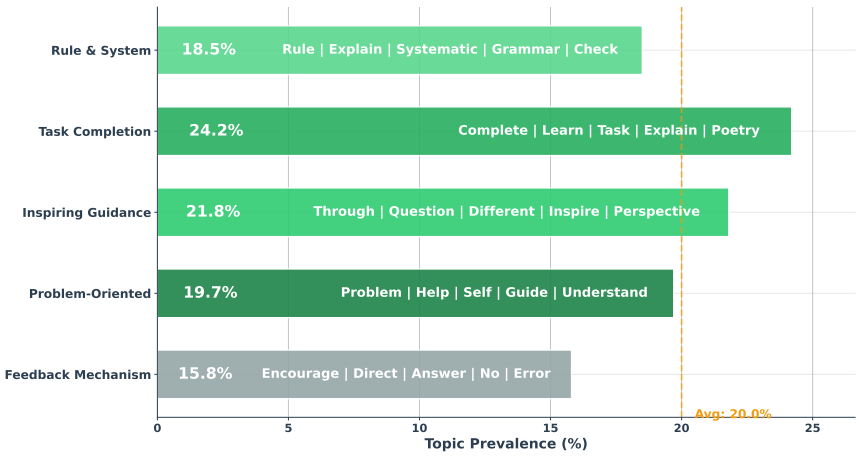


Fig. 13. Topic Distribution in Parent-Child Interactions

visualized in our TF-IDF keyword analysis (Figure 14), provide an empirical contribution by linking linguistic markers to affective and instructional orientations, offering the HCI and education communities new evidence on how micro-level communication choices shape the quality of tutoring interactions.

Importantly, we found that affective support is underrepresented: encouragement accounted for only 32 instances out of 649 coded behaviors, and sensitive responses only 35. At the same time, conflicts were most often triggered by *knowledge gaps* (29.3%), with rule-related disagreements most likely to escalate to high severity. Together, these results suggest that insufficient affective scaffolding may amplify the risk of conflict, particularly when cognitive challenges arise. For HCI researchers, this underscores the importance of designing systems that do not solely provide informational or instructional guidance but also help parents recognize and respond to the emotional dimensions of tutoring. In practice, interventions should promote both cognitive strategies (e.g. , guided inquiry) and affective strategies (e.g. , encouragement and patience) to balance learning progress with emotional well-being.

7.2 Design Implications for Parent Support Systems

Our findings from the design and evaluation of **EduHome** offer critical insights for the future development of parent support systems. We distill these into two key design implications that move beyond surface-level features to address the core psychological and behavioral needs of parents.

7.2.1 The Balance between "Technology" and "Human Touch": Personalization and Emotional Support. Research indicates that parents assisting with homework need not only methodological guidance but also emotional support and empathy. However, traditional approaches that offer generic advice, such as books and lectures, often lack personalization and emotional care. **EduHome**, by analyzing real audio conversations, not only provides strategies but also reconstructs dialogue scenarios, allowing parents to "see" their own emotions and behaviors, which in itself constitutes a deeper form of empathy and support.

The system acts as an "empathetic partner", addressing users' deep emotional needs to be seen and understood. The semi-structured interviews with both parents and experts underscored the importance of this balance between empathy and guidance. They articulated a clear need for systems that feel supportive rather than "cold and clinical." This

