DIA: Supporting Teacher Professional Development in Low Infrastructure Settings

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Abstract

Governments in developing countries aim to improve education through novel teaching approaches as taught in pedagogical programs. These pedagogical programs rely on government teacher training infrastructure. However, these programs face challenges in rural parts of Africa where there is a lack of experts and teachers are isolated. Therefore, pedagogical programs consider using technology to overcome some of these challenges.

Prior work has used a conversational agent to address the challenges of limited expert knowledge and providing personalized interactions. Still, it is unclear how this work can translate to rural African contexts with low technology infrastructure. Additionally, teachers in these contexts are newly adopting technology and thus require additional support to accommodate technology adoption. Therefore, there is a need to discover appropriate conversational agent designs that support these teachers in implementing pedagogical programs in low infrastructure settings.

This design process needs to overcome several practical, technological design, and theoretical challenges to find appropriate designs in this context. Beyond being usable, the designs had to support an intervention aligned with the teachers' goals and the professional development program. Lastly, theoretical grounding for designing technology in low resource contexts is still emerging.

Therefore, I use an iterative design-based research (DBR) approach by working closely with teachers implementing a pedagogical program in rural Côte d'Ivoire to understand problem context and technology designs and generate theory. My work iteratively identifies design directions and validates these directions through prototypes shared among the teacher community. In my proposed work, I intend to understand the impact of these features at scale.

This thesis proposal document describes prior work in this area (Chapter 2) before describing three studies that have been already conducted as part of the iterative design process (Study 1, 2a, 2b, and 3). My work has led to a conversational agent, which we dub "DIA". A key finding in these studies is that teachers valued community-based features. Therefore, I intend to learn: Will designs for community support have more impact than individual support towards teachers in low infrastructure settings? To answer this question, I propose a large-scale and
long-term study that seeks to understand the impact of community-based features at scale (Study 4).

This thesis intends to extend the literature on Human-Centered AI in low infrastructure settings through iterative design-based research. My work will also provide initial design recommendations for governments to utilize conversational agent's to support teachers in implementing pedagogical programs.

On the theoretical front, my work expands designing for teacher "aspirations" or long-term desires to allow sustainable systems. My theoretical grounding in aspirations led me to uncover the critical role of the teacher’s community in supporting them in their career. Therefore, I designed participatory content in a conversational agent to allow teachers to connect to community members and rely on their collective agency. As aspirations are relatively emerging in low resource contexts for technology, my work extends the theory to designing technology.
Acknowledgement

“Happiness can be found, even in the darkest of times, if one only remembers to turn on the light.”

— Albus Dumbledore
(Headmaster of Hogwarts)
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Declaration

Parts of this document were used from prior publications by the author:


[Study 2B] Vikram Kamath Cannanure, Eloísa Ávila-Uribe, Tricia Ngoon, Yves Thierry Adjji, Sharon Wolf, Kaja Jasinska, Timothy X Brown, and Amy Ogan. 2022. We dream of climbing the ladder, for getting there, we have to do our job better: Designing for Teacher Aspirations in rural Côte d'Ivoire. In ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies (COMPASS) (COMPASS 22), June 29-July 1, 2022, Seattle, WA, USA. ACM, New York, NY, USA, 26 pages. https://doi.org/10.1145/3530190.3534794

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Vikram Kamath Cannanure
Introduction

Today school enrollments in low and middle-income countries are growing exponentially, but basic primary school educational outcomes still lag international standards [98, 112], thus impeding economic growth and equity [6]. Early simulations show that COVID-19 has aggravated this situation, and up to 91% of students will fall farther behind in Sub-Saharan Africa [7]. Governments are trying to address this crisis by investing heavily in new pedagogical programs that deliver targeted instruction to align with student learning levels [60]. Successfully implementing these pedagogical programs requires well-trained teachers, but programs for training teachers in low-income countries are challenging to deploy. As pedagogical programs scale, they rely on governments’ teacher training [60] infrastructure to teach new approaches and provide support to teachers. However, implementing teacher training interventions in rural and isolated areas is challenging due to infrastructural [15, 61] and socio-cultural complexities [129, 84]. This gap is prominent in sub-Saharan Africa, especially in rural areas with less economic infrastructure, such as roads and energy supply. [2]. Therefore, pedagogical programs are considering technology to scale and increase their impact [60].

Technology has shown promise in teacher training interventions in some contexts, but it is unclear how this body of work can support designing technology for rural African contexts. Prior projects have supported teacher training by providing resources digitally through tablets [85], videos [118] and audio contexts [79]. These interventions are often new to the context leading to overhead investments in setup, training, and monitoring costs [85]. Recent work has reduced the overhead of introducing new technology by capitalizing on teachers’ own devices and using applications, such as WhatsApp, that are already familiar to users [58, 88, 110]. Teacher support groups on WhatsApp have allowed fostering of digital teacher communities in Indian [144] and African contexts [92], but connectivity issues prevent streamlined access and participation of rural teachers [92]. Additionally, there tend to be fewer administrators in rural Africa [15, 61], who are critical to facilitating and moderating these groups digitally [92].

Conversational agents, also known as chatbots, are one way to support scaling expert knowledge and have seen initial success on social media in rural African contexts [19]. Some conversational agent research has scaled expert knowledge

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[1] Also referred to as teacher professional development or professional learning.
by using innovative AI techniques in Western settings [57, 121]. An exploratory deployment of a conversational agent on WhatsApp in rural Côte d'Ivoire by the authors [19] found initial evidence that such technology can provide personalized and context-specific support to teachers. However, AI research is often disconnected from low infrastructure contexts due to socio-cultural nuances [119]. Prior work has attempted to bridge this disconnect [156, 87, 64, 19] through qualitative design studies with stakeholders. Therefore, there is a need for design-based work to understand the potential for conversational agent to support teachers in low infrastructure settings.

To design impactful systems, Toyama [141] urges researchers to extend traditional HCI approaches that understand user needs [96] and follow an aspiration-based approach, i.e., to channel user aspirations while designing technology. The objective is to shift researcher thinking from problem-solving for user needs to supporting users to achieve what they aspire for themselves with technology [141]. Toyama describes an aspiration as an individual’s long-term desire that is persistent and aiming for something higher than one’s current situation [141]. Understanding aspirations has shown to have practical benefits for developmental projects [114, 47] as well as theoretical benefits [5] which improve research generalizability for the HCI4D space [27]. Although research on aspirations has emerged in education [101], students career [117] and healthcare [105], research on teacher aspirations is still developing. Therefore, I use a theoretical lens of aspirations to uncover conversational agent design directions to support teachers in implementing pedagogical programs in low infrastructure settings.

However, finding appropriate designs for this problem faces practical, contextual, and theoretical challenges. On a practical level, the context of the teachers’ and the pedagogical program along multiple dimensions was unknown to the researchers. Additionally, beyond being usable to users who are new to technology use [31], the design had to conceive an intervention aligned with the goals of both the teachers and the professional development program. Lastly, on a theoretical dimension, aspirations are relatively emerging in low infrastructure contexts for technology thus increasing the complexity to design for new populations such as teachers implementing pedagogical program in rural Côte d'Ivoire.

To overcome these challenges, I used a design-based research (DBR) approach [11, 35] by working closely with teachers implementing a pedagogical program in rural Côte d'Ivoire. DBR work helps researchers work in a new context and understand contextual knowledge using mixed methods, i.e., qualitative and quantitative data collection methods. Throughout my work, I followed a DBR approach with teachers and ministry officials in rural Côte d'Ivoire to uncover conversational agent designs. My work involved sharing prototypes among community members, through which I
iteratively identified and validated the design directions. In my proposed work, I use this knowledge to understand the impact of the resulting designs and generate theories in context.

![Diagram](image)

**Fig. 1.1.** I used an iterative design-based research to bridge the gap between theory, technology, and design through my former studies (Study 1, 2A, 2B, 3, 4). My proposed work (Study 4) is to answer: *Will designs for community support have more impact than individual support towards teachers in low infrastructure settings?*

Therefore, I have conducted three studies (refer Fig 1.1), as part of a design-based research process to support teachers implementing a pedagogical program in rural Côte d’Ivoire. My first study used a qualitative approach to explore technology’s role in teacher professional development. Then, in the second study, (a) I deployed and evaluated an early version of a conversational agent (DIA) (b) my interview data revealed the positive role of community support in teachers’ engagement in a pedagogical program. Finally, in the third study, I updated my conversational agent designs with features for community support through participatory content. My preliminary analysis revealed that teachers valued the community-based features.

Therefore, this led me to my thesis’s question: *Will designs for community support have more impact than individual support towards teachers in low infrastructure settings?*. To answer this question, I will evaluate the impact of community support designs in a conversational agent through a longitudinal, large-scale deployment. I have categorized impact as teacher motivation, training knowledge, and technology adoption using my prior studies. I hypothesize that community support features will have a better impact than individual support due to early adopters, who will support their fellow teachers through the intervention. Therefore, I plan to run a longitudinal study in two regions receiving community or individual support.

This thesis intends to extend the literature on Human-Centered AI in low infrastructure settings through iterative design-based research. I expect to contribute to the following.
• (a) Community support in a conversational agent: I have extended prior work in community support [140, 147] in ICTD to conversational agent's in low infrastructure contexts.

• (b) Opportunities and barriers for early conversational agent adopters: I expect to understand the opportunities for early adopters to contribute content, participate, and champion technology adoption. Additionally, I intend to understand the digital and socio-technical barriers that inhibit intervention adoption.

Outside academic impact, this thesis supports practitioners and policymakers through:

• Designing for teacher aspirations theory: I used a design-based research to uncover design ideas from the theoretical aspirations-based approach. As aspirations are relatively emerging in low resource contexts for technology, my work extends the theory to aspirations-based designs. I expect my approach will help ICTD practitioners convert theory-based work on aspirations to practical design-based interventions.

• Initial evidence of social impact: My work will also provide initial design recommendations for governments to utilize conversational agent's to support teachers in implementing pedagogical programs in rural African contexts.
2 Related Work

In this section we summarize the related work spanning teacher professional development, technology to support teachers in developing contexts, designing for aspirations and lastly, intelligent messaging in low resource contexts.

2.1 Pedagogical Programs and Teacher Training

In recent years, developing countries have invested in novel pedagogical programs to address the learning needs of primary school students [60]. These programs teach students foundational skills tailored to their learning levels [139]. The level-appropriate teaching for students and tailored guidance from facilitators help the students improve at their pace [151]. Prior work has used community volunteers, learning camps, and teachers as facilitators to guide students to enhance their foundational skills [9, 10]. Teachers have shown to be ideal for sustaining these programs in sub-Saharan Africa [36, 42, 135]. African governments have operationalized these programs using their teacher professional development infrastructures [36, 42]. Pedagogical program deployment differs from typical teacher training programs because they have more resources (financial, operational) and rigorous evaluations to understand their impact [60]. However, they also receive many of the same benefits and challenges as teacher training programs.

Significant research on teacher training tells us that ongoing and lifelong professional learning is an integral part of supporting teachers [43, 130, 68, 63]. Research has found that giving teachers expert feedback in person for their teaching sessions [14] through thoughtful reflection is an effective approach. Prior work on modeling teacher growth informs that teacher growth is non-linear; therefore, teacher training programs should consider building individual teacher capacity with personalized support [23]. Teacher training literature in the Global North has developed material to foster self-efficacy [8], self-reflection [123], and collaboration [24], some via interactive tools [45, 55]. However, it is unclear how this work transfers to developing contexts where experts are less readily available [15].

Although teacher training programs have been shown to improve children’s education in developing countries [86, 111, 33, 10] it is challenging to implement them
in rural contexts [93, 33, 61]. Teacher training interventions often require a cultural shift [129, 84] in which teachers are asked to change some of their long-held teaching beliefs and practices, making it difficult for teachers to implement the pedagogical approaches of a new program without frequent mentoring [2]. In developing contexts, teachers are mentored through regular visits by ministry officials [61]. Still, infrastructural challenges (i.e., poor roads, travel costs, etc.) and lack of mentors reduce the frequency of mentoring visits [93, 15] leading to challenges in teacher training implementation. Hence, it is helpful to support teachers in rural contexts who might need more mentoring and support in implementing these pedagogical programs.

2.2 Designing Technology for Teachers in Low-Infrastructure Contexts

Although technology has shown promise in education in developing contexts, a large portion of the research is focused on giving resources to children [103, 74, 143] or supporting school administration [116, 44, 25]. Prior projects that focus on teachers have helped them with teaching resources through video content [4, 118, 85], audio content [79], and text messaging [69], but it is not clear that simply providing teaching resources is sufficient to support teachers in implementing novel pedagogical programs [60]. Additionally, introducing new technology requires extra digital training and monitoring to promote engagement [85].

Prior work has mitigated training and monitoring costs by using popular social media applications, such as WhatsApp, which is a familiar tool for teachers [58, 88, 110]. In Indian contexts, NGOs have extended technology support beyond teaching resources by creating groups [154] to foster peer support and remote administrative help for teachers [144, 145, 146, 95]. In particular, these initiatives showed success in decreasing teacher absenteeism.

However, internet technology [88, 19, 20] in rural Africa is still lagging behind its Global South counterparts like India [50, 54]. In rural Côte d’Ivoire, a related project by Motteram et al. [92] found initial evidence that Whatsapp groups could foster support for language teachers, but rural teachers lagged on usage due to connectivity issues. [92]. In rural contexts, teachers use the internet infrequently or in specific locations due to low cell tower infrastructure [19, 92]. Therefore, to understand this design space, we extend the literature on WhatsApp based support for teachers, specifically for pedagogical programs in a rural context like Côte d’Ivoire where infrastructure is emerging [50, 54].
2.3 Designing for Aspirations

To build sustainable systems [104] for Information and Communication Technology and Development (ICTD) some researchers have shifted focus from user needs [96] to designing for users' aspirations [141]. Toyama describes aspiration as an individual’s long-term desire that is persistent and aiming for something higher than one's current situation [141]. Learning user aspirations has shown to have practical benefits [114, 47] as well as theoretical roots [5] which improve research generalizability for the ICTD research [27]. Therefore, prior work in ICTD has explored aspirations in mental health [105], healthcare [71, 62], community networks [34], agriculture [52] and accessibility [73]. In education, prior work used aspirations to understand career paths for high school students [76], undergraduate students [70, 117] and vocational workers [138].

For African teachers, aspirations have been explored for pre-service undergraduate teachers’ aspirations (i.e., teachers in training) in South Africa [17]. In prior work by the authors [20] on primary school teacher aspirations in Côte d’Ivoire we discovered teacher aspirations for (1) Students’ success: teachers expressed that they wanted to see their students improve on the curriculum over the short term and improve professionally in the long term; (2) Improving teaching skills: Teachers expressed aspirations to improve their teaching skills to support their class better; (3) Career progression: Teachers aspired to progress in their career to become advisors and inspectors to have a broader impact on the community. However, we discovered aspirations for career progression conflict with their current teaching role, complicating the design space. Therefore, this paper explores how these aspirations intersect with the pedagogical program to design relevant technology for low infrastructure settings.

To design for aspirations, Kumar et al. [76] showed that aspirations are deeply intertwined with the community (embedded), aspirations are achieved after a time frame (i.e., have temporal boundaries) and can adapt with time (mutable). Additionally, Kano al. al [70] found the importance of role models in influencing the future aspirations of undergraduates in Bangladesh. In Côte d’Ivoire, we [20] found that teachers' professional aspirations conflict with their teaching responsibility. However, teachers' role models help them navigate this conflict between current aspirations (to support students) and future aspirations (to advance their careers). These insights, like Kumar et al. [76] and Kano et al. [70] have implications for designing systems that not only support interface design but also lead to developmental outcomes or better lives for marginalized users.
2.4 Intelligent Messaging in low resource settings

Early work in text messaging focused on sending one-way messaging [30, 113] to provide information to the user but users found it challenging to interact without feedback. Therefore, projects have moved towards providing two-way feedback for health [108], education [155], and agriculture [150] with expert support. Researchers have extended expert support to create human-machine hybrids in finance [29] and healthcare [107] by automating a part of the interaction. However, text messaging-based applications are limited by the cost of messaging reducing sustainability and lack of availability of experts reducing scalability [108, 107, 155]. To improve sustainability, research has shifted to use text messaging on social media in education [144], healthcare [41], activism [122], and election monitoring [91]. However, this work on text messaging through social media platforms is dependent on the availability of experts which is a scarce resource in developing contexts.

Chatbots or conversational agents have the power to scale up expert knowledge through artificial intelligence [49]. The first chatbot Eliza was developed in 1966 to emulate a therapist using simple rules of language understanding [152]. Today chatbots are being used by 1.4 billion users on various platforms like home assistants and social media platforms like Skype, WhatsApp, and Facebook [127, 40]. On Facebook Messenger alone, it is estimated that there are 300,000 chatbots [127]. Chatbots have been classified based on usage [40], customer support agents for product search (Alibaba), personal assistant chatbots (Amazon Alexa, Google Home) for content curation (CNN News) and coaching (WoeBot [100]). Prior work has tried to scale chatbot capabilities by using human-machine hybrids [49] or humbots which combine expert knowledge with innovative AI techniques [57]. Additional research has expanded chatbots through Crowd-AI hybrid architecture to automate conversations over time [57] by utilizing crowd workers to support AI when it fails to retrieve an appropriate response. Additionally, prior work has used chatbots to mediate experts critique learners in short intervals of time on social media [140]. However, a majority of this work is focused on western settings in the English language [127] which may not transfer to developing contexts due to lack of language datasets or translation support leading to a further need to rely on experts. In developing contexts, prior work has focused on a voice-based chatbot for low literate users [65] and explore design opportunities for novice urban users interacting with Facebook Messenger chatbots [66]. However, more research is needed to explore opportunities to design chatbot based systems to support local language interaction using text messaging in low resource settings.
2.5 Conclusion

In sum, some pedagogical programs have been found to improve teaching practices successfully, but they must be adapted to support rural teachers in low infrastructure settings. Although prior work has used technology to support teachers, it is unclear if chat applications like WhatsApp—which many teachers worldwide use—can help teachers sustainably in rural Sub-Saharan Africa with low internet infrastructure. Prior work in ICTD has proposed an aspirations lens to design sustainable interventions, but it is unclear how teacher aspirations intersect with new implementations of pedagogical programs. Lastly, conversational agents have shown promise to support scalable interventions, but it is unclear how to translate such interventions for teachers in places like Côte d'Ivoire. Therefore, we explore this design space for pedagogical programs in developing rural contexts.
Study 1: Exploration

I’m fine where I am, but I want to do more

— P14
Exploring Teacher Aspirations

3.1 Overview

Fig. 3.1.: The goal for study 1 was to explore the (a) technological design space in Côte d’Ivoire and (b) discover opportunities to design for teachers’ aspirations.

