Involving Parents in Tutoring Systems to Increase Content Confidence: A Design Probe Study

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Abstract. Caregiver involvement in homework is a key contributor to student success, yet its interaction with intelligent tutoring systems remains underexamined. To address this gap, we conducted a technology probe study exploring how a conversational support tool might enhance caregiver assistance during remote math homework within tutoring systems. Interviews with six caregiver-student dyads conducted before and after tool use indicated that the tool primarily strengthened caregiver confidence and emotional support rather than enabling direct content assistance. Sessions were typically brief and focused, covering one to two problems. Qualitative chat log analyses highlighted design challenges, including students seeking direct answers and caregivers joining sessions with delays after SMS notifications. Despite adoption hurdles, our findings offer new evidence that tutoring systems can bolster caregiver confidence, which is a known predictor of parental engagement in education.

Keywords: technology probes, human-centered design, intelligent tutoring systems, K-12, mathematics education

1 Introduction and Background

Caregiver support, both motivational and instructional, is a well-established contributor to student achievement [22, 3]. Yet many caregivers face barriers such as limited time, resources, or subject knowledge [21]. While intelligent tutoring systems offer effective content-level support [16, 23], their potential to assist caregivers during homework remains insufficiently examined.

Tutoring systems may either (a) *compensate* for caregivers' knowledge gaps, allowing them to focus on emotional and motivational support, which are critical for persistence and self-regulation during homework [14, 11]. Alternatively, (b) tutoring systems may *amplify* caregivers' abilities by providing tools to tutor effectively and gain insights into the learning process [9].

To compare both lenses, we created a tool that helps caregivers give better instructional support, based on our prior research showing they often lack content knowledge and chances to tutor remotely [20]. We conducted a technology

probe study in two middle schools, integrating the tool into existing homework practices. Over two weeks, six caregiver-student dyads used the tool for homework and completed pre- and post-use interviews. We asked: **RQ1:** How much do caregivers use tutoring aids for homework support? **RQ2:** How did caregivers and students interact in the caregiver support module of the tutoring systems? **RQ3:** How do caregivers and students perceive intelligent caregiver support?

2 Methods

The study involved two middle schools. East School, a suburban school located in the Northeastern US, and West School, a suburban school in the Pacific Northwest. School and IRB approval were obtained. A recruitment letter was sent to families for tool access. Informed consent and student assent were obtained through an online form. Participants received $40 gift cards for two interviews.

The sample included six caregiver-student pairs across two schools. Five of the caregivers were White, and four were female; the mean caregiver age was 45.2 years (SD = 6.3). Four of the students were White, and two were Hispanic (three female, three male), with a mean age of 13.3 years (SD = 0.5).

2.1 Technology Probe Design

The *intelligent caregiver support module* was integrated into the Lynnette tutor for linear equations [18]. The probe design was informed by past needs-finding design research [20]. In a prior design version, a struggle detector identifies when students fail to master skills, prompting the student to request help from their caregiver [9, 2]. After feedback at East School, we added continuous student SMS access for student help requests to caregivers. First, it gave caregivers real-time insight into students' problem solving, aligning with their preference for content-level support in math homework. Second, it featured an SMS module and remote conversational support that allowed students to notify caregivers, addressing caregivers' need for efficient, targeted support (Fig. 1).

Initially, students practiced math in class or at home independently, with the option to message caregivers. If contacted, caregivers could join via an SMS link, activating a chat panel for real-time support (Fig. 1). Once connected, the system supported caregivers in helping their student in three ways. ***Problem-Solving Broadcast:*** Caregivers observed student work in real-time, accompanied by correctness feedback and hints. ***Adaptive Message Recommendations:*** Caregivers received prompts after each learner action, based on student step accuracy and hint usage, drawn from 25 expert-designed messages emphasizing effort-based praise, indirect feedback, and understanding checks [25]. Informed by design research [20], the prompts prioritized conceptual explanations, effective system use, and emotional acknowledgment. The messages can also feature LLM recommendations [26, 5], though such recommendations were not tested in this study. ***Problem-Solving Step Previews:*** Caregivers can view up to three viable next steps with brief explanations, addressing content challenges [21, 7].

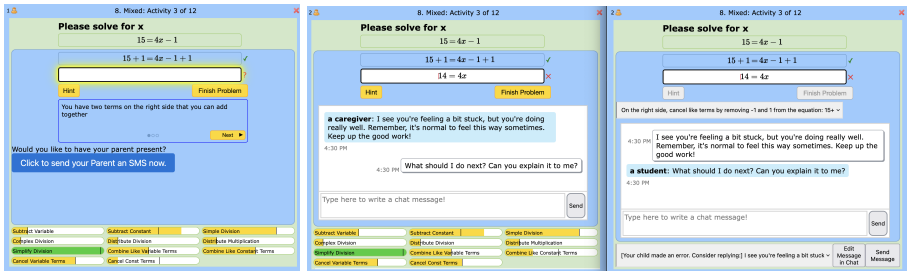

Fig. 1. Caregiver support module with (left) student view during practice and caregiver SMS notification button; (middle) student view during caregiver-student interaction; (right) caregiver view including next-step and conversation recommendations.