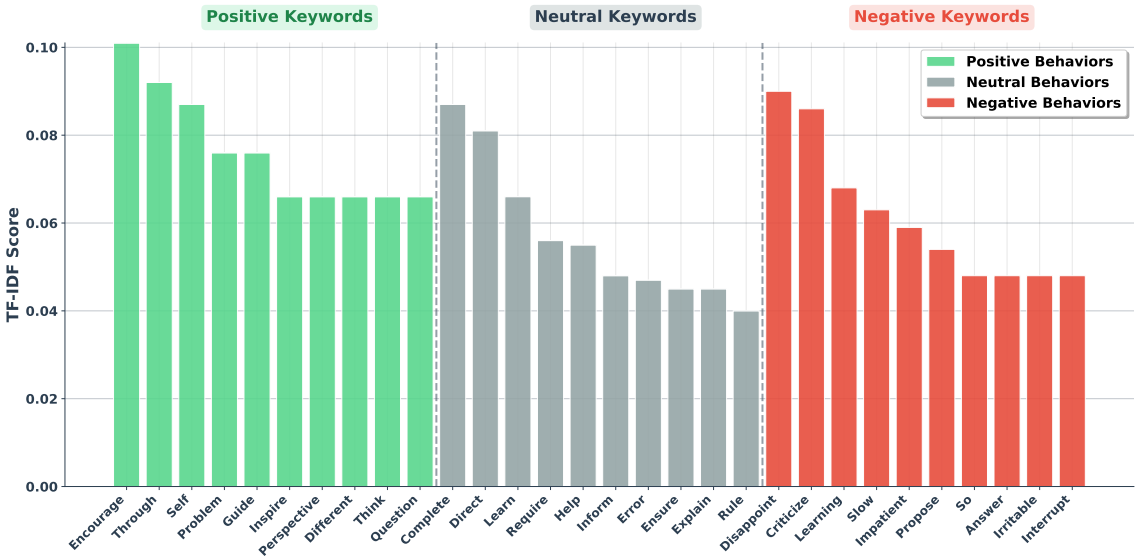


Fig. 14. TF-IDF Behavior Type Keyword

highlights critical design consideration: 1) Human-Centered Language: The system's language and tone are paramount. Using phrases that acknowledge the difficulty of the situation (e.g., "Parenting during homework can be challenging...") before presenting analysis can significantly reduce the feeling of being judged. 2) Lowering Communication Barriers: The LLM-based approach provides a low-cost, private, and non-confrontational space for reflection. Parents can engage with the "expert" analysis without the social pressure or defensiveness that might arise in face-to-face consultations, creating a safer environment for vulnerability and growth.

The tension in design between "guidance vs. judgment" is crucial; even the best advice can be ineffective if delivered in a way that makes the user feel judged. This inspires future improvements in interaction design to strengthen emotional connection through more humanized approaches, such as AI avatars and a warmer tone of language. While AI cannot fully replicate human empathy, it can simulate understanding and provide a safe, non-judgmental space for expression.

7.2.2 Harnessing the "Mirror Effect": Objective Data as the Core Intervention. The presentation of objective data about a person's behavior can be a powerful catalyst for change. This "mirror effect", allowing users to see their own behavior objectively — is a central driving force behind the system's effectiveness. In semi-structured interviews, parents mentioned that hearing their own tone of voice and seeing their behavior patterns in the reports had a more significant impact than traditional methods.

This approach transforms data collection from a mere assessment tool into an intervention mechanism. The system does not just tell parents what to do; it shows them what they have done, allowing for self-reflection and discovery. This objective perception helps to circumvent the defensiveness that can arise when receiving direct advice. For support system designers, this underscores the importance of not only providing recommendations but also creating tools that help users gain their own insights from their data. Visualizing behavior patterns, recreating key moments, and presenting data in a clear and non-judgmental way are crucial for facilitating this self-discovery and promoting lasting behavior change.

7.3 Limitations and Future Work

This work represents the first application of LLMs in the context of family education strategy development based on real-world audio recordings, offering a new approach to personalized educational support. However, we acknowledge several limitations that also point to important directions for future research.

Firstly, the study is constrained by sampling bias. A significant majority (87.18%) of the participants were mothers. Moreover, the participant's education level was generally higher than the national average in China. The reasons are possibly two-fold: 1) more educated parents are more motivated to participate to obtain a family education report; 2) these parents might have greater access to our advertisements through social media and other means. For the children, we observed that the academic ranks (reported by parents) were not as evenly distributed as expected, with most being 'above-average'. This disparity suggests a sampling bias, as students with higher grades may have parents who place greater emphasis on education, thereby increasing their likelihood of participating in our study.

Secondly, the study's findings are limited by their specific cultural and situational context. This research was conducted within the cultural context of East Asia (particularly China), where family education often places a strong emphasis on academic performance. While the core concept of EduHome—alleviating conflicts through improved communication—proved effective, its cross-cultural universality requires further verification. For instance, in Western family education theories that emphasize individual autonomy (e.g., authoritative vs. authoritarian parenting styles), the power boundaries, communication patterns, and conflict focal points may differ significantly. Furthermore, our study focuses exclusively on homework-related practices. While homework is a common and critical scenario in family education, future work should extend the application of LLMs to a broader range of contexts to provide more holistic support. Promising areas include facilitating dialogic reading during parent-child reading sessions, offering empathetic communication strategies for conversations with adolescents, and guiding collaborative family rule-making.