In this chapter (refer Fig 3.1), I explore the design space for teacher professional development in developing contexts with technology. Prior work in ICTD has proposed an aspirations theory to design sustainable interventions, but it is unclear how teacher aspirations intersect with their professional development or technology. Therefore, we interviewed 22 teachers across two regions of rural Côte d’Ivoire over two years to understand their aspirations and how it influences their professional development and technology use.

3.2 Research Questions

To address this, we use the aspirations-avenues-agency framework [75, 76] to analyze our qualitative study. Aspirations translate to longer-term desires [141], Avenues are pathways both traditional and non-traditional that users take towards fulfilling their aspirations and Agency is the capacity that people build to create these avenues [75] (e.g. Aspiration: Teachers want their students to excel in class, Avenue: They use technology to captivate children’s attention, Agency: They download technology-based classroom examples). This framework lead to the following research questions:
RQ1: What are the aspirations of teachers in low-resource contexts in rural Côte d’Ivoire?

As professional development is a key to teacher growth we ask:

RQ2: Through what avenues do teachers currently access and implement professional development?

To see whether technology can have a role in this growth we ask:

RQ3: What agency do teachers currently have to support their professional development with technology?

3.3 Methodology

This study is part of an ongoing research program on supporting literacy in cocoa farming communities, conducted by an interdisciplinary team of American and Ivorian researchers. The project aims to improve children’s education in rural Côte d’Ivoire through poverty reduction and improved educational quality. For this study, we interviewed 22 teachers from 2 regions of Côte d’Ivoire (Adzopé and Soubré), the interviews were conducted in 3 sessions from April 2018-May 2019. We transcribed, and translated the interview data into English and formed the low-level themes using grounded theory [21, 132, 94] and used affinity diagramming [16] to synthesize the themes for our research questions.

3.3.1 Participants and Data Collection

With approval from the Ivorian government and our university IRBs, participants were introduced to us by the school director who was first briefed about the study. The interviews were conducted with voluntary verbal approval from the participants who were offered no compensation. The data collection was conducted in French by an Ivorian researcher with help from a US researcher. The US researchers had a limited French proficiency and the Ivorian researcher would occasionally pause to translate answers to English. We attempted to reduce social distance [28] from our participants by having one of the Ivorian co-authors lead the data collection. However since the foreign researcher sat nearby, this may have affected participants’ responses. The data was primarily analyzed by non-Ivorian researchers (3 of US origin and 1 of Indian origin) but these non-Ivorian researchers regularly discussed the data and interpretations of emerging findings with the Ivorian researchers.
Fig. 3.2.: An interview session in a school in Adzopé.

<table>
<thead>
<tr>
<th>PID</th>
<th>Gender</th>
<th>School</th>
<th>Class</th>
<th>Age</th>
<th>Career Aspiration</th>
<th>Smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>M</td>
<td>Region-A</td>
<td>CM1</td>
<td>42</td>
<td>inspector</td>
<td>Y</td>
</tr>
<tr>
<td>P2</td>
<td>F</td>
<td>Region-A</td>
<td>CM1</td>
<td>39</td>
<td>counselor</td>
<td>Y</td>
</tr>
<tr>
<td>P3</td>
<td>F</td>
<td>Region-B</td>
<td>CP1</td>
<td>34</td>
<td>teacher (other than primary)</td>
<td>Y</td>
</tr>
<tr>
<td>P4</td>
<td>M</td>
<td>Region-B</td>
<td>CE1</td>
<td>41</td>
<td>counselor/college teacher</td>
<td>Y</td>
</tr>
<tr>
<td>P5</td>
<td>F</td>
<td>Region-B (2)</td>
<td>CP1</td>
<td>32</td>
<td>business</td>
<td>Y</td>
</tr>
<tr>
<td>P6</td>
<td>F</td>
<td>Region-C</td>
<td>CM1</td>
<td>33</td>
<td>college teacher</td>
<td>Y</td>
</tr>
<tr>
<td>P7</td>
<td>M</td>
<td>Region-D</td>
<td>CE2</td>
<td>54</td>
<td>private school owner</td>
<td>Y</td>
</tr>
<tr>
<td>P8</td>
<td>F</td>
<td>Region-D (2)</td>
<td>CE1</td>
<td>39</td>
<td>counselor</td>
<td>Y</td>
</tr>
<tr>
<td>P9</td>
<td>M</td>
<td>Region-E</td>
<td>CE1</td>
<td>51</td>
<td>primary teacher</td>
<td>Y</td>
</tr>
<tr>
<td>P10</td>
<td>M</td>
<td>Region-E</td>
<td>CE1</td>
<td>37</td>
<td>NGO worker</td>
<td>-</td>
</tr>
<tr>
<td>P11</td>
<td>M</td>
<td>Region-E (2)</td>
<td>CM1</td>
<td>49</td>
<td>primary teacher</td>
<td>Y</td>
</tr>
<tr>
<td>P12</td>
<td>M</td>
<td>Region-F</td>
<td>CP1</td>
<td>35</td>
<td>counselor</td>
<td>Y</td>
</tr>
<tr>
<td>P13</td>
<td>M</td>
<td>Region-G</td>
<td>CE2</td>
<td>30</td>
<td>high school teacher</td>
<td>Y</td>
</tr>
<tr>
<td>P14</td>
<td>M</td>
<td>Region-H</td>
<td>CM2</td>
<td>37</td>
<td>literacy counselor</td>
<td>Y</td>
</tr>
</tbody>
</table>

Tab. 3.1.: This Table summarizes the demographics and aspirations of teachers in the Adzope region.

3.3 Methodology
3.3.2 Data Analysis

Table 3.1 summarizes the demographic of our data collection session in May of 2019 and Fig. 3.2 depicts a typical interview session. Interviews were recorded, transcribed, and translated into English before they were analyzed by the authors. We coded the transcripts to identify low-level themes using the aspirations-avenues-agency framework [75, 76]. We synthesized the data by using an affinity diagramming [16] approach guided by this framework (aspirations-avenues-agency) to generate findings to answer our research questions.

3.3.3 Context

This study was conducted in two rural cocoa-producing regions in Southeast and Southwest Côte d’Ivoire (the Adzopé and Soubré region). These sites primarily have an agricultural economy based on cocoa and coffee, which has been the primary source of income of residents for decades [72]. French is the official national language of Côte d’Ivoire but there are nearly 70 local languages, including Attié which is widely spoken in the Adzopé region, as well as mother tongues for each tribal group [126].

Primary School Teachers in Côte d’Ivoire

Primary school teachers are selected through an entrance exam called DECO (Direct Competitions organized by the Examinations and Competitions Department or DECO) with eligibility criteria of secondary school completion. Upon, passing the DECO, teachers undergo an education program in a leadership institute called CAFOP (Centres d’Aptitude et de Formation Pédagogique) for 3 years where they are taught by teacher trainers. Trainers teach pedagogical methods and also closely mentor teachers through internships. Once teachers graduate, they receive tenure in a school [125]. A single teacher teaches all the subjects (e.g., maths, French, social sciences, humanities) for their class. The school is managed by a headmaster who often teaches a class of his own.

Teachers in Côte d’Ivoire have a rigid centralized curriculum and schedule which is followed by the entire country. The ministry offers a guidebook to support the teachers on a daily basis. The guidebook offers lesson plans (fiches) which help teachers conduct the lessons. The lesson plans have guidelines, as Participant 3 (P3) states “There are cards that are established, there is a canvas, there is a methodology that must be respected to prepare the cards”. Additionally, teachers are encouraged
to adapt their lesson plan to create a “learning situation” or an environment for children to learn. Headmasters receive training in management and advising, so they also serve as official support for all the teachers.

**Challenges in teaching**

Although the centralization of curriculum planning brings uniformity to the education system, it widens existing inequalities in rural contexts, thereby increasing the burden on rural teachers. We observed that teachers in rural Côte d’Ivoire had similar challenges observed in other developing countries, such as poor student literacy rates, absenteeism, and working with large class sizes [37, 33]. Many teachers expressed that students had poor literacy skills and they were able to notice this in older students (e.g., CM1 or fifth graders). In fact, a recent evaluation by our team found that 50% of fifth graders in the Adzopé region cannot read an age-appropriate word [67]. Teachers are trained to deal with a class size of 30 students [99], but we found that teachers in rural contexts often have to deal with large classes, of more than 60 students. A large classroom also brings students at multiple levels of proficiency, making it harder for teachers to teach a class and give individual attention to students. Teachers mentioned that students are absent often making it hard for them to catch up with subsequent lessons.

### 3.4 Findings

We describe our findings categorized into sections on teachers aspirations, avenues taken by teachers for their professional development and teacher's agency in technology. Although these sections are interconnected, we have organized our findings to answer specific research questions and highlighted key themes to improve readability.

#### 3.4.1 RQ1: Aspirations

In this section, we explain teacher aspirations and then proceed to individual findings in the subsequent sections.
Teacher Aspirations

We found that teachers’ aspirations were in two categories of (1) community aspirations (or embedded [76]), for students evolution which emerges from their students and their teaching; and (2) personal aspirations for career progression.

Student Evolution: We found that teachers derived happiness in seeing their students evolve academically and professionally. Teachers had smaller goals concerning improved comprehension from students as P11 tells us "This morning you saw that I was evaluating students. I'm happy because I know that at least 90 or 95% understood my lesson". On the long term, teacher aspirations involved their students’ professional success as P1 expresses that "for the 12 years I've been teaching, the first students I taught, some have come out of nursing, some are police officers. When we see that it amazes us, we are happy". This finding resonates with work from other contexts [124] where teachers mentioned that they were vested in their student’s success.

When students come back after 23 years and say, "Sir, you’ve taught us good values and good attitudes when we were children in primary school and those same attitudes have transferred to us, to our work, today". Such remarks make me happy. I do not wait for them to come and give me money, but just that they understand that the good attitudes I instilled in them allows them to live a useful life - [P11]

Teacher Growth: Teachers expressed aspirations to improve their teaching skills to support their class better. Although teachers undergo rigorous training before teaching primary schools, they expressed that often their training did not transfer well to their classroom practice [93, 37]. Teachers mentioned that to fulfill their aspirations for growth they tried learning from their peers and kept practicing for example, P11 talks about writing on the board.

I write well on paper but I found it difficult to write on the board when I started. Today, when I see my writing, I feel it's improved but it could be better. So every day I practice writing different texts on the board to improve my writing. - [P6]

Career Progression: Teachers organically mentioned career progression when we asked them their personal aspirations for the next five years. Teachers expressed that they would like to advance to new roles in education with primary school being a stepping stone towards their long term aspiration. As P2 aptly summarizes"Like any person, I would like to evolve in my career, that is to say, not just stay at the primary level. Personally, move on".
Career Progression Conflicts with Teaching Role

We discovered teachers’ personal aspirations by asking where would they see themselves in five years’ [141]. Almost all teachers said that did not want to continue teaching in primary schools, as P14 mentions “In five years, I will definitely not be a teacher anymore. Even if I’m in education, I’m not sure if I’m still going to be a school teacher”.

Teachers aspired to join positions they perceived to be better than their current role as a primary school teacher i.e., to high school, teacher trainers or inspectors. Although most teachers did not want to continue teaching in primary schools, majority of them wanted to work in other positions in education. To reach those positions, teachers mentioned that they need to qualify in competitive exams and they hinted that it was very difficult to succeed. In fact, all participants hadn’t succeeded during their term (average of 12 years) but they hoped to qualify in the next five years. One teacher mentioned that he attempted the exam all his career but sadly he could not succeed, he has now accepted that he supported his siblings and takes solace that he made a difference in their lives.

I tell you that from 1997 until today when I speak to you, there is not a year where I did not try at least two or three exams. Unfortunately, maybe I’m so stupid that it never worked. […] We had to find someone to help the little ones. Now, I do not feel I have succeeded, but still, I was able to at least help two or three who give me satisfaction today. - [P7]

Some teachers (n=4) organically told us that they chose the teaching profession as a short term solution to support a family’s financial crisis. For example, P11 mentions he was training to become a doctor but his family problems forced him to terminate his education halfway and switch to teaching “I studied for two years in the Faculty of Medicine from 92 to 94 and because of the difficulties with my parents, I applied for a teacher’s post”. Similarly, others mentioned that they tried multiple career choices that did not pan out so they ended up working as primary school teachers.

I always wanted to help others. First, I opted for the army […] unfortunately, it did not work. After that, I tried medicine to help the sick, but that did not work either, hence I became a teacher. So I say to myself that I’m fine where I am, but I want to do more. - [P14]

Therefore these factors tell us that teacher’s career aspirations conflict with their current role as a primary school teacher. Similar to our finding, prior work in Côte d’Ivoire found that teachers chose teaching careers to get out of unemployment or
to transition to other career positions [99]. In context of professional development, teachers in Côte d’Ivoire have little or no incentive for attending these training sessions as documented by the World Bank [18], therefore it does not align with their aspirations to progress in their career.

### Education Role Models Influence Teacher Aspirations

However, the sense of community among educators helped teachers find role models who influenced them to stay motivated towards their education career aspirations as well as inspired them to teach.

> Well, five years, the goal is to go up, to have promotions. As I said, there are people as role models who started in primary education, and today they are counselors, others are college teachers. So it's with this in mind, too, that I'm thinking of five as well - big promotion, with a promotional cost. - [P4]

To understand teacher role models and their influence, we asked participants about teachers they admired while asking them to mention specific qualities about these teachers that they admired. Almost all participants (n=13/14) mentioned that they had a role model in education, many (n=6) admired their colleagues and a few (n=3) organically mentioned that their role models led them to their current career.

We found that teachers not only admired their role models but **teachers drew inspiration from their education role models to advance their career as well as improve their teaching**. P8 expresses this well when she talks about her trainer in teacher education school who inspired her "*whatever you ask for, even if it does not concern teaching, she (trainer) answers. She explains so well that sometimes it makes you want to be like her. [...] She makes you want to teach*".

We found that role models were often teachers in the same school, school principals, counselors, and a few mentioned their parents. Our participants also talked about skills and qualities that they admired in their role models, which they tried to incorporate into their teaching. For example, P3 mentioned her role model was a colleague who proactively learned from his peers which led her to admire him and inspired her to do the same.

> This person (colleague) is always going to others(teachers) to learn [...] This way of doing this person I liked and it makes me try to copy the same thing every time, try to collaborate with the colleagues who have just arrived. - [P3]
In some cases, role models influence a teacher’s career path, for example, P7 mentioned "He’s a gentleman who impressed me a lot. First, by his way of doing, his charisma and then by the way of teaching even, but he was a professor of Mathematics. (And) I became a teacher”. A few teachers mentioned that a parent who influenced their career choice. Some participants mentioned that although they admired their past role models, they were cognizant that today they need to adapt and grow beyond their role models, as P2 expresses "It must be said that the generations are different. So, wanting to look like the model we estimated, it is not possible”.

Our findings replicate prior work that aspirations are embedded in the community as teachers derive their aspirations from their role models who are community members i.e. peers, superiors, or family. We also observe the mutable nature of aspirations as teachers express the generation gap between them and their role models. Additionally, as mentioned in developmental economics and ICTD, we found that role models play a major role in a user’s aspirations [141, 47] but for teachers, they happen to be educators in their community.

3.4.2 RQ2: Avenues for PD

In this section, we give a brief context of professional development (PD) in Côte d’Ivoire and then discuss existing challenges in this environment. In the subsequent sections, we explain how teachers find avenues (or pathways) to overcome these challenges.

Challenges in Teacher Professional Development

Professional development is conducted as workshops for teachers to help them learn new pedagogical methods. Professional development workshops are held outside the village in peri-urban towns. Teachers are required to travel to these locations for a week and then return to implement the new method in their subsequent classes.

It happened in the neighboring village called Ananguie, Our counselors have their offices there. So when there is professional development all the teachers go there [...] then we come back to practice what we have learned. - [P6]

Training sessions are lectures hosted by counselors for teachers of the same grade. School directors have similar training sessions but are trained on the administrative and leadership aspects of managing a school. Teachers mentioned that there could be up to 80 teachers per training session. Teachers expressed that the lecture-style
lessons make it hard for them to transfer their learning back to their classroom. P2 suggested that they could have practical lessons "professional development is like class sessions or sessions in lecture halls. I want it to be a little practical".

Upon completion, teachers are offered teaching material (documents) that are needed to implement the new pedagogical method back in their schools. Teachers use these documents to create a new lesson plan to implement their PD lessons. The lesson plan acts as a guiding tool but teachers acknowledge that they need further support to implement the new method correctly, as P10 expressed "not that everything will be perfect, but at least you have a driver in front of you".

Teachers expressed that the teaching material from PD is slow to transfer to rural areas. Since the class material and the lessons are centralized, teachers find it hard to adopt PD lessons without consistent availability of documents. Even when teachers receive documents, they lack adequate material making it difficult to implement it correctly.

So our problem is the same as I said if there is no material, the current material does not follow the new program. When the material arrives, it comes late after we have started our classes - [P7]

Teachers expressed practical challenges to implement student-centric methods due to cultural nuances. Teachers mentioned that the Western nature of PD required teachers to alter their cultural values to implement it in their classrooms. In Côte d'Ivoire adults have a superior status to children and a student-centric approach conflicts with their social norm.

Today, a child can sit on the table, even stand on the table. If it was the old way, you’d get upset [...] but now you say "Excuse me, come down". You are even obliged to ask the child for forgiveness. - [P6]

Proper implementation of pedagogical methods is overseen by counselors who supervise their region by visiting individual schools. Counselors are ministry officials tasked with mentoring teachers and supporting schools with the administration in a region. As P4 aptly mentioned "this training is followed by class visits, that is, the counselors come to the class to follow how we put it into practice".