2.2 Procedures

Data collection took place in Spring 2024. In week one, we conducted 20-minute semi-structured Zoom pre-interviews with caregivers and students about homework practices, challenges, and support needs. In week two, students practiced with Lynnette for 30 minutes daily in class, starting 12-problem assignments they were expected to finish at home. Week three introduced the technology probe (Section 2.1), with students continuing practice. In week four, 20-minute post-interviews explored tool use, compatibility with routines, and homework practice changes. Teachers followed regular routines, occasionally supporting students during practice. Researchers addressed technical issues. Students without caregiver participation used the tutoring system without our module.

2.3 Data Analysis Methods

RQ1 examines caregiver use, evaluated through time-stamped system logs (e.g., a hint request, chat messages). We counted SMS, chat use, and unique joint practice sessions. To study caregiver-student interactions (RQ2), we conducted an inductive thematic analysis on 95 chat logs across nine sessions. Two researchers first separately conducted one round of open coding [28], which was followed by a round of closed coding of messages with consensus-based discussions (e.g., "Caregiver provides emotional support"). We similarly open-coded interview transcripts to study participant tool perceptions (RQ3), focusing on support modes (e.g., "tutoring"). After discussing these codes, each coder independently grouped the themes [24] using affinity diagramming. Another round of discussion and consolidation of the resulting themes was held to minimize bias.

3 Results

3.1 RQ1: How Much Did Caregivers Use the Probe?

Caregiver sign-up rates in both schools were generally low (5 or 11.4% in East School and 4 or 12.9% in West School). Moreover, 20% of households in East

School and 50% in West School did not use the tool post sign-up. Six students whose caregivers used the tool received help through it in 10 of 41 (24.4%) tutoring sessions, whether at school or home. The six caregivers' presence covered 13 of the 158 problems students solved (8.2%), aligning with the system's design for facilitating short sessions on specific problems. When caregivers used the tool, they provided help for a median of 1.5 problems. These metrics were generally comparable between East and West Schools. However, East School dyads sent 11 times more SMS (11 vs. 1), exchanged 20 times more chat messages (208 vs. 100), and spent nearly three times longer chatting (8.1 vs. 2.8 mins).

3.2 RQ2: How Did Caregivers and Students Interact?

Theme 1: Response Latency Was Common but Did Not Impact Support Response latency, the time between a student's initial help request and a caregiver's response, ranged from 3 to 20 minutes (M = 10.33, SD = 7.16). In the 3East, 4East, and 1West dyad, the student had already solved their issue by the time the caregiver joined due to the latency. In the 1West session, a 20-minute latency resulted in the student progressing to other problems. The caregiver then intervened with direct math guidance on other problems such as *"Check your math on 3 x 3x"* and encouragement such as *"Now you got it!"*. In all cases, we observed that caregivers continued providing support as students persisted.

Theme 2: Caregiver Preparedness Had Varied Impact on Tutoring Caregivers' familiarity with the tool before sessions substantially varied. All East dyad caregivers independently explored the interface and tested features before tutoring sessions with their students, while West dyads did not. Consequently, the 3East caregiver blended system prompts like *"How about you request a hint and walk me through it?"* with personalized guidance, whereas the 1West caregiver relied only on ad hoc support such as *"Check your math on 3 × 3X"*. While East dyads exhibited more timely help (mean response latency of 5.5 vs. 20 minutes in West dyads) and more chat engagement (see Section 3.1), these patterns were not uniformly effective. For instance, 4East dyad's caregiver heavily used pre-generated prompts, resulting in inflexible encouragement rather than math guidance.

Theme 3: Caregiver Reliance on Pre-Generated Messages Differed by Content Challenges The system's pre-written messages served both instructional and emotional roles with varying outcomes. In 3East, the caregiver started with open-ended prompts but, when unsure about math concepts, switched to system-provided hints or offered direct answers. Of the system-provided prompts sent by the 3East caregiver, 66% followed a caregiver's expression of content difficulty. In contrast, for dyad 4East, over-reliance on static, pre-generated praise (33% of responses) limited conceptual engagement. While these messages uplifted students (*"I'm so smart"*), they sometimes bypassed opportunities for deeper learning.