Finally, although the use of real-world audio is a core advantage over subjective recall, this single modality does not capture the entirety of the "truth." Audio can reveal "what was said" (content) and "how it was said" (tone), but it loses a significant amount of crucial non-verbal information, such as facial expressions, body language, and eye contact. A helpless smile, an encouraging glance, or a restless leg can be essential for accurately interpreting the interaction's atmosphere and true intentions. To overcome this limitation, a crucial direction for future work is the integration of multimodal data. By employing powerful Large Multimodal Models (LMMs) to analyze video recordings in conjunction with audio, future systems will be able to capture these vital non-verbal cues, thereby achieving a more comprehensive and accurate understanding of family dynamics.

8 Conclusion

This paper presents EduHome, an LLM-powered multi-agent system that analyzes real-world audio recordings of homework conversations to provide parents with personalized behavioral insights and actionable strategies. Co-designed with parents and educational experts, we surfaced key pain points in family education and distilled 6 key findings to design our system. In a 4-week user study with 20 families and 3 educational experts demonstrated the system's effectiveness in improving parent-child dynamics. We observed reductions in conflict frequency and severity, shifts toward more constructive behaviors, and high perceived authenticity and comprehensibility across modules, alongside a strong willingness to recommend the system. Furthermore, through analyzing interview and system usage data, we gained deeper insights into parent-child tutoring dynamics and distilled critical implications for designing future

parent support systems. We hope our work contributes to the future research and development of LLMs in the family education domain.

9 Acknowledgements of the Use of AI

We used a large language model, ChatGPT (OpenAI; accessed Aug–Sep 2025), for grammar check and correction. For programming, We used AI-powered coding tools, such as Cursor, to assist in the development of our system. All resulting code was manually reviewed and thoroughly tested by the authors. Crucially, AI was not used to generate any research data, statistical analyses, figures, or conclusions. The authors take full responsibility for the final content and any errors herein.

We are grateful to the anonymous reviewers for their careful and constructive feedback, which significantly improved this paper.

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A Appendix

A.1 Semi-structured Interview Questions with Parents and Experts

Table 5. Semi-structured Interview Protocol for Co-Design with Parents and Experts

Theme	Interview Question
Model Usability	1. Do you find the model of generating family-education strategies from uploaded recordings useful? Why? 2. Compared with questionnaire surveys, what advantages and disadvantages do you see in this approach? 3. Was it convenient to use this feature? What inconveniences did you encounter? 4. Do you think this model can authentically reflect your family-education situation? 5. Would you consider using this model over the long term? Why?

Continued on next page

Theme	Interview Question
System Design	1. Which features would you most like to add (e.g. , uploading multiple recordings, updating the personal profile)? 2. Are the interface and interaction design user-friendly? What could be improved? 3. After analyzing recordings, what kinds of feedback and recommendations would you like the system to provide? 4. Are the system's feedback messages detailed and practical? Which parts need further explanation? 5. How should the system help you implement strategies more effectively? What specific supports or resources are needed? 6. What are your views on privacy and data protection? Do you have any suggestions?
Strategy Design	1. Do the current generated strategies meet your needs? What needs improvement? 2. Which elements should an effective strategy include or exclude to improve parental practices and behaviors? 3. Do you find the strategies evidence-based and scientific? Is there expert backing or advice? 4. What difficulties did you encounter during implementation? Did the system provide effective help? 5. Would you like the system to offer different strategies for different contexts (e.g. , homework tutoring, emotion regulation)? If yes, please specify. 6. In addressing parent–child interaction issues, what aspects of the system could be improved? 7. Is the system effective at recognizing and addressing parents' emotional issues? Any suggestions for improvement?
Demo Feedback	1. During use, did you encounter repeated questions or other annoying issues? 2. How well does the system help parents identify their own problems and improve family education? 3. What new features would you like added, or which existing ones improved, in future versions? 4. When receiving intervention strategies, what forms of support do you prefer (e.g. , video guidance, written instructions, phone counseling)? 5. Would you recommend this system to other parents? Why?