During school visits, counselors observe teachers teach in their class followed by a feedback session. Teachers mention that the counselor critiques their teaching and directs them toward appropriate ways of implementing pedagogical methods. Teachers not only get feedback on their pedagogy but they also learn about their shortcomings in their use of support material, classroom management, and teaching behavior. Teachers also mentioned that there is a self-critique (reflection) element
to their feedback so teachers can articulate their shortcomings to explicitly to seek feedback from the counselor.

He chooses certain subjects of the day which you have to teach, he then observes your performance. He will correct your inconsistencies, express what's wrong, express what you should do, how you should lead children so they understand better, and what material you used that was not good. That's why he comes and then, in the end, there is a criticism. First, you make your self-criticism to see if the lesson you have done is past. After that, he makes the criticism, and then he gives you advice on how to improve yourself. - [P3]

Counselors not only evaluate teacher classroom performance, teaching methods but they also foster teacher growth by mentoring and improving their teaching. As OP1 said "I didn't have training in the APC system (teaching method). When the counselor came here, he showed me how to teach the lesson and gave me a supporting document". Therefore counselors are the human infrastructure [120] behind teacher professional development. However, we found that counselor visit frequency varied by region, some regions often had received visits in a month while some had not received a visit in the academic year. In Ivorian contexts, teachers receive teacher training for an average of 2 days a year [67].

In summary, we discovered breakdowns in professional development due to teaching style, transfer of resources and cultural nuances. We also found evidence of tension between Ivorian culture and student-centric PD methods as observed in other developing countries [93, 33] and counselors are the human infrastructure [120] of PD. However, we found that teachers have a strong support system and are creating avenues to implement and access PD which we will discuss in the subsequent sections.

**Teacher Solidarity**

We found that teachers have a strong social bond which creates a sense of belonging. Their social bond leads them to perceive themselves as a family which P10 aptly said "Now, socially, we are a family. We have friendships, we have a solidarity fund [...] which we use to support each other through joy and misfortune". They use the solidarity fund for joyous occasions such as parties and during periods of misfortune such as sickness or death. Their solidarity fund is a physical reflection of their social bond, which helps them collectively handle professional and personal issues. Teacher solidarity expands beyond the school level to a district level and beyond as unions.
Now we teachers of Region2 have our union called the association of teachers Region2. So once someone is touched, it means that all of the Region2 teachers automatically are affected. - [P12]

This finding of teacher solidarity resonates with work in the South African context which discusses the spirit of Ubuntu [51] or the sense of oneness shared by the people in the region. We found that Ubuntu also exists in teachers in rural Côte d'Ivoire. Professionally, teachers use this solidarity to find role models to inspire them (as discussed in the earlier section) or to support each other when they do not have support from the administration.

**Solidarity Supports Accessing Professional Development**

Although teacher professional development has challenges, teachers' work around these problems by leveraging their solidarity. Teachers' sense of solidarity extends to support both personal and professional problems. Teacher solidarity is acknowledged by the administration. P11 (director) mentioned how his school teachers use their solidarity to fill in for a teacher when he is sick.

The solidarity must be created between us because one person can be sick while school is in session and the children have the right to education. But at the same time, the teacher is also entitled to care, being sick, he can not teach. I as the team leader of the school make pedagogical solidarity so I can take his course and work until a certain time and then hand it over to another teacher. - [P11]

Professionally, teachers use this network to support each other when they do not receive visits from the counselor. When teachers need additional mentoring, they support each other by (1) passively advising each other informally, as P11 expressed this sentiment "if I have difficulties in a subject or my perception of something, I approach a colleague and ask for help. We can help each other at this level". (2) they actively seek help by critiquing each other by role-playing as a counselor in each other's classes.

I can teach a course that may be in history, and the other teachers come to observe me. For example, they come to my class, and then note all the mistakes I make. After that, I do my self-criticism, and then they criticize me [. . .], my shortcomings and what to do next time so that it can go better. - [P6]
Teachers expressed the reciprocal nature of support i.e. teachers learned from each other irrespective of experience levels. Each level of experience had something new to offer i.e. more experienced teachers had field exposure and techniques which they had perfected during their tenure while new incoming teachers would bring new methods that they recently learned during their initiation. P6 summarized this well "There are people who have 30 years of service who are there. Often, we go to them, but often by research, we who are new, we also teach some things to our deans, so it's reciprocal".

We found that **solidarity helps teachers find alternate avenues to access professional development**. This finding helps us learn about existing networks of support among teachers which originates from their strong sense of belonging. The sense of community highlights the community spirit of Ubuntu [51] that exists in the South African context, our work shows how this phenomenon is present in teachers of Côte d’Ivoire and how it influences teachers handle breakdowns in PD. Lastly, our finding supplements teacher co-learning as observed in Western settings by Clement et al [24] which we found to exist in the rural context of Côte d’Ivoire.

### Teachers Create Avenues to Implement PD

Teachers of Côte d’Ivoire have challenges in PD implementation as discussed earlier, however, they find workarounds or avenues to handle these challenges. Teachers have a rigid centralized curriculum but they have the freedom to contextualize their lesson plan for their classes. Teachers prepare their lesson plans at home and they acknowledge class preparation to be an integral part of teaching. As P8 mentioned "The most important thing is to prepare my classes at home, read, understand before you come to class. That’s what makes you a good teacher".

(1) Teachers mentioned that they **prepare lesson plans** by supplementing the centralized guideline with relevant content for their classes. They expressed that it is cumbersome to search relevant material for adapting lesson plans for rural students, mainly because the students are below the expected centralized literacy levels.

We prepare our cards (lesson plans) at home by preparing for the lesson you teach, there is a guideline that will show you how to do it for your student's level. You try to adapt the card to the level of your students during the preparation. If your children are high, you try to raise the vocabulary too. Now, for the students of the village, it is difficult to use the complex vocabulary, so it is necessary to tailor it to their level - [P3]

Additionally, teachers mentioned that students' home environment affects learning at school. For example, students in rural contexts are more accustomed to interacting
in their native language (like Attie) at home rather than French, leading to lowered fluency and literacy. As P10 told us "We are in a rural area. French is not easy for these children. They speak more in their dialect".

(2) Since Côte d’Ivoire is multilingual, teachers often face scenarios where they are unfamiliar with the local language spoken by the students and might not be able to communicate with them. However, teachers mentioned that they use **students as resources** to work around this issue to implement their lessons. Teachers use knowledgeable students in the class to play the role of translators to help them teach to students of low French proficiency.

For example, when I say "a mountain" in French, students do not understand. So I ask students, as we are in an area of Attie. "In Attie, how do we say mountain?" He who understands mountain in French says: "In Attie, we say like that". And then the others say "Aaah! What we have just said here, in French, is called a mountain." - [P10]

In our class observation, we also saw that the teachers use older students as teaching assistants to manage the classroom. Teachers also mentioned that they manipulate seating arrangements based on student proficiency to support peer learning. Additionally, we observed a teacher using peer grading among students as an initial evaluation of a test. P14 explains that it’s his own idea to distribute the notebooks randomly among students to grade their peers so they learn.

(3) Teachers are trained to deal with a class size of 30 students and are taught to implement their lesson plans for the same, however, they often had to work with large class sizes. As P9 stated "when you find yourself with 100 students, it becomes an audience. It’s not a class anymore. You speak in noise and it is not easy". Additionally, large classrooms also lead to students of multiple learning levels in the same class i.e. a class can have advanced students who find the material less engaging and lower level students who need additional support. Teachers mentioned that they manage their class using **creative teaching methods**. Teachers implemented their lesson plan to help lower level students by using music, technology, songs and stories to engage students. P10 expressed that he takes a playful approach of shouting like a bird when children are distracted.

When I feel that students are distracted, I imitate the cry of an animal or a bird. I say "Ouhou !!". Then they (students) repeat after me. They see this as a game, so it relaxes them. - [P10]

Teachers face contextual challenges of inappropriate content material, low student literacy, and large class sizes. However, teachers find avenues by preparing lesson plans, leveraging students as resources, and by creating new methods to engage
classes. Although teachers feel that these methods are useful, it is unclear if they are improving student learning outcomes. A study in the region found poor literacy rates among primary school children [67], which suggests there are opportunities for channeling these avenues to improve student learning. Additionally, teachers mentioned that technology played a role in helping them prepare for a class or implement a lesson plan.

3.4.3 RQ3: Technology Agency

This research question is focused on understanding teachers use of technology for professional development. Our focus was on information technology i.e. devices (smartphones and laptops) and common applications used by teachers. We were interested to learn how teachers build agency towards PD using technology.

Teachers' Perceptions of Technology

We found that all teachers had exposure to smartphones and almost all (n=13/14) currently owned a device. They used it for using social media, playing games, and sharing media using Bluetooth services like Xender [158]. WhatsApp and Facebook were the prominent applications used among teachers, matching the global usage statistics of these applications in the developing countries [154]. For teaching, they used dictionary applications to find the meaning of words, conjugation, or searched on Google to find content for their lesson plan.

Teachers expressed a positive attitude towards technology and its benefits to education. They saw technology as a positive force connected with evolution, as P10 aptly summarized "I think technology is a very good thing. Normally, all schools should have computers. As the world evolves, I think schools too must evolve for education to evolve". This positive attitude towards technology is similar to perceptions of teachers in India [144]. However, participants expressed that they were concerned that technology for students needed supervision to benefit their learning.

Generally, what I dread is that, when you give someone a tool (technology), he automatically sees the playful side and that's a bit dangerous. However, if we manage to channel the tool, it's very good - [P7]

Teachers used technology to address this concern by channeling children’s curiosity for technology to engage them in their lessons. Technology supports them to deal with classroom challenges such as managing large class sizes. Therefore, teachers find avenues using technology to tackle contextual challenges i.e. teachers use
technology in non-traditional ways to discipline and captivate their students towards learning.

Children are captivated by my laptop. I do not know if it’s the color or the screen that makes them follow better. When I use my device, they feel more comfortable and they understand better. So if someone talks, I do not use it. We know that at least there is a student who will disrupt the class, I say "as you chatted, we will not use the computer today." -[P6]

Outside of class, teachers used computers to print documents to manage student’s scores or printing their lesson plans. Few teachers mentioned that they were encouraged by the ministry to use technology to prepare their lesson plan and they were open to using it more if they had official orders.

**Teachers Use the Internet to Prepare their Lesson Plans**

Teachers mentioned that professional development is implemented by preparing a lesson plan before class. Although they had preparation material, they expressed that it often does not match the updated curriculum or the tailor to rural students. Therefore, teachers may spend hours searching through various documents to find appropriate content for a lesson plan.

We have the old FPC (old method) documents with us, while the course content uses a competency-based approach (new method). Do you see it? [...] So, today to do a 30-minute course, you can easily spend three hours searching through documents for the content. - [P7]

However, we found that teachers take ownership of this problem and use the internet to help them find appropriate resources for their lesson plans. As P11 mentioned "I am obliged, as a teacher, to search on Google. I either do my research there or I need to use the old documents". Teachers expressed that they either used their smartphone or their computer at home to do internet research. Although they are able to leverage the internet, they also mentioned that it is necessary to adapt the content to support the rural students.

I research using Google for more information and how to better run the course so students can understand. We call this learning situation. I first read a short text orally so that students are centered and captivated in the lesson. They are curious to know the rest of the story so they continue to listen. - [P6]
Although they find value in using the internet, they expressed that this process is cumbersome and it is not easy to use technology, as P6 mentioned "Often, while of searching (on the internet), we have migraines". However, teachers voluntarily chose to spend this additional time after school to find content because they believe this will benefit their students in the long run. Teachers also mentioned that although it is difficult at first, they eventually get better at research and even use their expertise to teach their superiors. P6 summarized this well "Often by research, we who are new, we also teach some things to our deans". Therefore, teachers use technology to build their agency for implementing professional development to support students’ learning.

Using technology to work around the challenges in professional development is an expression of teacher voice [89, 80, 1] against the difficulties in their context i.e. lack of documents and appropriate material. This phenomenon opens opportunities for amplifying and connecting teacher voices [5] to reach higher administration thereby creating a social change in teacher professional development.

3.5 Discussion

In this section we briefly discuss reflections on our aspiration-based approach, which leads us to open questions. We then propose some design recommendations for answering these open questions and conclude with limitations of our work.

3.5.1 Reflections on Aspirations-based Approach

Our research helped us understand teacher needs and aspirations in the context of Côte d’Ivoire. We found breakdowns in teacher professional development which helped us understand their need for mentoring (frequency of visits), contextual support (for rural students), and access to resources (PD documents). However, by understanding aspirations, we learned that teacher aspirations for career progression conflicts with their role as a primary school teacher. The pathway towards achieving their aspirations is through individual performance in competitive exams which does not involve the community (students or peers). Therefore designing technology to address professional development needs alone limits its impact on the teachers as predicted by Toyama [141]. Although technology can play a role in career progression to provide access to mentors or resources, it’s ultimately up to the teachers to build their capacity to use these resources to achieve their aspirations. Social impact for teacher PD is possible when career aspirations align with their role i.e. teachers are incentivized towards their career progression by teaching better,
educational outcomes or attending PD. However, technology can be channeled to act as a catalyst towards influencing policy by amplifying teacher voice. We also observe how a community influences aspirations (or aspirations are embedded [76]) when teachers derive inspirations from their role models or have aspirations for their students. Therefore these community aspirations can be leveraged to motivate and support teacher PD.

We acknowledge that we have scoped aspirations to a teacher's profession but similar scoping has been done by others [17, 76, 117]. More research is needed to understand deeper levels of career-related aspirations, non-career related aspirations, and creating a hierarchy of aspirations [141]. Although we explored aspirations in our work, it is unclear how to channel teacher aspirations towards social change with technology. Furthermore, it is unclear how to balance career and community aspirations or even measure the developmental impact on the aspirations of teachers. We provide some ideas to design technology-based interventions to answer the questions above.

### 3.5.2 Design Implications

We found that a high percentage of teachers had access to smartphones, therefore smartphones can be a medium of design. Designers interested in creating sustainable interventions can draw upon an asset-based approach [104] to leverage existing assets (i.e. smartphones) and applications popular in the context e.g. we found that teachers used WhatsApp, Facebook Messenger, and Google in Côte d'Ivoire. However, we also found that teachers are still learning to use their smartphones. Therefore designers need to be mindful that any new design will need a shallow learning curve so teachers can adopt it. Alternatively, designers can incorporate training when they deploy their technology [56]. As an example scenario, consider a chatbot on Facebook Messenger that mentors teachers on PD. This scenario uses existing technology and has a low learning curve as teachers are familiar with it. We will use this scenario as an example in subsequent sections.

**Balancing Career and Community Aspirations**

We know that teachers' career aspirations conflict with their current role as teachers i.e. their professional success criteria do not intersect with children’s success. Therefore technology design needs to focus on balancing both career and community aspirations to create a social change in teacher professional development. Our data suggests that role models (colleagues, counselors, inspectors) play a dual role to inspire teachers in their career aspirations as well as motivate them to improve their
teaching. Prior work used role models in a documentary to demystify the path to financial independence [134]. Hence designers can use such interventions with relatable role models to inspire teachers towards their career progression while showing examples of good teaching practices. Designers can use role models for best practices using multimedia such as video [4] or audio [79]. Such multimedia can also act as tutorials to change behavior to help teachers adopt technology into their curriculum. However, care must be taken to focus the role models in the primary school domain so teachers are motivated to improve themselves in their schools while being inspired to advance their careers. Using our chatbot scenario, teachers can be shown videos of role models performing a teaching method to inspire them to implement PD methods. Additionally, the same role models can talk about their success stories and strategies motivating teachers towards their career progression.

**Measuring Impact on Aspirations**

Prior work on measuring the economic impact of aspirations [81] used a self-efficacy scale to measure the perception of the user's agency. Since the agency is built towards achieving aspirations [75], measuring perceived agency can help understand a user's present circumstance towards their aspirations. Therefore researchers interested in designing and measuring teacher aspirations can utilize self-efficacy scales to measure the impact of their interventions on teacher's perceived agency (or self-efficacy). Prior work in a controlled environment found that building teacher computer self-efficacy could influence teacher self-efficacy in PD [38]. Therefore designers can extend this research to learn about teacher aspirations and technology in a long term field setting for PD. Additionally, researchers can create custom scales to focus on individual aspirations i.e. student evolution, teacher growth, and use self-efficacy to measure the impact or relationship between each aspiration. Using our chatbot scenario: if the goal of the project is to improve student learning, then a customized self-efficacy for student evolution can be used to evaluate the intervention.

**Designing for Social Change using Feminist HCI**

Although we learned about teacher aspirations, it is unclear how to channel their aspirations towards a social change. To bring about a social change, we recommend a Feminist HCI [12] approach towards supporting teachers with their professional development. The feminist HCI approach is inspired by feminism and provides guidelines for designers to balance societal problems while preventing marginalization of social groups (in our context teachers). Feminist HCI (through pluralism
and participation) suggests different users (teachers) need individual support therefore there is no universal design. Therefore designers can learn from these ideas to provide personalized [23] and adaptive technology [69] to support individual teachers. Using our Messenger chatbot scenario: Artificial intelligence could be used to provide personalized support to teachers with each teacher having individualized support.

Teachers have strong solidarity to support each other and this phenomenon can be leveraged to build online forums to expand their support network. These forums can provide pathways for teachers to seek mentoring, acquire role models, or express their voice. We found that teachers express their voice against challenges in the context by inventing new methods and finding innovative uses of technology for their PD. Designers can channel these activities towards amplifying community voices for social change [5]. To promote a social change, designers can leverage the concept of advocacy (from Feminist HCI [12]) to allow political expression. To allow teachers to have a political voice, designers can include administrators i.e. directors, advisors, and ministry officials [25, 79] who can draw insights from communal phenomena to make official decisions. Using our Messenger chatbot scenario: a summary of teacher challenges surmised from chatbot interactions can be sent to the regional advisor to prioritize his visits to mentor teachers.