3.3 RQ3: What are Caregiver and Student Perceptions of the Tool?

Theme 1: Caregivers Primarily Provided Emotional and Motivational Support. Caregivers reported mostly providing emotional and motivational support when

interacting through the intelligent caregiver support module. Participants found the tool helpful when being stuck as it helped alleviate frustrations and regulate negative emotions, helping students persevere. **Care1West:** *"I do think that I use some of the hint stuff just to again sort of go wait! How do you do this? Or what are you supposed to do in this situation."* **Stu1West:** *"I had some help with it when I was being frustrated. I was able to get calmed down."* The tool also provided touchpoints for "being there" through the probe as useful to foster conversations about homework in enjoyable ways. **Care3East:** *"[Student] appreciated being able to kind of show off like, Oh, I got all these right."* **Stu4East:** *"I think I like I liked working with it together. We just like ended up talking about it later anyway."* **Care4East:** *"It was like we were there together."*

Theme 2: Caregivers Use Instructional Support to Drive Conversations and Gained Confidence in Tutoring Caregivers appreciated the tool for enhancing their ability to tutor math, especially given shifting curricular standards [12]. Three caregivers actively used the tool to improve their understanding of the material and avoid incorrect guidance. Prior to using the tool, they noted: **Care2East:** *"The materials that are provided aren't exactly I would say useful, or what I'm used to...and the answer that we came up with. Obviously, it was not the answer that was anticipated...did I steer them wrong? Did I make them, you know, mess up the test?"* In contrast, after using the caregiver support tool, caregivers shared that they gained confidence in becoming actively involved in their student's math: **Care3East:** *"I didn't have to worry like. Did [Student] get that question right or wrong? It was like green. If [Student] got the question correct and red, if it was incorrect."* **Care1West:** *"At what step was incorrect, was helpful for her and for me to see where she was struggling."*

Theme 3. Caregiver Accountability. Two caregivers with little tool engagement described their role as holding students accountable. In Dyad 1 East, for instance, the caregiver motivated homework completion by restricting enjoyable activities like soccer: **Care1East:** *"If he wants go to sport, he needs a good learning."* The theme of accountability was also present in Dyad 2 West, which exhibited a *reactive and corrective* approach to homework support when the student was falling behind: **Care2West:** *"So if we notice like, hey, you're you're kind of falling back. You know. You're at a cusp. Now, kind of thing like, let's let's look at that cause."* Overall, some caregivers felt insufficiently supported in their natural homework support style of accountability through the tool.

4 Discussion

Prior work shows caregiver homework support is positively related to student achievement [22, 3], but many caregivers face barriers, especially low content confidence [21, 20]. We conducted probe studies in two US middle schools to explore how tutoring systems might help overcome this barrier.

In addressing caregiver engagement (RQ1), only 12% of caregivers enrolled in the support module, resulting in a sample skewed toward self-selected volunteers. One-third of caregiver-student dyads came from the diverse West School, likely

reflecting participation barriers such as language differences among minoritized families, although translation plugins were provided. Low enrollment may stem from the tool's perceived burden, including the need for sign-up and login. Goal-setting contracts [1, 4] may cater better to accountability-oriented homework support styles and pose fewer barriers to some households.

Examining student-caregiver chat interactions (RQ2), we observed frequent delays in caregiver responses. These delays might have contributed to caregivers prioritizing motivational over content-specific supporting. Future designs might address this by allowing students to suspend working on problems they need caregiver help on and later resume where they left off at a time when both student and caregiver are available to review them together. These design revisions should also involve teachers, an important stakeholder not included in this study.

Based on student and caregiver perceptions (RQ3), we identified encouraging evidence that tutoring systems can help caregivers compensate for a lack of content confidence, a common obstacle to involvement [21, 20]. This finding is crucial because whether or not caregivers believe they can positively influence their child's education is one key factor in their decision to become involved [10, 19]. Hence, caregivers may be motivated to provide more critical homework support that some students lack when given access to intelligent tutoring, which is substantially more scalable than past interventions such as paper-based worksheets [27] and more customizable than instructional videos [17].

Theoretically, our findings support the notion that caregivers and AI have complementary strengths [6, 8]. While the tutoring system often met students' cognitive needs, caregivers played a key role in providing emotional support. Students valued caregiver presence for acknowledging frustration, fostering connection, and reinforcing persistence [14, 11, 15] and help close achievement gaps driven by differences in practice engagement [13]. Our findings show that well-designed tools can effectively facilitate caregiver involvement.

5 Conclusion

We designed and deployed an *intelligent caregiver support module* in a middle-school math tutoring system to explore how technology could facilitate meaningful caregiver involvement. Findings from six caregiver-student dyads revealed improved caregiver content confidence, a critical factor known to increase homework support. Moreover, caregivers often responded to student help requests with encouraging comments or minimal guidance, emphasizing compensatory motivational strategies. Future AIED systems may more fully activate the benefits of caregiver support by supporting caregiver homework monitoring in addition to hands-on support, for example, through goal setting.

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