A.2 Educational Expert Interview Questions

The predefined questions for the educational expert interviews are as follows:

- Content Accuracy: Do you think the information and analysis in the report accurately reflect the interaction between parents and children? Are there any areas that need further correction or improvement?
- Scientific Validity: Do the educational strategies and suggestions in the report align with current educational theories and practices? Are there any aspects that should be adjusted or updated?
- Applicability: In your opinion, are the strategies in the report applicable to different types of families (e.g. , those with varying cultural backgrounds or educational levels)? Are there contexts in which certain strategies might not be suitable?
- Feasibility: Are the strategies proposed in the report practical and easy to implement in real-life scenarios? Would any adjustments improve their feasibility?
- Sensitivity: Did you identify any content in the report that might provoke negative emotions in parents or lead to family conflicts? Are there parts that should be removed or revised?
- Ethical Considerations: Do the suggestions and strategies in the report adhere to educational ethics? Is there any content that could potentially have a negative impact on the family?
- Overall Quality: How would you rate the overall quality of the report? Has it met the expected educational outcomes?
- Improvement Suggestions: Do you have any further suggestions to improve the report?

A.3 Parent interview questions

The predefined questions for the parent interviews are as follows:

- **Understanding and Usability of Report Content**
  - *Understanding Difficulty:* How difficult did you find it to understand the content of the report? Were there any parts that you found unclear or confusing?
  - *Practical Usability:* Are the suggestions in the report easy to implement in daily life? What do you expect the outcomes to be?
- **Module Feedback and Experience**
  - *Module Usability:* Which module in the report did you find most helpful? Why?
  - *Module Suggestions:* Were there any parts that did not match your actual situation? Which part, specifically, and do you have any suggestions?
- **Behavioral Change and Conceptual Shifts**
  - *Behavioral Change:* Do you think these strategies have helped you improve the way you assist your child with homework? Can you share a specific example?
  - *Conceptual Shift:* Has the report changed your views or beliefs about family education? If so, what specific changes have occurred?
- **Impacts and Results**
  - *Expected Short-Term Impact:* What changes in family relationships or your child's behavior do you expect in the short term after implementing these strategies? (Open-ended question)
  - *Expected Long-Term Impact:* What are your expectations for the long-term application of these strategies? What long-term benefits do you think these strategies will bring? (Open-ended question)

- **Report Improvement Suggestions**
  - *Overall Improvement:* What areas of the report do you think could be improved? Are there any parts that need further simplification or more detailed explanation?
  - *Additional Needs:* Do you wish to add or remove any content from the report? Are there any areas you feel were not covered but would be helpful to you?

A.4 Code Book for Code Agent

Table 6. Consolidated EduHome codebook (one-table layout). Blocks A–C cover behavior codes (18), conflict taxonomy (7), and emotion dimensions (PAD). Abbreviations are expanded in-line (e.g. , ENC—Encouragement).

Block	Code (Expanded Name)	Definition (Key Criteria)
A. Behavior Codes (Valence: Positive / Neutral / Negative)		
Positive	ENC—*Encouragement*	Provides supportive feedback on effort/progress to boost confidence and motivation.
Positive	SP—*Specific Praise*	Commends a concrete behavior/achievement with explicit reference targets.
Positive	GP—*General Praise*	Non-specific praise without a clear behavioral referent.
Positive	GI—*Guided Inquiry*	Uses questions/cues to scaffold independent thinking.
Positive	SR—*Rule Setting*	States clear rules/standards relevant to the homework task.
Positive	SRS—*Sensitive Responding*	Detects and responds to the child's emotions/needs with empathy.
Neutral	DI—*Direct Instruction*	Gives the method/answer directly, low elicitation.
Neutral	IT—*Information Teaching*	Systematically explains knowledge/skills or background.
Neutral	EC—*Error Correction*	Identifies errors and guides revisions.
Neutral	MON—*Monitoring*	Tracks progress and checks output quality.
Neutral	DC—*Direct Command*	Issues explicit, strongly imperative directives.
Neutral	IC—*Indirect Command*	Uses suggestions/hints to request compliance.
Negative	CB—*Criticism/Blame*	Negative evaluations or fault-finding about the child.
Negative	FT—*Force/Threat*	Coercion via consequences or pressure to enforce obedience.
Negative	NI—*Neglect/Indifference*	Ignores the child's needs/emotions; emotional unavailability.
Negative	BD—*Belittling/Doubt*	Demeans ability or dismisses prospects.
Negative	FD—*Frustration/Disappointment*	Expresses disappointment or dejection about performance.
Negative	II—*Impatience/Irritability*	Shows impatience or intolerance toward delays/mistakes.
B. Conflict Taxonomy (7 Types; severity = High/Medium/Low per instance)		