3.5.3 Limitations and Future Work

We conducted our research in two regions but we focused on aspirations only in one region. Future research can address if teacher aspirations vary by region. Secondly, although teachers have a social bond it is unclear if this bond transfers to a technology media. Participants mentioned that an unofficial Facebook group for teachers exists in Côte d’Ivoire but some said they weren’t active users because they preferred in-person communication. Therefore, future work can learn about social media usage by teachers and understand how much of their social interactions transfer online. Although we did not specifically ask for career aspirations, teachers organically mentioned that they would like to change their career in the next five years. We expect there could be an availability bias as preceding questions in the interview were on their professional life. Future research can focus on encouraging participants to discuss deeper levels of career aspirations or alternative ones such as having a family, building their own house or achieving fame.
3.6 Conclusion

Teaching is challenging in rural contexts in developing countries because of contextual challenges that lower teacher motivation and educational outcomes. Teacher motivation and educational outcomes can be improved by teacher professional development programs but these programs are limited by poor infrastructure in rural areas. Although infrastructural challenges can be overcome by information technology today, it is unclear how such technology can support teacher training. Therefore to explore opportunities to promote social change in teacher professional development in low resource contexts with technology, we conducted a qualitative study with 22 teachers of rural Côte d'Ivoire by following an aspiration based approach. Our findings reveal that (1) teachers aspire to achieve higher posts in education which conflicts with their current role as a primary-school teacher; (2) teachers have a solidarity which helps them (a) find role models for their career and teaching, and (b) tackle breakdowns in professional development; and (3) teachers also take ownership of their professional development by finding workarounds by inventing new methods, taking student support and using the internet to prepare their lesson plan. Based on these findings, we discuss design directions for balancing teachers’ community and personal aspirations, ideas to measure aspirations and provide implications for designing for social change in teacher professional development.
4.1 Overview

The goal of study 2a was to explore the feasibility of a conversational agent to support rural teachers. I derived from study 1 that teachers used smartphones and were already using them to support their work.

The previous chapter described teachers’ smartphone usage in rural Côte d’Ivoire. I learned that teachers had challenges in professional development but used smartphones to support their classroom teaching. In this chapter (refer Fig 4.1), I describe the initial designs of a conversational agent to support teachers in pedagogical programs. Prior work in conversational agents has shown promise to support scalable interventions, but it is unclear how to translate such interventions for teachers in places like rural Côte d’Ivoire. Therefore, I built DIA a conversational agent to scale expert knowledge and support localization. I chose DIA as a it is short for DIA-logue flow [32] by Google, which was used in the earlier version of the system. The later iterations of DIA uses Rasa [97] an open source framework.

This chapter (refer Fig 4.1) addressed the following research question.

**RQ1:** What is the feasibility of a conversational agent (DIA) to mentor teachers in low resource contexts like rural Côte d’Ivoire?

4.2 DIA

Therefore, we developed DIA a human-chatbot (humbot) hybrid system to design chat-based interventions for low resource contexts. Our tool is a human chatbot

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1DIA (pronounced as diya) also means lamp in Indian culture, which is a symbol for light and positivity.
hybrid designed to scale expert knowledge. We designed it for social media to improve sustainability and to allow local-language interaction to support emergent users. Users interact with the system using social media messaging platforms such as Facebook Messenger or WhatsApp. An NLU (Natural Language Understanding) engine parses user response and returns a response from the appropriate module of (1) Automated intents, (2) Knowledgebase or (3) request help from an expert.

(1) **Intents** consists of simple pre-built conversations for engaging in small talk (such as greetings, introductions, jokes). These pre-built intents are triggered upon a keyword or a specific command for e.g. *Tell me a joke*. Another set of intents is dynamic and ideal of task-specific conversations. Task-specific conversations are classified into two modules of actions and surveys.

- (1a) **actions** which are scripts tasked with local computation (e.g. dictionary, calculator) or fetching information from the internet (e.g. Wikipedia). This information is parsed and returned to the user with an excerpt and a link if applicable. e.g. *(What are the citations of Kant?)*

- (1b) **surveys** that can be used to gather qualitative or quantitative data from the user by asking sequential questions. The survey module can also be used...
to send information with text or multimedia (videos, audios, or pictures) to create a human conversation. e.g. (In which school do you teach?)

(2) Knowledge-base is the database of content-specific questions that form the core curriculum of the chatbot interactions, they are curated by seeding the chatbot with data initially or by dynamically building from the database by interactions with experts. e.g. (How to Implement TaRL?)

(3) Experts form the final source of content when the chatbot fails to assign appropriate automated response. Our system gives the user a choice to request help from an expert, following the HCAI principles [3] e.g. (I am sorry, I don’t know the answer to this, would you like me to ask my superior and get back?)

All the data is stored in the database to add expert interactions to the knowledge base and improve the agents’ linguistic capabilities. Therefore over time, expert knowledge can be populated to the database leading to more automated and natural interaction. The interactions described so far have been user-initiated.

DIA can initiate interactions by sending personalized bulk messages [109, 29] to the users which can be used to trigger conversations or conduct surveys. The survey questions are monitored by the administrators who can add or remove questions from the dashboard. The qualitative and quantitative data collected from user surveys can be used to collect insights about the community. Lastly, the system can also detect the read status of the user to understand internet usage and different forms of user engagement.

This study is part of an ongoing research program on supporting literacy in cocoa farming communities in rural Côte d’Ivoire. This project aims to improve child education through poverty reduction and improved educational quality. Educational outcomes [53, 46] can be improved by teacher training but implementing such interventions in rural areas is challenging due to infrastructural issues and lack of available teacher trainers [15, 61]. Recently in Côte d’Ivoire, a new teacher training method i.e. Teaching at the Right Level (TaRL) has been implemented by the TaRL Africa team [137] in collaboration with the Ivorian Ministry. Prior research has shown the success of this teacher training method in Indian and other African contexts [9, 136]. This project is a collaboration with the TaRL Africa team to learn the feasibility of DIA to mentor more teachers in the teacher training method (NewMethod) with technology. We conducted a pilot study in Méagui a rural area of Côte d’Ivoire during the NewMethod implementation session of January 2020. The research team introduced the teachers to the WhatsApp assistant during the NewMethod training classes and we instructed teachers to chat with the assistant to seek support with NewMethod. We also told the teachers that the chatbot can answer questions outside TaRL but our system will prioritize answering questions related to
NewMethod and teaching. Teachers were not given any incentive to interact with the chatbot. We conducted the study for 4 weeks to answer the following research question.

**RQ:** What is the feasibility of a conversational agent (DIA) to mentor teachers in rural contexts in low resource contexts like Côte d’Ivoire?

### 4.3 Field Deployment

To conduct a preliminary evaluation of our system, we received IRB approval from the University of Delaware (protocol 1478038-1) and we deployed DIA on WhatsApp to mentor 38 teachers in the rural context of Côte d’Ivoire for 4 weeks. The system was developed using Flask [39] (a Python framework) and Twilio [@142] to support interactions on WhatsApp. We used DialogFlow [32] for basic intents (i.e. for small talk, jokes) and writing custom functions in Flask for complex intents (i.e. Wikipedia, conjugations, calculator). We built our knowledge base using the TaRL manuals and we used cosine similarity to match the appropriate response. Lastly, we built a dashboard where researchers played the role of experts and answered questions referring to the manual on the teaching method [135] and Google search for complex questions.

![Fig. 4.4.](image)

*Fig. 4.4.*: This figure shows the cumulative usage of DIA by the teachers every hour. We see that teachers use the system on Saturday afternoons or after school hours.

We deployed the bot for 4 weeks and learned about the feasibility of using DIA for supporting teachers in rural Côte d’Ivoire. Teachers were encouraged to use the system whenever they needed support with teaching and there was no incentive provided for using the chatbot. Teachers interacted on a total of 2132 messages (930 from users), more than 98% of the conversation used accurate French words (indicating teachers usage of autocorrect). Although we intended the bot to be teaching method focused, we received a total of 97 questions related to education, football, current affairs, health, and finance.
The Fig. 4.4 above shows the usage of the chatbot for 4 weeks. Teachers communicated most with the chatbots on Saturday afternoons, during their breaks (12:30-2), or after class. We inferred that teachers do not have access to the internet daily through message delivery logs. We also conducted chat-based surveys about the teaching method and sent motivational messages to the teachers. We observed that all 35 teachers answered the initial entry survey of 8 questions, 32 (91%) teachers answered 12 follow up questions in the first week and 12 (34%) answered all questions by the end of 3 weeks with approximately one reminder a week.

4.4 Discussion

Our current implementation had some workarounds to function smoothly on WhatsApp. Firstly, WhatsApp API [153] restricts free-form interaction with the user in a 24-hour session, beyond which only template greetings (e.g. Your code is XYZ) are allowed to be sent to the user. Since the pre-approved templates in Twilio [@142] were in English, we added a French question after the English template which may have led to low survey feedback from the teachers. Secondly, we had to break a few conversational guidelines [48] for designing chat interactions to speed up prototyping (press 1 for contacting an advisor while chatbot design guidelines suggest that conversations with agents must be natural). For future work, we intend to fix this limitation by contextualizing the chatbot conversations for local contexts through Wizard of Oz [26]. In our pilot study, our research team answered questions which the chatbot could not answer as this study was intended to understand the feasibility of the intervention. In the next phase of the project, we plan to provide opportunities for administrators to support teachers mediated by the chatbot similar to prior work [140]. Additionally, we acknowledge that our system although intended to support the design of chatbots for emergent users in developing contexts has been piloted in a rural context. We expect more research is needed to understand the feasibility of DIA in other emerging economies in Latin America or the Caribbean. However, we expect our work has given a platform for future researchers to leverage our system to design chatbots in developing contexts.

We see opportunities to extend DIA using Crowd-AI architectures like Evorus [57] to seek support from novices to automate meaningful conversations to reduce the load on experts. In addition to using the architecture, research can learn from novices instead of crowd workers to use voting for content moderation like Sangeeth Swara [147] and content generation like Avaaj Otalo [102]. Such systems can also be used to build a crowdsourced corpus of languages with fewer data sets [115].
Furthermore, *DIA* can be used to expand research on microlearning in developing contexts by utilizing Intelligent tutors [77] on social media. The Knowledge-base from *DIA* can be used as a question bank to test users through multiple choice questions or short answers. Multimedia can be used to provide enriched content such as GIFs or short videos to create engaging conversations and questions [128]. Additionally, short and progressive incentives can help users stay motivated to complete the lesson and to cover their internet costs [133] or provide them with an additional source of income [149].

In summary, we observe from our preliminary deployment that *DIA* is feasible to mentor teachers in low resource contexts like Côte d’Ivoire. *DIA* helped us collect a database of topic-specific questions from teachers and understand the unique mobile phone usage of teachers in rural contexts. We learned that teachers use autocorrect in French through chat logs and teachers use the internet on their smartphones intermittently during the week through message delivery logs. We were also able to collect teaching-related survey responses from teachers. Although all teachers answered the first 8 questions, only 35% of teachers answered all 20 survey questions. We see opportunities for building on this research to design chatbot based interventions for the developing world.
Study 2B: Design

"We dream of climbing the ladder, to get there, we have to do our job better".

— D1
Designing for Teacher Aspiration

5.1 Overview

![Diagram](image)

Fig. 5.1: The goal for study 2b was to extend theory (aspiration) to technology (conversational agent) designs to support teachers with pedagogical programs.

Study 1 explored teachers’ smartphone usage and their aspirations in rural Côte d’Ivoire. I learned that teachers use smartphones to support their classroom teaching and address challenges in professional development. Although prior work has used smartphones to support teachers, it is unclear if chat applications like WhatsApp—which many teachers worldwide use—can help teachers sustainably in rural Sub-Saharan Africa with low internet infrastructure. Therefore, in Study 2A, I built and evaluated DIA a conversational agent to scale expert knowledge. I learned that such designs were feasible to support teachers’ early system deployment [19]. Additionally, in study 1, to extend aspirations theory to conversational agent designs, I discovered that teachers aspired to benefit their students through teaching and progress in their career hierarchy to become trainers. However, it is unclear how these teacher aspirations intersect with new implementations of pedagogical programs.

Thus, in this chapter (refer Fig 5.1), I explore this design space for pedagogical programs, teacher aspirations, and conversational agents in low resource contexts. In study 2B, I conducted two related studies to examine the use of such technology
in this design space. The first was a qualitative study with 20 teachers and ministry officials in rural Côte d’Ivoire to understand opportunities and challenges in technology use for these stakeholders. Second, I used our data from Study 2A as a conversational agent probe over WhatsApp to uncover realistic use cases from these stakeholders. In this chapter, I address the following research questions:

5.2 Research Questions

**RQ1a:** Given prior findings on the limitations of connectivity and infrastructure, what are the opportunities and challenges for technology to support teachers’ implementation of a new pedagogical program in low infrastructure contexts like Côte d’Ivoire?

**RQ1b:** Based on their use of a technology probe, how do teachers engage with a technology like a conversational agent?

Finally, to explore sustainable designs using a theoretical lens on aspirations, we investigate:

**RQ2:** How do teachers engage with the implementation of a new pedagogical approach in rural Côte d’Ivoire?

5.3 Study Design

This study is part of an ongoing research project to improve children’s education in rural Côte d’Ivoire through poverty reduction and improved education for rural cocoa farming communities. An interdisciplinary team from Ivorian and North American universities conducted this study in partnership with the Ivorian Ministry of Education. We received approvals from all our institutional boards (Carnegie Mellon University protocol STUDY2019_00000510) and the Ivorian government to conduct the study.

5.3.1 Site Description

We conducted the study in a southwest region in Côte d’Ivoire. French is the official language of Côte d’Ivoire, but there are nearly 70 local languages [126]. This site primarily has an agricultural economy based on cocoa and coffee, which have been residents’ primary source of income for decades [72].
The study site is a rural farming town in the Soubré region. It has a few urban schools inside the city, while the remaining rural schools are distributed in communities away from the city. Communities situated away from the city have lower infrastructure: i.e., they lack adequate water, electricity, and telephone signal. Remote communities have poor road conditions, which further impedes travel and increases their isolation. Students in these rural communities have low literacy rates, influenced by the rural context and low infrastructure [83, 82] 1.

A year before the study (2018-2019), the site hosted a new pedagogical program (NewMethod) to improve students’ foundational math and French skills. The program found successful improvements in students’ skills in initial pilots. These initial successes inspired the NGO to scale the program to many schools in the region.

5.3.2 Background on NewMethod and Teacher Training

The NewMethod program is a teacher training program implemented by an international NGO. This program aims to improve foundational math and French of 3rd, 4th, and 5th-grade students. Teachers first perform a baseline test to split the students into three groups by their learning proficiency. Throughout the year, teachers conduct activities with these groups of children in dedicated 45 mins slots every day for French and mathematics skills. These activities are child-centered and playful to deliver instructions at a skill-appropriate level. Teachers test the students again during the middle and the end of the year to evaluate the student’s progress.

The NewMethod program is embedded in the Ivorian education system and utilizes the stakeholders in the ministry to implement and monitor the intervention.

Teachers form the main stakeholders. NewMethod uses 3rd, 4th, and 5th-grade teachers to implement the activities. The NewMethod program encourages teachers to play the role of facilitators. NewMethod activities use hands-on games to teach foundational skills to children.

Directors are senior school teachers appointed by the inspector to manage the school. Directors act as the first line of support for the teachers for NewMethod; they receive special mentorship training and coordinate the NewMethod activities in the school.

Pedagogical advisor is a remote mentor who visits schools and provides teachers with professional development support. For NewMethod, pedagogical advisors

1Note: More details about typical school setting and teaching can be found in our prior work [20] in section 3.3.1
Fig. 5.2.: A typical NewMethod activity in a rural setting. Students are split into levels based on proficiency in French and math. At each level, they participate in participatory activities for 45 mins a day for each subject led by their teacher.

visit schools to observe teachers perform NewMethod activities and guide them to implement the method correctly.

Inspectors serve as administrative and pedagogical supervisors for the region. Inspectors visited schools to observe teachers implement NewMethod and motivated them.

Master trainers are high-ranking ministry officials specializing in pedagogy. Master trainers supported the teacher training and visited schools to observe the teachers.

Teachers receive training for NewMethod in week-long workshops before implementation. These workshops are held at a school near the city; most rural teachers temporarily stay in the city to participate in workshops. Our research team started the research project during the NewMethod training workshop at the study site in February 2020.

5.3.3 Data Collection

Our data collection team consisted of a US-based HCI researcher and a linguistics graduate student from Côte d’Ivoire. The data collection was conducted in French by an Ivorian researcher with help from a US-based researcher with moderate French proficiency. We described the study and the purpose of our visit during the welcome keynote session. The Ivorian researcher verbally explained the research and the protocol risks to each participant before collecting data. The Ivorian researcher obtained individual participants’ oral consent as appropriate in the context.
Tab. 5.1.: Summarizes our data sources collected by the team

<table>
<thead>
<tr>
<th>Observations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>∼70</td>
</tr>
<tr>
<td>Duration</td>
<td>6 days (9AM - 5PM)</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Teachers ∼60, Directors: 4, Master trainers 2, Advisor: 1</td>
</tr>
<tr>
<td>Timeline</td>
<td>(Week 1) - during NewMethod training</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surveys</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>37</td>
</tr>
<tr>
<td>Gender</td>
<td>Female: 9 Male: 28</td>
</tr>
<tr>
<td>Stakeholders (4)</td>
<td>Teacher: 28, Directors: 6 Advisors: 2, Inspector 1</td>
</tr>
<tr>
<td>Timeline</td>
<td>(Week 1-3) - mostly during training</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interviews</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>20</td>
</tr>
<tr>
<td>Gender</td>
<td>Female: 3 Male: 17</td>
</tr>
<tr>
<td>Stakeholders (5)</td>
<td>Teachers: 10, Directors: 4, Official: 6</td>
</tr>
<tr>
<td>Schools (4)</td>
<td>Urban: 1, Rural 3</td>
</tr>
<tr>
<td>NewMethod Observations</td>
<td>10 hrs</td>
</tr>
<tr>
<td>Subjects</td>
<td>CP1-CM2 (3rd-6th grade)</td>
</tr>
<tr>
<td>Timeline</td>
<td>(Week 1-3) - after training</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conversational Agent Probe</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>38</td>
</tr>
<tr>
<td>Duration</td>
<td>14 weeks</td>
</tr>
<tr>
<td>Timeline</td>
<td>(Week 1-14) - after training, till the end of the academic year</td>
</tr>
</tbody>
</table>

Study participation was voluntary, and participants were not compensated for any method.