Continued on next page

Table 6. Consolidated EduHome codebook (continued)

Block	Code (Expanded Name)	Definition (Key Criteria)
Conflict	EXPECTATION_GOAL—*Expectation & Goal Misalignment*	Parent's expectations misfit the child's ability/goals/interests; often accompanied by social comparison or pressure.
Conflict	COMMUNICATION_STYLE—*Communication-Style Conflict*	Inappropriate style (criticism, negation, blame) elicits resistance and opposition.
Conflict	LEARNING_METHOD—*Process/Method Conflict*	Disagreements about steps/strategies/order; forceful imposition of one's preferred approach.
Conflict	RULE_CONTROL—*Rules vs. Autonomy Conflict*	Task rules and standards collide with the child's autonomy/flexibility needs.
Conflict	TIME_ENERGY—*Time/Energy Management Conflict*	Disputes over scheduling, pacing, or allocation of effort.
Conflict	KNOWLEDGE_GAP—*Knowledge/Understanding Gap*	Parent misestimates difficulty or explains beyond the child's current cognition.
Conflict	ATTENTION_FOCUS—*Attention/Focus Conflict*	Frequent interventions for inattention/slow pace create pressure and pushback.
C. Emotion Dimensions (PAD; utterance-level, aggregated to segments/conversations)		
Emotion	Pleasure (Valence)	Hedonic tone of the utterance; from negative/aversive to positive/pleasant.
Emotion	Arousal (Activation)	Physiological/expressive activation; from calm/low-energy to excited/high-energy.
Emotion	Dominance (Control)	Perceived sense of control/agency; from submissive/helpless to controlling/assertive.

Note. Each conflict record includes *cause*, *process summary*, and *severity (H/M/L)*. Severe spans seed the Conversation Agent for contrastive rewrites and targeted guidance (cf. Fig. 2).

A.5 Post-system survey with 20 parents

Table 7. Post-system satisfaction statistics (N=20): item-level descriptive summary.

Question	Mean±SD	Median
Basic Satisfaction (Q1–Q12)		
Q1. Overall satisfaction with strategies	4.30±0.66	4.0
Q2. Analysis reflects daily interaction	4.20±0.83	4.0
Q3. Strategies relevant to family context	4.15±0.88	4.0
Q4. Confidence in strategy implementation	4.10±0.91	4.0
Q5. Learned new educational methods	4.35±0.81	5.0
Q6. Shift in family-education mindset	3.95±0.89	4.0
Q7. Ease of daily integration	4.25±0.79	4.0
Q8. Helpfulness for homework support	4.35±0.75	4.5
Q9. Helpfulness for parenting philosophy	4.20±0.83	4.0
Q10. Expected impact on academic performance	3.90±0.85	4.0
Q11. Expected impact on family relationships	4.20±0.89	4.0
Q12. Expected improvement in communication	4.35±0.81	5.0
Module Accuracy (Q13A–D)		
Q13A. Scenario Reconstruction	4.20±0.83	4.0
Q13B. Family Portrait	3.95±0.69	4.0
Q13C. Conflict/Behaviour Detection	4.40±0.75	5.0
Q13D. PET Strategy Coaching	3.95±0.83	4.0
Module Effectiveness (Q14A–E)		
Q14A. Family Education Panorama	4.25±0.79	4.0
Q14B. Communication Magic	4.35±0.75	4.5
Q14C. Emotional Code	4.20±0.77	4.0
Q14D. Tailored Parenting Tips	3.85±0.75	4.0
Q14E. Long-term Navigation	3.95±0.83	4.0
Recommendation Willingness (Q15)		
Q15. Intention to recommend the system	4.50±0.51	4.5