We collected data for three weeks through observations, surveys, and interviews. We also deployed a conversational agent probe to 38 teachers to learn technology use cases to support teachers. Table 5.1 summarizes the data collected from these various methods.

Field Observations

*NewMethod* training involved about 60 teachers from selected schools in the region. The teacher training had a tight schedule from morning to evening, with a few short breaks and a lunch break in the afternoon. Directors and pedagogical advisors led the program and frequently selected a teacher from the group to guide the activity. A selected individual role played as a teacher implementing the activity, and the rest role-played as students. After a few mock sessions, there was a question-answer session where the teachers answered questions raised by their peers. Often when a question was challenging, they would ask the directors or master trainers. To support inexperienced teachers, directors assigned tasks such as note-taking or
leading activities to increase their involvement. Although the training was rigorous and formal, directors lightened the mood by occasionally introducing informal activities like singing and dancing.

The research team observed and participated in the activities throughout the week. These observations helped us understand the NewMethod program and the various classroom activities implemented by the teachers. We were able to glimpse the situated struggles (sitting on the floor for long-duration, heat) and bonding experiences (singing, dancing) during this challenging week. We recorded our field notes and discussions in our research journal and used these lessons to refine our questions for our surveys and interviews. NewMethod observation data is used for RQ2 5.4.3.

**Surveys**

We used a Google form in French on a tablet to conduct surveys. The surveys had questions to understand participants’ technology and social media usage, demographic questions, and questions related to NewMethod to get initial perceptions of teachers. Responses helped us structure our interview protocol. Fig 5.3 depicts a survey session in a school where the interviewer is helping the teachers. Survey data is used for RQ1a 5.4.1.

Participants were given the tablet device and encouraged to complete the survey independently. Participants often requested help navigating the sections of the Google form and requested clarification for specific questions. The surveys took approximately 30 mins. Thirty-eight participants responded to the surveys (29 teachers, 6 school directors, and 3 advisors). Most survey responses were recorded during breaks or after the teacher training sessions. We also collected additional responses from participants during interview sessions if they hadn’t attempted it before.

**Interviews**

The week after the training, the research team observed baseline tests and the first week of the NewMethod activities. We collected photos, videos, and a diary of events and had various discussions offline to understand the training teachers’ perspectives. We also interviewed teachers during these observations to get contextual information about the program.

We chose four schools (one urban school and three rural) after discussions with the pedagogical advisors and master trainers. Schools were chosen to observe NewMethod in different locations and interview the stakeholders to get a holistic
understanding of NewMethod at the study site. We interviewed the director and 2-3 teachers for every school based on their availability. The interviews were conducted with voluntary verbal consent from the participants, and they were offered no compensation for participating. Individual interviews of between 1-1.5 hours were performed, with our field team conversing personally with ten teachers, four directors, two advisors, and one inspector. We also report data from our discussions with three master trainers from 2019. Interview data is used for RQ1a 5.4.1 and RQ2 5.4.3.

Conversational Agent Probe

We then piloted a conversational agent technology probe [59, 157, 22] during the NewMethod training workshop (Fig 5.6) January 2020. Probes, as per Hutchinson et al [59], are a design method used to co-design technology with users to learn their needs and desires in real-world settings. Using technology probes also helps researchers learn from the usage data to inspire new design directions. The probe was designed using prior work [19], and was intended to support teachers during NewMethod implementation. Our conversational agent employed a humbot architecture, with a database [19] of frequently asked questions about NewMethod which were answered automatically (Fig 5.4 B). When questions fell outside this database, teachers could ask for help (Fig 5.4 A). If teachers requested help with a particular question, it would be flagged in the database, and teachers would receive the answer in a few days (Fig 5.4 C).

We instructed teachers to ask questions to seek help during implementation, i.e., after the training workshop. We also told the teachers that the conversational agent
would prioritize answering questions about *NewMethod* and teaching but they were free to ask any questions outside *NewMethod*. Teachers were free to ask questions at any time and were not given any incentive to interact with the conversational agent. Researchers responded to questions referring to the *NewMethod* manual on the teaching method [135] and Google search for complex queries. We found that teachers used the system outside school hours intermittently during the week, i.e., with peak usage on weekends or during evenings on weekdays (refer to our prior work [19] for more information on usage insights). The log data from teachers’ questions are used to answer RQ1b 5.4.2.

Fig. 5.4.: A representative screenshot of our conversational agent probe [19]: (A) the agent asked the user to type “1” to request human support if the question was outside the database. (B) the probe had some questions related to *NewMethod* and returned responses immediately. (C) When the team answered the question, the agent returned the answer with the user’s question.

5.3.4 Data Analysis

We used qualitative analysis to analyze the (1) observations and interviews and the (2) conversational agent log data.

(1) We combined observation notes and interview data from our field into a single data set. We transcribed and translated the interview data into English and formed the low-level themes using thematic analysis [21, 132, 94, 16] to synthesize the themes for our research questions.

We use the *aspirations-avenues-agency* framework [75, 76] to annotate our themes. *Aspirations* translate to longer-term desires [141], *Avenues* are pathways both traditional and non-traditional that users take towards fulfilling their aspirations [114] and *Agency* is the capacity that people build to create these avenues [75].
also use this framework to situate our findings with our prior work on teacher aspirations [20] and extend this analysis to a pedagogical program.

(2) We transferred the questions from the teachers (110) to a spreadsheet after an initial data cleaning. We translated the questions from French to English and then annotated them into codes, e.g. (Grammar questions, History quotes). These codes were categorized based on the type, i.e., Math; History was classified into "Subject." Finally, these categories were grouped into seven higher-level themes. Table A.1 summarizes our codebook.

5.3.5 Self-disclosure

Our team consists of HCI researchers, economists, and linguists. We are based in North America and Côte d'Ivoire and have conducted research in various developing regions. The first author and the second author are from developing countries, and they formed the protocols and analyzed the data after discussions with the Ivorian team and faculty. We picked conversational agent as a design direction based on our conversations with our partner NGO's team members. Our goal with the subsequent studies is to deploy and evaluate this intervention at scale. The long-term goal of our project is to support teachers with low-cost technology to implement the pedagogical program.

5.4 Findings

We now discuss key themes from our interviews with the teachers around their (1) NewMethod and technology, and (2) NewMethod and aspirations. We then use these findings to discuss the importance of designing for aspirations.

5.4.1 RQ1a: Technology Opportunities and Challenges

This section describes existing smartphone use by teachers, initial perceptions of new technology, and cultural themes relevant to technology design.
Opportunity: High smartphone adoption, demand-driven internet access

Smartphone access was pervasive among teachers at the study site, and they used it more during the weekends. 33/37 had access to smartphones, and they often had multiple SIM cards from different service providers (MOOV, MTN, and Orange). 21/37 had more than one SIM, 8/37 had all three operators and the rest had one SIM. All had at least one Orange SIM. Teachers switched SIMs for better phone networks, internet, and phone call rates. Teachers mentioned they used their smartphones often to make phone calls and send messages. Teachers said that they used technology after school or during breaks in the context of teaching.

*I use it once a day, but it depends. Since I work from Monday to Friday, I use my smartphone on weekends than during school hours on working days. In short, it’s more during my days off because I have time and I don’t have the pressure of preparing for lessons, correcting a notebook* - T3

Teachers said that internet access was a luxury and network access varied by location. Most teachers mentioned that they would connect to the internet only if they needed something, i.e., such as searching for something on the internet or accessing social media. Teachers used internet passes, which temporarily gave them a quota of data to access the internet. Our survey data showed that teachers spent ~1000 CFA (~$2) per week on the internet. Internet access was also dependent on the presence of a phone network in their schools and homes. Teachers who lived in urban areas had access at home, but teachers in remote areas connected if they traveled to the city on weekends. Among social media, teachers said Facebook Messenger and WhatsApp are prominent tools for one-on-one interaction due to their convenience and privacy.

Opportunity: Technology usage for professional development and peer support

Teachers used their smartphones for learning new terms on Google and French vocabulary. They used offline applications to look up the meaning of new words in dictionaries and find verb conjugations. According to our survey data, 26/32 teachers used technology to support their classrooms.

*I may use the phone at school when I need to know the meaning of a word. I research on the internet to get the answers. It’s fast on the internet. Some verbs are difficult to conjugate, so I download applications that allow me to work easily.* - T3

Teachers used phone calls to interact with their peers about their professional development. They would call other teachers to discuss a teaching practice or a
problem in the classroom. They chose to perform these activities outside class hours. Teachers said they had both requested and helped others through these phone calls. Here, D1 tells us how she calls her friends in the morning.

Classes start at 7:30 a.m. and already at 7:10 a.m., I’m here so I have time to call [a teacher] to ask them: this is such a lesson, or this is such a difficulty that I encounter and how can you help? - D1

**Challenge: Smartphone adoption by advisors was limited**

Unlike teachers, advisors and trainers did not use smartphones regularly. We observed that trainers did not have smartphones or were still learning to use their devices to access the internet. Master trainer (MT2) had a tablet but accessing the internet drained his battery considerably. Maintaining phone batteries was important because trainers traveled regularly, and they needed their devices to make phone calls to plan their school visits. Advisor (A2) had a smartphone at home, but it did not have internet access as it didn’t have a SIM card. He mentioned that his grandkids used the device to play games, and he used the basic phone to make calls. Their prior phone usage patterns, busy travel schedules, and nature of work inhibited them from using the internet on their smartphones.

**Opportunity: Initial social media and smartphone usage for the pedagogical program**

Teachers also mentioned that they use informal teacher support groups on social media, but social media support for NewMethod was still surfacing and limited to directors. Directors mentioned informal social media groups about NewMethod where they could post questions related to the training activity. Our surveys found that 10/38 participants were members of the unofficial Facebook group for NewMethod directors, and 5/38 knew about it but were not members. D2 mentioned that they would get support for their problems after class. These informal groups were piloted for selected directors, and NewMethod team wanted to extend this support to teachers.

Yes, we created a NewMethod Facebook group, when we had difficulties at the beginning, you could express your problem in the group, and the other members of the group bring solutions, but it is in the evenings that this is happening. There is also a WhatsApp group where we expressed our difficulties. - D2

Lastly, teachers mentioned that multimedia could be helpful in learning activities. We found that directors shared photos and videos of themselves performing the
activity on the Facebook group. These posts received better engagement and created a sense of camaraderie. D4 echoes the utility of multimedia to explain a method to a teacher: *I had images and a video of the session with them (NewMethod team) that I showed him. I lifted [the stick], I present when it goes in the other hand and say 'ONE!'. He looked at the video and saw that it matched what I did.* - D4

**Challenge: In-person visits had a socio-cultural benefit that could not be substituted by technology**

Advisors, inspectors, and the NGO explained the importance of visits they believed technology could not substitute. A2 explains that meeting teachers and the students provides a human connection that is not into technology. He mentions how he encourages teachers and reinforces their influence on their students.

*Advisor: When I visit teachers, I tell them that what they are doing is good. For example, when I observe children who can write, I tell them that they [their teachers] are doing a good job and the reward is not far. We must help teachers, encourage them, and tell them that they are good and can still do better.*

*Interpreter: can you do it on the phone?*

*Advisor: We can do it over the phone, but it is not enough, we have to go to the field, and the phone alone is not enough.*

Inspector explained the importance of visits which went beyond monitoring but to forming a social connection. The inspector said that teachers feel isolated and need additional social support to help them overcome their struggles. The awareness that their superiors cared enough about their work to visit them improved teachers’ motivation to work harder. I1 expresses the benefits of in-person visits:

*There is a psychological effect, the fact that the teacher knows that we will come to see him puts him more to work, then on the other side the advantage is that he feels he is not alone. By coaching him, he is also more motivated, and he sees that it is not a solitary adventure.*

Despite this perceived value of presence, teachers suggested that they are open to using technology for the pedagogical program if a tool helped them reduce dependence on the advisor. They were mindful of internet access challenges but were willing to spend money if it benefited them. Here T6 expresses his feedback on a storyboard (Fig. A.1,A.2):
We can work with the tech if there is an application available with certain information that can help us simplify and improve our work while allowing us not always to call on the advisor for certain things.

5.4.2 RQ1b: Conversational Agent probe usage

Teachers used the probe for 14 weeks, without incentives. The system was deployed in the context of COVID-19, which was at its peak during weeks 8-12 in the country, and schools were closed during the lockdown. Although schools reopened in 4 weeks there were attendance restrictions due to social distancing, NewMethod implementation was halted after the lockdown for the safety of the students.

Teachers asked a total of 110 questions to the probe. Our analysis revealed six higher-level themes as shown in Fig 5.5.

![Question themes by week](image)

**Fig. 5.5.:** Summarizes key themes and their distribution over the duration of the study

Training (24%): high to low level understanding of the program

Pedagogical training questions progressed from questions about goals and motivation, to operational questions, and finally to activity implementation. Initially, teachers asked for general information related to NewMethod, e.g., teachers were interested in the objective of the pedagogical program: *What is the purpose of NewMethod?*. Later questions were related to NewMethod operations. For instance, teachers were curious about why lower grade students (primary students in the first two grades) were not exposed to the program: *Why is NewMethod not implemented*

This number was likely affected by the sudden COVID disruption, beyond challenges of internet access in the context.
in CP2?. Finally, we saw activity-level implementation questions during implementa-
tion: How to carry out a NewMethod activity on the image description, and meta-level
questions: How to arrange activities for better learning?. These categories and trends
hint at different levels of needed support, i.e., general to specific implementation for
pedagogical programs.

Subject (27%): short questions about classroom knowledge

We observed that teachers frequently asked questions related to disciplinary sub-
jects from their classroom teaching; in fact, this was the most prominent theme
seen consistently across weeks, see Fig 5.5). Teachers asked questions related to
Geography, History, Maths, Science, and Grammar, i.e., subjects that they taught at
school. These questions were short answer questions, such as geographical facts
What is the smallest state in the world? or quotes from history What are the citations
of Kant?. We also saw similar questions asked by more than one teacher, hinting that
these questions were related to ongoing classroom topics. Teachers stopped asking
questions related to teaching during the lockdown and then restarted asking them
once schools reopened.

Non-teaching themes (10%): News, Sports, and COVID-19 information

We also observed that teachers asked miscellaneous questions related to news, sports,
and entertainment. Teachers asked about trending news in Côte d’Ivoire and across
the world. Some were specifically Ivorian: we received a question when a former
Ivorian president was trending - I want to have the news about the trial of former
Ivorian President Laurent Gbagbo. Others related to world affairs: I want to know
the name of the NBA player who died and the circumstances of his death, related
to Kobe Bryant, a US basketball player’s sudden death due to a helicopter crash.
Sports questions were about the English premier league or soccer transfers. Teachers
mentioned that soccer was their passion in interviews and played tournaments
among teacher groups regularly. Importantly, when the COVID-19 pandemic started
and schools locked down, questions were dominated by COVID-19 symptoms, news,
and vaccines. While answering these questions, we acknowledged that we were not
experts and sent them links from Google.

Social (22%): Conversational messages and greetings

Lastly, we observed that the teachers often greeted the conversational agent infor-
mally during interactions. Teachers used smileys: :) :) :) or short forms: Bsr (short
for Bonsoir or Good evening) to greet the chatbot. Our formal French language model did not classify these messages as greetings and misinterpreted them as questions. Additionally, teachers wished good thoughts to the conversational agent on occasion about the pandemic or for local festivals (We pray that this pandemic ends.; Happy Easter to all! images.app.goo.gl/cha8w34c21bqe7zka”).

5.4.3 RQ2: How do teachers engage with the implementation of a new pedagogical approach in rural Côte d’Ivoire?

This section explains how teachers engage with the newMethod using a lens of aspirations (Section 2.3). We present how teachers’ aspirations [20], i.e., students’ success, improving teaching skills, and career progression intersect with the newMethod. Our goal is to use these intersections and translate them into design recommendations in the discussion. newMethod is not the subject of this paper but provides a ripe opportunity to observe these teacher aspirations in practice.

Alignment with teachers’ aspirations to improve adoption

newMethod is centered on students’ success. Supporting the attainment of student success was a short-term teacher aspiration that we described in prior work [20]. Teachers mentioned that they could directly observe the benefits of the new pedagogical program through students’ increased enthusiasm, participation, and learning. As T10 mentions:

Children love to play and where there is play, children get involved and since the activities are conducted as a game, the children are interested and they play, letters and numbers are like a game, but by playing, they learn.

Teachers explained that they observed a positive impact on their students after only a few weeks of implementation. Teachers also observed improved participation during program slots which later transferred to regular classroom activities, thus leading teachers to believe that newMethod would play an integral part in students’ success. Observing improvements and centering the program on their existing aspirations shaped teacher aspirations towards program adoption. Here, a school director (D1) expresses the program’s positive role in students’ education in the next few years.

My greatest wish is that most children can read and calculate as required by the newMethod. Because if most children can read, I believe they will do well in composition.

3We asked teachers what change they would like to see in their student’s education (i.e., aspirations for their students) inspired by Toyama [141]
Subjects or the exam. During the various assessments, [...] reading and mathematics are the problems. So if the next three years, if they improve in them, I think the Ivorian school would have won. - D1

Lastly, the program uses teacher role models in the community to inspire the teachers about NewMethod. Ministry officials such as advisors, inspectors, and master trainers regularly visited the teachers in their schools to support and encourage program implementation. These officials also perform these activities with the students, which encouraged teachers to implement these activities well. Senior members (master trainers) mentioned regular interaction with the teachers was the program’s strength.

Creating new intermediate aspirations through achievable roles

Our prior work found that teachers aspired to progress in their careers to have a broader impact (as advisors or inspectors) on the community but were impeded by the difficult civil service exams required to obtain those roles. The program created new alternative roles that were achievable for teachers to attain simply through program participation. For instance, teachers are called as "facilitators" whose new role is to guide the children towards their learning. All teachers become facilitators after the training. The teacher's role as the facilitator is to build a good relationship with the student, ultimately breaking the authoritative barrier between the teacher and the student. The teachers could play this role by implementing student-centric activities.

Fig. 5.6.: A Director takes the role of a mentor to teach an activity to the teachers during training

The program also offered new leadership positions to create new intermediate aspirations for teachers. Teachers were actively given leadership positions termed as mentors (see Fig 5.6) based on their performance in the program. Mentors
were offered a superior social status, additional training, and frequent interactions with superiors. Teachers were chosen as mentors based on their performance and participation in the program over the year. As T9 explains, how active program implementation helped his colleagues achieve mentorship positions:

And after the training that took place [...] among all those who took part in these training, I saw some who became mentors because they took seriously what they did. In life, when you do something, you have to take it seriously. Even if we put everything at our disposal, if we work negligently, we will not evolve. -T9

Allowing teacher’s collective agency to scale and sustain the program

NewMethod creates pathways that allow teachers to realize their potential, whose collective work benefits teachers themselves and the program. As described above, teachers’ career progression was impeded by difficult exams. The program’s mentor role created an alternative pathway for teachers to exercise their agency for intermediate career progression. The mentor role required training and supporting fellow teachers providing mutual benefit to the program and the teacher. Here D2 explains how his aspirations to improve in his career led him to utilize these pathways to rise in the program’s ranks.

In everything, we dream of climbing the ladder; to get there, we must do our job better [...] I want to become an inspector or educational advisor [...] This is why when there is a new pedagogy. I appropriate it with all my heart and one hundred percent. I go through all means to master it to be able to dispense it well. Here we are four who have been listed as mentors not because the others are bad, but you have to know how to be noticed positively. - D2

Teachers rising to mentor positions also paved the way for scaling and sustaining the program. The mentor roles were structured to fill in for the limited pedagogical advisors when the program scaled to more schools. Mentors also acted as the first support system to their fellow school teachers and teachers in the vicinity, reducing their dependency on the advisor, who would usually be remote. Ministry officials also recognized teachers’ potential and welcomed their support. Here, Advisor(A2) explains that he will retire soon but believes teachers are the future.

Logically, I am going to retire in July 2021 so I have 1 year left. [...] but they (teachers) are still young and we need someone to do the training if the NewMethod is to be popularized on a national scale. There are more than 17,000 schools in the Ivory Coast, if all the schools have to implement NewMethod then we need people to train them because there will not be many national trainers(superiors) to do all this work. -A2
5.5 Discussion

This section connects our findings from the technology probe and teacher aspirations toward designing sustainable systems. Our probe’s goal was to learn the scope for remote mentoring for teacher training in NewMethod (see storyboard Figs. A.1 and A.2). Teachers were able to engage with a new technology over many weeks, demonstrating the usability of the tool in a new context. Our qualitative analysis of teacher questions identifies themes in teaching, teacher training, and non-teaching scenarios expanding the scope of support such a tool could provide in remote mentoring. In the first section, we use findings from RQ1a (Section 5.4.1) and RQ1b (Section 5.4.2) to demonstrate sustainability challenges by situating technology purely on teachers’ needs and then, suggest ways to overcome these limitations using data from RQ2 (Section 5.4.3) and theoretical connections to aspirations.

Critiquing designs on needs-based approach

Our data from RQ1a (Section 5.4.1) and RQ1b (Section 5.4.2) discovered that teacher needs could not be addressed solely digitally by advisors, as there was a cultural significance to in-person visits. We expected a tool like this to amplify the relationship between stakeholders digitally, i.e., teachers could seek help from their supervisors (advisors) using a tool like a conversational agent in the future. However, our data suggest that such a tool is not practical for this scenario because advisors could not transfer all their work digitally. Firstly, we expected the advisors to answer teachers’ questions, but we learned that the advisors did not have smartphones or were already overloaded to take on this additional responsibility. Instead, advisors and trainers continued to spend their time on in-person visits, which they believed played a significant role in supporting the teachers. Secondly, all stakeholders mentioned the cultural significance of in-person visits, which technology could not substitute. Advisors said that meeting the teachers in person positively affected teachers as they saw a respected person take an active role in their lives. Approaching the problem with a needs-based approach creates an external imposition [141, 104] which fails to allow for practical use cases. Needs, as Toyama mentioned [141] are centered on negative feelings, thus leading to designs that are externally imposed or aim to support fleeting problems.

We also learned that teacher needs were transient [141, 104]. We noticed that question topics gradually changed over time; some went outside the scope of teaching or teacher training. Teachers asked questions about COVID-19 symptoms or very context-specific, e.g., (How to start cattle business?). This question trend
confirms that teacher needs are transient [141, 104]. Hence it is hard for future designs to support such scenarios in the long term.

5.5.1 Towards Designing for Teacher Aspirations

We now describe alternative approaches to address the limitations of needs identified in the previous section using data from RQ2 (Section 5.4.3) and theoretical connections to aspirations. For each subsection, we first explain our finding, then provide an example in the context of our conversational agent scenario and then connect it to the broader literature.

Designing for Teacher Agency

Our finding on utilizing collective teacher agency can be translated into technology design through improved structures that enhance their capacity to engage in peer support in rural communities. While in-person support from experts was seen as vital, our data also supports peer-based learning; for instance, D1 describes how she comes to school early to seek help from peers for her lessons:

I'm here (early), so I have time to call someone (teacher) to ask them: *this is such a lesson, or this is such a difficulty that I encounter and how can you help?*. However, rural teachers’ existing collegial networks for relevant professional development support was limited, as regions tend to be small. Technology can expand a rural teacher’s limited collegial network by providing connections outside their social circle to teachers in different regions with different perspectives on professional development support. Beyond simply greater access to peers, conversational agents could have a role in better facilitating these support conversations. Prior work by Toxtli et al. [140] allowed expert users to provide asynchronous answers to novices’ questions through a conversational agent. We can extend Toxteli et al.’s [140] designs to focus on teacher peer support (instead of limited experts) by allowing teachers to answer each others’ questions within a conversational agent. For instance, agent designs could facilitate appropriate conversations by making connections to the most relevant peers based on expertise, location, or usage. Drawing on A2’s assertion that teachers themselves are needed to scale and sustain the program, a conversational agent design could also learn from teachers’ answers to their peers and answer future similar questions, reducing reliance on limited experts in low-infrastructure contexts while drawing on teachers’ own expertise [49, 140]. Therefore, there are opportunities to extend peer support to rural teachers in chat-based scenarios that rely on collective teacher support to enhance in-person support provided by advisors.
Shaping Aspirations for Technology Adoption

Our findings for role model champions and aligning interventions towards existing aspirations could be translated towards improved technology adoption. In our context, ministry officials championing the program and centering the program’s messaging on students’ success led to organic program adoption among the teachers. For our chat-based scenario, role models could be integrated into intervention deployment as community champions [90] i.e., inspectors and advisors could advocate and use the technology during school visits to explain the intervention’s valuable role towards student success. ICTD literature has emphasized the importance of role models and mentors [76, 141, 70]. Prior literature in economics has demonstrated how villages with female leaders showed improvements in parents’ investments in their daughter’s education [13]. In these villages, parents’ and children’s educational aspirations increased when they observed these female leaders taking a more ambitious role in society. In the ICTD literature, Pérez et al. used role models in Tika Vani to choose characters of marginal groups (lower caste) as protagonists in their designs to inspire inclusive m-health technology adoption [106]. Such interaction techniques allow for positive social proof [148] by observing the success of people similar to them, therefore helping them become more ambitious about their aspirations. Designers could use this construct to shape aspirations by using role models in their technology designs.

Creating New Aspirations for Behaviour Change

We learned from our findings that interventions could create new aspirations to allow positive behavior change. Our data reveals that NewMethod created leadership roles (mentors) aligned with teachers’ aspirations to increase their impact on their community through career progression [20]. These roles acted as an achievable intermediate aspiration towards impacting the community allowing for a positive behavior change, i.e., convincing teachers to implement the program. For our chat-based scenario, digital and non-digital leadership roles could be designed for teachers to support community members. For digital roles, teachers could be given a superior status based on their technology usage, such as community moderation roles given to active users in Sangeeth Swara [147]. Alternatively, voluntary positions (technology mentors) could be created outside technology to allow mentoring on technology-related issues. In ICTD literature, creating aspirations can be linked with Kumar's perspective [75] on how aspirations can be modeled as sequential milestones, i.e., achieving one aspiration improves agency to achieve future aspirations. Therefore creating the apt intermediate milestone can change behavior by utilizing user aspiration. Prior work has demonstrated this at scale: no toilet no bride
campaign [131] used the aspirations of youth to find eligible brides to convince them to build a toilet in their homes. In rural India, the campaign improved ownership of latrines by 21% in homes with the youth of marriageable age. These examples show that creating new aspirations that align with broader users’ aspirations can change behavior. Designers can use these opportunities to model new aspirations inside or outside technology to help promote behavior change.

5.5.2 Reflections on applying Aspirations

Providing agency, creating and shaping aspirations align with Appadurai’s [5] suggestion to raise the user’s capacity to aspire. Users in low resource contexts often lag in their aspirations, are unable to harness capabilities, or lack the relevant information to convert their desires from wishful thinking to thoughtful wishing. Our findings demonstrate a positive role that can be played in supporting users in their aspirations by using interventions to shape existing and create new aspirations. We are excited for ICTD researchers, practitioners, and theorists to extend our work.

Our research taught us that it is essential to convince partners on Why aspirations?. During our research, we discovered that our NGO partner was more interested in their organizational goals to deliver improved educational outcomes than prioritizing teachers’ long term career aspirations. The NGO deeply cared about teachers and was doing its best to support them, but teachers career aspirations fell outside their scope. We believe more work is needed to demonstrate the impact of aligning long term aspirations to practitioners and policymakers outside academia.

Our research also induces the question: Which aspirations? Who prioritizes them?. We chose career aspirations to align with our expertise and funder goals. However, teachers also had personal aspirations related to their families’ well-being or financial outcomes, which we could not support through this project. Kumar et al. [76] highlight this question in their research when they mention the role of the researcher in uncovering aspirations in their work.

5.6 Conclusion

Most technology projects in developing contexts, even if well-intended, fail to deliver long-term impact beyond academic research. Therefore ICTD scholars have suggested an aspirations-based approach to design sustainable systems. However, recent research found that teachers’ professional aspirations can conflict with their current professional responsibilities, increasing the complexity of design technology
in such circumstances. We first deployed a chatbot probe over a 5-month long study to support teacher training to understand such complex design spaces. Although the tool successfully addressed teacher training needs, our data show that needs-based approaches are not sustainable as needs varied over time, amplified existing inequalities, and took agency away from the teacher. Secondly, we uncover design ideas for teacher aspirations through a qualitative study with 30 teachers in rural Côte d'Ivoire during a new teacher training program. We show that the teacher training program relies on teachers aspirations, shapes their future aspirations, and relies on teacher agency leading to a sustainable ecosystem to achieve long-term outcomes. We use our data to recommend design ideas to operationalize aspirations by creating communities and designing for teacher agency. We reflect on the importance of communicating why aspirations to practitioners, which aspirations to prioritize, and how to address these aspirations. Our contributions present initial design ideas towards developing sustainable technology in low infrastructure settings for teacher aspirations.
Study 3: Pilot

6.1 Overview

Fig. 6.1.: The goal for study 3 was to pilot my initial set of designs about community support. My work from study 2A led me to designs that allowed for community support in a conversational agent.

Study 1 described teachers’ smartphone usage and their aspirations in rural Côte d’Ivoire. I learned that teachers had challenges in professional development but used smartphones to support their classroom teaching. Therefore, in study 2A, I deployed a conversational agent probe and teachers’ engagement with a pedagogical program. I discovered initial evidence that a conversational agent is feasible to support teachers through remote mentoring.

I extended my work in study 2B to uncover design ideas for teacher aspirations through a qualitative study with 30 teachers in rural Côte d’Ivoire during a new pedagogical program. I showed that the program is centered on teachers’ aspirations, shapes their future aspirations, and relies on teacher agency leading to a sustainable ecosystem to achieve long-term outcomes. Using my findings, I proposed creating community support designs that allow for teacher agency.

Therefore for study 3 (refer Fig. 6.1), I expect to pilot an initial design with community support designs for a conversational agent. To explore this new design space, we deployed a conversational agent on Messenger to 120 teachers for four weeks to support a new pedagogical program in rural Côte d’Ivoire.
6.2 Design Iteration

We extend prior [19] work through the following design iterations. The flow chart depicts the various features of the conversational agent and the menu hierarchy for accessing them.

- **USSD Menus**: We redesigned the conversational agent using USSD menus (menus with numeric options), which are interactions familiar to the context. Users would be presented with a menu with numerical options which lead to the subsequent menus or features.

- **Main Menu**: The main menu was the default content shown to the users. Users could always access it by typing "0".

- **NewMethod Information**: This menu gave users (a) Tips: curated short content about the NewMethod program from the manual, (b) Manuals: NewMethod manuals gave users access to documents related to NewMethod for French and Math.

- **User Profile Menu**: This menu gave users (a) Goals: which allowed users to view and modify previously selected goals. These were supposed to support the teachers reflect on their work for the week (b) Profile badge: users could view a visual of their profile picture and demographic information.
• **Questions:** Users could directly interact with the conversational agent by asking questions. However, we added a menu option to guide users who may need additional scaffolding. We still had the human-AI hybrid interaction with an improved database of questions.

• **Community Menu:** We also had the community feature where users could (a) share and read experiences about *NewMethod*, (b) share and read jokes, or (c) could answer curated questions. These were experimental with sample content curated by the researchers.

• **Introductory tutorial:** There were introductory survey questions with example interactions to onboard the teachers into the system. These questions were intended as conversational agent training sessions during the teacher training.

### 6.3 Research Questions

**RQ1:** How do teachers engage with a conversational agent with a community support feature?

**RQ2:** What are the usability challenges for teachers using the conversational agent's features?

### 6.4 Study Design

This study is part of an ongoing research project to improve children’s education in rural Côte d'Ivoire through poverty reduction and improved education for rural cocoa farming communities. An interdisciplinary team from Ivorian and North American universities conducted this study in partnership with the Ivorian Ministry of Education. We received approvals from all our institutional boards and the Ivorian government to conduct the study.

#### 6.4.1 Site Description

We conducted the study in a southwest region in Côte d'Ivoire. French is the official language of Côte d'Ivoire, but there are nearly 70 local languages [126]. This site primarily has an agricultural economy based on cocoa and coffee, which have been residents' primary source of income for decades [72].
Tab. 6.1.: Table summarizing our data sources collected by the team

<table>
<thead>
<tr>
<th>Observations</th>
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<tbody>
<tr>
<td>Participants</td>
<td>~120</td>
</tr>
<tr>
<td>Duration</td>
<td>6 days (9AM - 5PM)</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Teachers ~100, Directors: 20, Advisors 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surveys</th>
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<tbody>
<tr>
<td>Participants</td>
<td>50</td>
</tr>
<tr>
<td>Gender</td>
<td>Female: 12 Male: 38</td>
</tr>
<tr>
<td>Stakeholders (2)</td>
<td>Teacher: 27, Directors: 23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>conversational agent deployment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>100</td>
</tr>
<tr>
<td>Duration</td>
<td>6 weeks</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Interviews (after 2 weeks)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>25</td>
</tr>
<tr>
<td>Gender</td>
<td>Female: 5 Male: 20</td>
</tr>
<tr>
<td>Stakeholders (4)</td>
<td>System users (2): Teachers: 15, Directors: 5</td>
</tr>
<tr>
<td>Schools (7)</td>
<td>System non users (2): Teachers (3), Directors (2)</td>
</tr>
<tr>
<td>NewMethod observations</td>
<td>Users: 5, Non users 2</td>
</tr>
<tr>
<td>Subjects</td>
<td>CP1-CM2 (3rd-6th grade)</td>
</tr>
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</table>

<table>
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<th>Think Aloud Surveys</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>20</td>
</tr>
<tr>
<td>Gender</td>
<td>Female: 4 Male: 16</td>
</tr>
<tr>
<td>Stakeholders (2)</td>
<td>Teacher: 13, Directors: 7</td>
</tr>
</tbody>
</table>

The study site Méagui is a rural farming town in the Soubré region. It has a few urban schools inside the city, while the remaining rural schools are distributed in communities away from the city. Communities situated away from the city have lower infrastructure: i.e., they lack adequate water, electricity, and telephone signal. Remote communities have poor road conditions, which further impedes travel and increases their isolation. Students in these rural communities have low literacy rates, influenced by the rural context and low infrastructure [83, 82].

Field Observations

The research team observed and participated in the NewMethod training activities throughout the week. We recorded our field notes and discussions in our research journal and used these lessons to refine our questions for our surveys and interviews. These observations helped us get a glimpse of the situated struggles (sitting on the floor for long-duration, heat) and bonding experiences (singing, dancing) during
this challenging week. Relevant media from these observations were shared on the Facebook page and the conversational agent to contextualize the intervention.

**Surveys**

Fifty users were surveyed during the teacher training. Most survey responses were recorded during breaks or after the teacher training sessions. The surveys were conducted using a form on ODK to account for network issues. The surveys about teachers technology and social media usage, demographic information and *NewMethod* questions. The surveys typically took 20 mins for the teachers.

**conversational agent pilot deployment**

We then piloted a conversational agent technology during the *NewMethod* training workshop (Fig 5.6) May 2021. The system was designed using prior work [19], and was intended to support teachers during *NewMethod* implementation. The conversational agent was a *humbot* architecture i.e. the questions were answered by the system and the moderator. When questions fell outside this database, teachers would receive the answer in a few days.

After the training sessions, we instructed teachers to ask questions about *NewMethod* to seek help during implementation i.e. after the training workshop. Teachers were not given any incentive to interact with the conversational agent. Teachers were also provided a Facebook page connected to the conversational agent. Researchers responded to questions referring to the *NewMethod* manual on the teaching method [135]. We collected log data from the conversational agent and the Facebook page for six weeks. However, the school year concluded in three weeks.

**Think Aloud Surveys**

After two weeks of deployment, we revisited the teachers in their community and conducted think-aloud sessions [78]. The think-aloud sessions involved a series of questions where teachers had to perform various activities on the conversational agent. For e.g. send a "hello" message to the conversational agent, like a post on the Facebook page, etc. Participants were given 3 attempts to perform the activity after which the interviewer recorded the attempt on a survey. We also recorded the teacher's screens as they performed the activity to get a contextual understanding of teachers' usage behaviors. The think aloud surveys typically took 20 mins for the teachers.
6.4.2 Data Analysis

We used mixed-method analysis to analyze the (1) observations and interviews and the (2) conversational agent log data (3) quantitative analysis of teachers usage.

(1) We combined observation notes, think aloud notes, Facebook page comments, and interview data into a single data set. We transcribed and translated the interview data into English and formed the low-level themes using thematic analysis [21, 132, 94, 16] to synthesize preliminary themes for our research questions.

(2) We analyzed the conversational agent log data based on teachers interaction with the menus and the different features. We transferred the questions and stories from the teachers to a spreadsheet after an initial data cleaning to understand some preliminary themes.

6.4.3 Self-disclosure

Our team consists of HCI researchers, economists, and linguists. We are based in North America and Côte d'Ivoire and have conducted research in various developing regions. The first author and the second author are from developing countries, and they formed the protocols and analyzed the data after discussions with the Ivorian team and faculty. The long term goal of our project is to support teachers with a low cost technology to implement the pedagogical program.

6.5 Preliminary Findings

6.5.1 RQ1: conversational agent engagement

![Graph showing daily messages over the first ten days.](image)

Fig. 6.3.: Total daily messages over the first ten days. Teachers engaged the conversational agent the most on Day3, i.e. when the advisor supported research team during teacher training.
Training and icebreakers: Teachers engaged the most on the day of the training session when the advisor supported the research team. We observed the highest engagement on Day 3 (see Fig 6.3) when the research team convinced the advisor in a region to help me. After being convinced, the advisor paused the NewMethod training session for a while to enable the DLA research team to train the teachers on the conversational agent. Our original idea was to train teachers during the break sessions (Day 1 and Day2), which worked less efficiently. Icebreaker sessions were typical during NewMethod training; teachers would be tired during the long training sessions. Hence the trainers incorporated; dancing and singing between sessions. Trainers improved social bonding in the NewMethod workshops by encouraging teachers to learn and support their neighbors (voisin).

Data constraints: We noticed that the teachers’ usage significantly tapered off after the training week. Teachers mentioned in our interviews that they had difficulty accessing the conversational agent as data was expensive or the network was unavailable. They requested more offline content that would support them during limited data constraints. As T9 explains with an example: The agent allows me to download (the manual) on my phone, and I take my time to read the textbook in French and was able to adapt it better(for NewMethod), and this is what I liked. - t9

Participatory content: We also piloted the participatory content features for stories, jokes, and questions. I found that teachers shared experiences with the NewMethod program. A representative story: Since I started studying NewMethod with the students, they have become very happy and participate a lot it allows many students to know how to read and write. Teachers also shared concerns. For example, sitting on the floor, which was part of the NewMethod program but new to teachers, here a teacher expresses this through a humorous example: One day during an activity NewMethod my students told me to stand up to talk to them. Inspired by icebreakers (in Study 2), we also allowed teachers to share jokes which generated content for NewMethod and general topics. Although NewMethod jokes were fewer, teachers shared a few related to the training activities, e.g., It took the NewMethod to see that teachers do not know how to dance.

NewMethod Questions: Like study 2, Teachers also asked questions to the conversational agent. We had 300 questions, and most were related to NewMethod. We found that the categories were very similar to Study 2, i.e.informational, operational, and activity. We had (a) informational questions about the program. What is the objective of the NewMethod?, The five principles of NewMethod. We also had (b) operational questions about the different processes: What is the role of the local mentor?, What are the stages of the Aser test. Lastly, we had specific (c) activity level questions: I would like more explanations on Step 5- Activities in-group understanding. We also
observed that, unlike Study 2, teachers asked a few questions outside of *NewMethod*. What does *Dia* mean? ??

**Experimental question answering:** We piloted an experimental feature that allowed teachers to answer questions. We curated a few informational and operational questions, to which teachers were able to provide answers. For example, the question: Why is the program not taught at the CP level, received: *The NewMethod is not at CP because it is essential, because the objective of the NewMethod is to give an excellent base to the other classes.* We also tested multimedia questions asking them to name an activity, and we got ten correct responses.

We also observed that teachers accessed the community menu from our log data. 28% of the aggregate interactions were the community menu, behind 32% of the default welcome menu and ahead of the subsequent 17% tips menu. Teachers also mentioned that they liked the stories and jokes from the conversational agent. In our interviews, teachers expressed that they liked the stories from their colleagues to be useful: *I learned some things, for example, the anecdotes, the stories that colleagues shared on the conversational agent- D1.*

### 6.5.2 RQ2: conversational agent usability

Most teachers, i.e., 16/20 (80%), we're able to navigate the system after two weeks, demonstrating its ease of use. Additionally, free basics on the MTN network helped teachers access Messenger and Facebook without incurring data charges. 14/20 teachers (70%) used more than half the features; I categorized them as experts and explained their usage compared to the remaining (novice) users.

Experts (70% top) were immersed in the conversational agent, i.e., had a nuanced usage. For example, they used the "buttons" instead of typing the numbers, which improved their navigation speed. They also remembered that "0" is the "home menu," which helped them get unstuck during complex navigation. Experts would also quickly zoom into the relevant section in the menu to focus on the relevant information rather than reading the entire text. Additionally, they would confidently navigate the current menu for subsequent tasks instead of restarting their search after every task.

Novices (remaining 30%) often got overwhelmed with the task or the information in the menus. Novices were often hesitant to attempt the task; the research assistant would encourage them at times to attempt instead of giving up without trying. Novices would also get overwhelmed by the amount of text in a menu and slowly read the menus. They would often derive wrong mental models of the menu system (e.g., referencing incorrect menus or typing the unintended menu option). Typing
Fig. 6.4.: Think aloud session with a teacher, conducted 2 weeks after training. The teachers were asked to access a feature while the interviewer recorded their attempt on a survey. Teachers were given 3 attempts per feature and the entire session was recorded on video.

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Fig. 6.5.: Success rate of the think aloud by feature and teacher. Each row represents a teacher and each column represents a feature. A green box indicates success and a red box indicates failure. The columns at the end indicate aggregate success percentage for the user. The last row indicates aggregate success percent for the feature.
wrong inputs often led them to wrong menus and lost focus; often, the interviewer had to remind them of their task. Additionally, novices didn’t remember that 0 was home, thus finding it difficult to complete or restart a task.

In general, teachers typed very slowly. We observed that all teachers typed very slowly, and often each input took an average of 2-3 mins to type 30 words of text. Teachers did not use auto-suggest. Instead, they typed every letter slowing their speed. We also noticed that some devices had physical limitations (scratches, cracks) or worked very slowly, making it hard to type and use the applications.

6.6 Discussion

Our data gave us initial evidence to confirm that these features for participatory content could provide community support. Community members could share information for NewMethod, jokes, and even answer questions. Our log data showed that the community was the most popular feature. Additionally, our observations taught that most teachers could use the conversational agent well enough and engage with the various components with basic training. Technology training worked well when we had support from the mentor. Lastly, we learned that teachers expected more offline interactions as they experienced difficulty accessing the conversational agent due to network or data constraints. The questions from teachers helped us augment our database for future studies.

These ideas helped us refine our thinking on community support designs, improve training content and design more offline interactions to accommodate access. We acknowledge that teachers used the system for a brief period, i.e., four weeks, and these weeks involved an above-average workload as teachers were concluding the school year. Additionally, teachers received the NewMethod training as an introduction for the subsequent school year. The short program implementation narrowed opportunities for the conversational agent to support teachers. Therefore, it helped us pilot features, but we expect to discover opportunities for impact from the conversational agent for future work.
7.1 Overview

My goal for Study 4 is to measure the impact of community support designs that I piloted in study 3.

Fig. 7.1.: My goal for Study 4 is to measure the impact of community support designs that I piloted in study 3.

My findings from study 1 helped me understand teachers’ smartphone use, thus designing a conversational agent that could address teachers’ professional development struggles. In study 2A, I discovered initial evidence that a conversational agent is feasible to support teachers through remote mentoring. However, it was still unclear after study 1 how to implement teacher aspirations in technology designs such as a conversational agent. In study 2B, to explore the use of a conversational agent technology in this design space, we conducted a qualitative study with 20 teachers and ministry officials in rural Côte d’Ivoire to understand opportunities and challenges in technology use for these stakeholders. We used our data from teachers and proposed designing for teacher aspirations through community support, i.e., collective peer support from teachers, allowing sustainable designs to overcome shortcomings of working purely on teacher needs.

In study 3, I piloted initial designs that allowed for community support through participatory content in a conversational agent. Our system allowed teachers to contribute and consume stories about the program, peer-based question support, and informal jokes. Our preliminary analysis from log data and interviews revealed that teachers valued these community features.
For study 4 (refer Fig 7.1), I expect to evaluate the impact of community support designs at scale. I categorize impact as teacher motivation, training knowledge, and technology adoption (refer Fig 7.3). I hypothesize that community support features will have a better impact than individual support, by allowing early adopters to participate easily. Therefore, I will deploy a conversational agent in two regions with the community and individual support as conditions respectively.

7.2 Thesis Research question

7.2.1 Will designs for community support have more impact than individual support towards teachers in low infrastructure settings?

7.3 Study Design

To answer my research question [7.2.1], I will conduct a large-scale longitudinal study in the year 2021-2022. I will deploy a conversational agent to 120 schools across two regions (region1 and region2) in the Southwestern region of Côte d’Ivoire. I expect 480 teachers trained in NewMethod will be enrolled in the study. We will split teachers into two groups (see Fig. 7.2) by region, i.e., (1) Individual support in region 1 and (2) Community support for region 2.

Fig. 7.2.: Study design and related conversational agent features
Individual support group will have features to support teachers directly with the pedagogical programs. The conversational agent will provide resources, question support, and connections to a Facebook page. The resources section will include (a) Program manuals: PDFs with detailed information about different *NewMethod* activities for math and french, respectively (b) Tips: short messages with relevant information from the manual. Secondly, we will have question support, i.e., teachers can directly ask questions to the conversational agent. They will receive an immediate automated response from the agent or delayed response from the NGO worker managing the system. Lastly, we expect the agent to be connected to the project’s Facebook page. We will regularly post motivational messages and updates related to the pedagogical program.

Community support group will have all the features of individual support but also allow teachers to connect with and support members from the community. We will add community-oriented features which such as participatory content which was valued in study3. Participatory content will enable teachers to view and share content with community members for jokes, stories, and questions. Teachers’ contributions will be moderated and curated by the NGO worker. Lastly, we add an experimental feature called the phonebook to provide connections to community members. A teacher’s phone book connection will have the teacher’s name, school, and phone number. Thus allowing the teacher to contact and form a new connection.

We followed a quasi-experimental design at a regional level to gain critical mass and to avoid contamination. Prior social network research suggests the need for critical mass to support intervention adoption. We also know from our data that teachers discuss with their communities through offline interactions. Therefore we expect offline interactions in the teacher community could influence impact. For example, a teacher in a school may learn from the conversational agent and share information with fellow teachers in the school, thus affecting their motivation and knowledge. Secondly, we also wanted to avoid this re-sharing with the control group (contamination). Hence we needed to choose schools that were sufficiently far from each other. Schools in regions 1 and 2 are 4 hours away through conventional travel, therefore lowering the probability of interaction between groups. Lastly, our local partners (IPA, NGO) were supportive of our quasi-experimental design as they felt that the regions were equivalent enough.

7.3.1 Categorizing impact

The diagram (Fig 7.3) explains how current teacher practice(left) is influenced by teacher training to lead to new teacher practice (right). Teachers are first trained during a week-long teacher training, giving them the foundational knowledge and
motivation to implement the training. After training, teachers are influenced by the teaching community and trainer visits. The teaching community consists of teachers in the same school and teachers in the vicinity. Therefore, teachers interact with these community members on official and social interactions throughout the year, influencing their knowledge and motivation. Secondly, trainers visit the teachers regularly to provide mentoring on the training, which influences teachers’ knowledge and motivation leading to new teacher practice. Lastly, early adopters of the training program re-share their experiences with the teaching community, thus positively influencing the teacher’s knowledge and motivation.

I categorize impact as (a) Teachers’ motivation to implement the program and (b) Teachers’ knowledge (and skills) about the training, and (c) Technology adoption by the teachers. An ideal intervention’s adoption would influence (a) and (b) through the various designs, leading to impact.

I will measure (a) Teacher motivation using a standard scale by self-determination theory that provides sections on competence, autonomy, and relatedness (to colleague support). I will adapt the questions for NewMethod and validate the scale. I will add a scale for trainer support (similar to relatedness). I will measure (b) Teacher knowledge/skills using a 20-question scale by our NGO partner; they will include questions on french, math, ASER test, and mentoring. The questions will be multiple-choice questions (most questions will have 3 options and a few will be true/false). Lastly, (c) Technology adoption by (i) log data using teacher-agent
interaction and (ii) usability using think-aloud observations (refer Table 7.1 for more information).

I hypothesize that the community features in the agent will amplify the support by early adopters to the teaching community. This strengthened support (re-sharing) will lead to more motivation and knowledge in the teachers, thus leading to better impact. Therefore, I expect to see some change in the community condition’s dataset.

7.4 Design Iteration

We iterated on the system based on our findings from study 3, which led to the following design changes. The flowchart depicts the updated system (Refer to Section 6.2 for prior system context) with the highlighted modifications.

- **Introductory tutorial**: We expanded the introductory survey and messages to guide the users through the various features of the conversational agent. The new tutorial provides teachers with a prompt to type the appropriate menu option. We followed Kraut’s suggestion to onboard users into a new social networking system. The research team guided the teachers using the features and the training manual (on paper), which explained each feature in detail.
- **Simpler menu structure**: We used think-aloud observation from study 3 to learn that teachers found it hard to remember menu information. Therefore, we used concise text *(NewMethod tips and manual)* instead of *NewMethod information* which was ambiguous. We found that teachers found it hard to read the entire text. Therefore we used emojis in the first letter *(Community)* to help teachers quickly grasp the menu content.

- **Consistent home menu**: In our observations from study 3, we found that teachers occasionally lost track of their navigation while browsing through the menus. Although we explained that 0 was home in the tutorial, teachers couldn't recollect it. Therefore, we tweaked the Facebook messenger settings to display a button: *Tap 0 for home* whenever teachers opened the conversational agent. Tapping the button would open the home menu, thus allowing teachers to continue navigating the conversational agent.

- **Support for two conditions**: To answer our research question 7.2.1, we created two versions of the conversational agent. Teachers in region 1 received menus that reflected individual support, while teachers in region 2 received menus with community support features. Connections to the community menus were omitted in the individual support (Fig 7.4).

### 7.4.1 Community Support Design Iteration

- **Improved Community Menu**: I also had the community features with participatory content. I found in Study 3 that teachers shared experiences about the *NewMethod* program and classroom experiences. Teachers expressed that they valued participatory content shared by their peers in our interview data. Thus, providing initial evidence to confirm that these features for participatory content could provide community support. Therefore, we updated our features with (a) stories: for teachers to share and read experiences about *NewMethod*, (b) jokes: share and read humorous content, or (c) question+answers: where teachers could answer questions from other teachers. The community content displayed the latest information shared by community members as a news feed. e.g., if the teacher opened a story menu, they would see the newest story from another teacher. We chose this design so teachers would have an example before inputting content. The community content served a personalized news feed, i.e., upon further navigation, each teacher would only see content that they hadn’t seen before, thus creating a dynamic experience for the teacher.

- **Phone book**: The conversational agent in the community condition provided contact details of fellow teachers through the phonebook feature. The sto-
ryboard explains the phone book (Fig 7.5) feature. We based this design on our data from Study 2, where teachers mentioned that they called each other to support. We expect the phone book could provide another channel to connect with the community members through offline interactions. The phone book would provide a personalized dynamic list of teachers every week. Before showing the first number, we provided teachers with a tip to encourage their colleagues over the phone. The list consisted of one active user, one moderately active user, and one inactive user. The teachers would get one phone number at a time and would have the option to provide feedback after a number. Additionally, we expected the phone book to serve as a channel for communication in low-data settings. Teachers in study 3 asked for more offline content because of limited data constraints. We designed the phone book to facilitate phone conversations when teachers were constrained on data as the phone number would be present on the chatlog even without the internet. We had a section in the training manual to explain this feature. We used neighbor (voisin), a vocabulary used in an icebreaker activity during NewMethod training sessions, to word this feature.

• **Question Answering:** In study 3, the researchers curated the initial content for community support as they were experimental. We found that some teachers provided reasonable answers to curated questions; therefore, we added an experimental feature to allow teachers to answer other teachers’ questions. We will display the "questions" in the "questions" section of the community menu in the conversational agent after approval from the NGO worker.

• **Content Moderation:** An NGO worker moderated all community content through a dashboard. The dashboard allowed the NGO worker to answer teachers’ questions and observe answers shared by the conversational agent. If the NGO worker responded to the question, the message would go to that conversational agent, and an SMS would be sent to the user, again to account for low data settings as requested by the users in study 3. The dashboard also had a page for editing and approving community-generated stories, jokes, and answers. The NGO worker asked for an editing feature as teachers often made mistakes when entering long stories through their phones.

• **Multimedia support:** Lastly, to improve interactivity, we allowed teachers to share multimedia interactions (video, voice, and pictures) through the conversational agent. We expressed using emojis that the system was open to image, voice, or text-related input. We observed that some teachers in study 3 organically shared the photos with the Facebook page and the conversational agent, thus inspiring us to foster more multimedia interactions. Our partners
Fig. 7.5.: Storyboard representing the phone book feature. The phone book would provide a personalized dynamic list of teachers every week. We based this design on our data from Study 2, where teachers mentioned that they called each other to support.

also informed us that directors in internal WhatsApp groups would share photos of NewMethod activity.

7.4.2 Technology training

Fig. 7.6.: These two pictures describe a sample training session held during study 3

We trained the teachers to use the conversational agent through short workshops during NewMethod training. Our five teams visited 15 sites during the NewMethod training. NewMethod training occurred for a week, and a site had 10-50 teachers. Each group visited an area 1-2 times during the week to train and conduct conversational agent workshops. First, for setup sessions: teachers were briefly introduced to the system features by a research team member. Then, the research team shared the Internet (through portable wifi) with teachers and guided them through the introductory tutorial section of the conversational agent. The setup session lasted for about an hour. After setup, we had practice sessions: in which teachers used the various conversational agent features in small groups. The individual support condition had two general practice sessions, while the community support condition had one practice session and one community activity. Teachers discussed their stories...
in small groups during community activity and then typed them digitally into the conversational agent.

Teachers were given a conversational agent training manual during the technology training. The manual had three pages of instructions on different features of the system. The training manual included a storyboard explaining the project and the conversational agent’s role in supporting teachers. The manual explained the various features with illustrations and a few key points to navigate and then use the feature. The manual also contained the contact information of the local research team members. We modified the training material and structure based on the condition. Teachers in the community condition received more instructions about community support features and a storyboard summarizing the same.

7.5 Proposed Evaluation

I expect first to clean the data sets and then follow a mixed-method approach to understand the potential for impact across the dimensions, i.e., motivation, knowledge, and technology adoption across two regions.

First, I will connect the various datasets across the multiple stages (Refer Table 7.1). I anticipate using teacher demographic information to find connections between the various datasets collected across the different stages of the study. I will seek support from ministry officials, data collection teams, collaborating universities, and CMU students to clean the data. Finding data connections will help understand longitudinal trends and triangulate data (e.g., between interview responses and system logs).

I will then use the survey data across different stages to understand the impact on motivation and teacher knowledge. I will use differences-in-differences analysis across the conditions for different scales. I expect to learn how the motivation and understanding of the teachers in the two regions change throughout the year. I will triangulate these results using conversational agent log data from teacher-chatbot interaction to determine the correlation with technology adoption. I will use teacher demographic information, trainer visit frequency, and student improvement outcomes for broader analysis.

Lastly, I will use qualitative analysis from interviews and observations to infer deeper insights into the quantitative results. I will combine the interview transcripts, think-aloud observations, and notes to form a collective data set for qualitative analysis [132, 94, 16]. I will follow an iterative approach to thematic analysis with my research team (a few master’s students and a postdoc) to inform and develop
codes. We will begin with open coding the raw data; then, we’ll generate abstract
axial codes, after which we will organize the final categories. Since this process
is iterative, we will also use discussions and meeting notes with team members to
support our lower-level codes. We will also have regular conversations with our
NGO partners, data collection teams (IPA, Proterrain), and collaborating universities
to contextualize our codes to the local context.

7.6 Data Collection

Tab. 7.1: Summarizes the different data collection proposed over the year. The green color
indicates work already completed.

<table>
<thead>
<tr>
<th>Stage 0: Pre intervention</th>
<th>September 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 in teacher survey</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 1: Mentor Training</th>
<th>October 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained 60 mentors to use the chatbot</td>
<td></td>
</tr>
<tr>
<td>12 mentor (directors, pedagogical advisors) interviews</td>
<td></td>
</tr>
<tr>
<td>60 surveys of mentor</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 2: Teacher Training</th>
<th>November 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained 400 teachers to use the chatbot</td>
<td></td>
</tr>
<tr>
<td>10 interviews of teachers and directors</td>
<td></td>
</tr>
<tr>
<td>80 surveys of teachers and directors</td>
<td></td>
</tr>
<tr>
<td>~480 teachers pre-test and post-test on training knowledge</td>
<td></td>
</tr>
<tr>
<td>~300 teachers log data (start)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 3: Midline</th>
<th>March 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 interviews (teachers and directors)</td>
<td></td>
</tr>
<tr>
<td>15 thinkalouds</td>
<td></td>
</tr>
<tr>
<td>395 phone surveys</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 4: Endline</th>
<th>June 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 interviews teachers and directors</td>
<td></td>
</tr>
<tr>
<td>17 thinkalouds</td>
<td></td>
</tr>
<tr>
<td>~300 teachers log data (stop)</td>
<td></td>
</tr>
<tr>
<td>60 mentor phone surveys</td>
<td></td>
</tr>
<tr>
<td>10 mentor + 2 director phone interviews</td>
<td></td>
</tr>
<tr>
<td>200 in teacher surveys</td>
<td></td>
</tr>
</tbody>
</table>

We will collect data in five phases during the academic year (Refer Table 7.1). Two
data collection agencies, i.e., IPA an international organization and Proterrain a local
Ivorian team, will support the data collection. IPA will help with in-person surveys
before and after the study (stages 0, 4). Proterrain will collect throughout the study
i.e. (stages 1,2,3,4) and help ministry coordination, and technology training.
Stage 0: pre intervention (completed)

IPA team conducted 150 surveys by visiting teachers in their schools before NewMethod training. Our survey had questions on: teacher demographics, technology usage, social media access and usage, Teacher career aspirations and perceived agency, Self-efficacy for teaching (scale), Perceived social support, Teacher burnout (scale), and teacher agency in the community. They also conducted surveys of teachers in the control condition (i.e., the parent study), where teachers did not receive NewMethod and technology.

Stage 1: mentor training (completed)

We collected the next stage of data during mentor training in October. Mentors, i.e., inspectors, directors, and pedagogical advisers, were trained to mentor teachers for NewMethod. All mentors (60 in total) were invited to an inspectorate office in Region 2 (for both regions) for one week for training sessions on NewMethod mentoring. The research team trained participants for two hours during the week. The first session focused on the conversational agent set up, where the participants were guided through the various features of the research team. The second session focused on community interactions where mentors shared stories in small groups during the first half of the session and then shared the stories into the conversational agent. The training sessions helped the research team practice the technology training protocols and helped the mentors get acquainted with the system (note: mentors were not active stakeholders for this school year).

We also interviewed ten mentors and surveyed 60 mentors during breaks or after the NewMethod training sessions. Our protocol is expected to understand (1) Existing practices of support with and without technology, (2) Existing practices for informal and formal role model support (3) Initial perceptions of the conversational agent. We also surveyed 60 mentors on demographics, smartphone usage, internet access, and social media usage and access.

Stage 2: teacher training (completed)

We collected the next stage of data during NewMethod teacher training sessions in November. During teacher training sessions, our five teams visited 15 locations (6 in Region1 and 9 in Region2). 460 teachers and directors were present in total. Mentors from stage 1 led these training sessions and helped us coordinate and support the training sessions. The research team trained the participants to use the conversational agent for two hours during the week. The first technology training
session was to set up the conversational agent and guide participants through various features. The second technology training session involved a practice session in refreshing teachers through the basic conversational agent features i.e., asking a question, browsing, and downloading manuals. The last training session differed between regions; teachers in Region1 practiced features again while teachers in Region2 practiced the story session. Our team set up the conversational agent for 319 users (additional 50 users need to be verified after data cleaning). We started collecting log data from the conversational agent usage.

We also interviewed 12 teachers and surveyed 80 teachers during breaks or after the NewMethod training sessions. Our protocol expected to understand (1) Existing practices of support with and without technology, (2) Existing practices for informal and formal role model support (3) Initial perceptions of the conversational agent. We also surveyed 80 teachers on demographics, smartphone usage, internet access, and social media usage. Interviews lasted for 30 mins; they were conducted in schools or towns near the school.

Additionally, the NGO surveyed teachers on training knowledge and skills before (pre-test) and after the week-long training (post-test). The knowledge questions consisted of four sections of five questions for math, french, ASER test, and mentoring. The questions consisted of multiple choice and true or false questions. These 20 questions will be used to evaluate training knowledge and skills throughout the study.

Stage 3: mid-line data collection (completed)

We collected mid-line data during March 2022, about 3 months after teachers started implementing the program. Two teams interviewed teachers in both regions by visiting them in their schools. The schools were chosen based on teachers’ usage of the technology. However, teachers’ availability, logistics of travel, and internet access affected the data collection.

We interviewed 23 teachers and conducted think-aloud [78] for 15 teachers in both regions. Our interviews expected to understand (1) conversational agent perceptions and barriers to usage, (2) NewMethod support from colleagues and trainers (3) NewMethod training knowledge access and barriers. Interviews lasted for 45 mins; they were conducted in schools or towns near the school. We also conducted think-aloud with 15 teachers (8 in Region1 and 7 in Region2). A typical think-aloud session required teachers to use the various features of the conversational agent while the interview recorded the interaction. Teachers were asked to use a particular feature (e.g., browse the conversational agent menus) and were given up
to 3 attempts to find the answer while they verbally explained their actions. These interactions were video recorded by the researcher.

We also surveyed 395 teachers over the phone to understand the impact of the intervention. The survey had questions on teacher demographics, smartphone usage and access, Facebook messenger and conversational agent usage, *NewMethod* motivation (competence support, autonomy support, colleague support, and advisor support), *NewMethod* knowledge/skills questions (chosen by the NGO), and general feedback on the conversational agent.

**Stage 4: end-line data collection (on-going)**

We collected end-line data during May and June of 2022, towards the end of the program and a few weeks after its conclusion. Similar to stage 3 [7.6], we conducted interviews and think aloud by visiting schools in both regions. Schools for this sample were selected based on recommendations by the inspector. Our interview protocol had questions to discover (1) conversational agent perceptions and barriers to usage (2) the influence of *NewMethod* or technology on teachers’ aspirations (3) *NewMethod* support from colleagues and trainers, (4) *NewMethod* knowledge access and barriers. Interviews lasted for 45 mins; they were conducted in schools or towns near the school. We also conducted think-alouds with 17 teachers (9 in Region1 and 8 in Region2) in favorable internet locations.

After the school year, we concluded the log data collection; we collected teacher-chatbot interactions over the entire *NewMethod* implementation (6 months of school). We recorded the meta-data between responses, i.e., the timing for sent, received, or failed feedback from these interactions. We also recorded the interactions by the moderator (NGO worker), who answered the questions using an internal dashboard. We also sent regular SMS reminders and Facebook page posts to improve the engagement on the conversational agent. We will use the messages and Facebook post content as additional data sets for understanding engagement.

In the next few weeks, IPA team plans to conduct 150 surveys (same teachers in stage 0 [7.6]) by visiting teachers in their schools. Our survey will have questions on: teacher demographics, technology usage, social media access and usage, teacher career aspirations and perceived agency, Self-efficacy for teaching, Perceived social support, Teacher burnout (scale), and teacher agency in the community. We added more questions for teacher motivation and teacher knowledge from stage 3 [7.6]. IPA will also conduct surveys of teachers in the control condition (i.e., of the parent study) where teachers did not receive *NewMethod* and technology.
Lastly, we expect to interview 12 mentors and survey 60 mentors to understand their possible roles in future interventions. We will interview ten mentors and two active directors in an administrative Whatsapp group. We expect to understand (1) social media usage, (2) conversational agent perceptions and barriers to usage (3) the influence of NewMethod or technology on mentors' aspirations (4) NewMethod support from colleagues and trainers. We will also survey 60 mentors. Our surveys will have questions on mentor demographics, technology usage, NewMethod motivation (competence support, autonomy support, colleague support, and superior support), NewMethod knowledge/skills questions (chosen by the NGO), and general feedback on NewMethod and the conversational agent.

7.7 Expected Contributions

This study will utilize design-based research to generate theory and design recommendations for supporting teachers in low infrastructure contexts using a conversational agent. I expect to contribute to the following.

- (a) Community support in a conversational agent: I have extended prior work in community support [140, 147] in ICTD to conversational agent's in low infrastructure contexts. I've implemented and demonstrated community support in a conversational agent through participatory content. My research aims to expand these designs to understand if community support can have more impact and allow for more sustainable outcomes. Through a quasi-experimental design, I expect to understand the potential for community support designs at scale.

- (b) Opportunities and barriers for early conversational agent adopters: I expect to understand the opportunities for early adopters to contribute to conversational agent content, support fellow teachers through digital and non-digital participation, and champion technology adoption among community members. Additionally, I plan to understand the barriers that inhibit intervention of low-level challenges like internet access, device usability, and financial issues to higher-level challenges like workload, frequent travel, etc. Understanding opportunities and barriers will support running future studies and practitioners to build impactful systems.

Outside academic impact, I have demonstrated translating a theory to practical designs, and I hope to make an initial social impact by supporting our partners using my data.
Designing for teacher aspirations: I used Design-Based Research to uncover design ideas from the theoretical aspirations-based approach. In study 2, I used teachers’ engagement from NewMethod to generate design ideas for teachers’ aspirations, i.e., shaping aspirations, creating new aspirations for behavior change, and designing for teacher agency. I have implemented these designs in Study 3 through community support and expect to evaluate them in Study 4. I expect my process will help ICTD practitioners convert theory-based work (primarily on aspirations) to practical work.

Initial social impact: Our final iterations from study 5 (future work) will serve as an initial design direction for the NGO and the ministry of Côte d’Ivoire to implement a conversational agent to support program implementation at scale. I will also use my data to generate a report for the NGO and the Ivorian ministry to better support teachers with large-scale interventions and technology. Lastly, I plan to release my conversational agent code in a public GitHub repository to inspire future implementation work in this direction.

7.8 Timeline

Tab. 7.2: This table summarizes my timeline to completion

<table>
<thead>
<tr>
<th>September 2021 - May 2022</th>
<th>ran study 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 15</td>
<td>thesis proposal</td>
</tr>
<tr>
<td>July 2022 - August 2022</td>
<td>submit study 3 (pilot) to CHI</td>
</tr>
<tr>
<td></td>
<td>write up study 4 (evaluation)</td>
</tr>
<tr>
<td></td>
<td>write statements for job application</td>
</tr>
<tr>
<td>September 2022 - May 2023</td>
<td>submit study 4 (pilot) to COMPASS/ICTD</td>
</tr>
<tr>
<td></td>
<td>run and support study 5 (future work)</td>
</tr>
<tr>
<td></td>
<td>apply to postdocs/jobs</td>
</tr>
<tr>
<td></td>
<td>write thesis</td>
</tr>
<tr>
<td>May 2023</td>
<td>thesis defense</td>
</tr>
</tbody>
</table>

Thus, providing initial evidence to confirm that these features for participatory content could provide community support.


[40] Asbjørn Følstad, Marita Skjuve, and Petter Bae Brandtzaeg. “Different chatbots for different purposes: Towards a typology of chatbots to understand interaction design”. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 2019 (cit. on p. 10).


[100] Lindsay C. Page and Hunter Gehlbach. “How an Artificially Intelligent Virtual Assistant Helps Students Navigate the Road to College”. In: *AERA Open* (2017) (cit. on p. 10).


[135] TARL. Teaching at the Right Level - strengthening foundational skills (cit. on pp. 7, 38, 48, 67).


Webpages

List of Figures

1.1. I used an iterative design based research to bridge the gap between theory, technology and design through my former studies (Study 1, 2A, 2B, 3, 4). My proposed work (Study 4) is to answer: Will designs for community support have more impact than individual support towards teachers in low infrastructure settings? .......................... 5

3.1. The goal for study 1 was to explore the (a) technological design space in Côte d'Ivoire and (b) discover opportunities to design for teachers’ aspirations. ................................. 13

3.2. An interview session in a school in Adzopé . .......................... 15

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5.1. The goal for study 2b was to extend theory (aspiration) to technology (conversational agent) designs to support teachers with pedagogical programs. ................................. 41

5.2. A typical NewMethod activity in a rural setting. Students are split into levels based on proficiency in French and math. At each level, they participate in participatory activities for 45 mins a day for each subject led by their teacher. ................................. 44

5.3. The researcher helps a teacher with a survey (left) and the researcher conducts an interview in a school (right). ................................. 47
5.4. A representative screenshot of our conversational agent probe [19]: (A) the agent asked the user to type "1" to request human support if the question was outside the database. (B) the probe had some questions related to NewMethod and returned responses immediately. (C) When the team answered the question, the agent returned the answer with the user’s question.

5.5. Summarizes key themes and their distribution over the duration of the study.

5.6. A Director takes the role of a mentor to teach an activity to the teachers during training.

6.1. The goal for study 3 was to pilot my initial set of designs about community support. My work from study 2A led me to designs that allowed for community support in a conversational agent.

6.2. This figure shows a flowchart explaining the various features of the system. A gray box represents a menu and a yellow box represents a feature.

6.3. Total daily messages over the first ten days. Teachers engaged the conversational agent the most on Day3, i.e. when the advisor supported research team during teacher training.

6.4. Think aloud session with a teacher, conducted 2 weeks after training. The teachers were asked to access a feature while the interviewer recorded their attempt on a survey. Teachers were given 3 attempts per feature and the entire session was recorded on video.

6.5. Success rate of the think aloud by feature and teacher. Each row represents a teacher and each column represents a feature. A green box indicates success and a red box indicates failure. The columns at the end indicate aggregate success percentage for the user. The last row indicates aggregate success percent for the feature.

7.1. My goal for Study 4 is to measure the impact of community support designs that I piloted in study 3.

7.2. Study design and related conversational agent features.

7.3. Theory of change explaining impact. We categorize impact as (a) Teachers’ motivation to implement the program, (b) Teachers’ knowledge/skills about the training, and (c) Technology adoption. We hypothesize that early adopters will utilize the community features, thus leading to more motivation and knowledge.

7.4. Flowchart of system features and design changes.
7.5. Storyboard representing the phone book feature. The phone book would provide a personalized dynamic list of teachers every week. We based this design on our data from Study 2, where teachers mentioned that they called each other to support. 

7.6. These two pictures describe a sample training session held during study 3

A.1. Storyboard 1: Here the chatbot is helping Teacher Eric with an activity to implement a pedagogical program.

A.2. Storyboard 2: Here, the chatbot supports an advisor to monitor the teachers in the region using a quiz.

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5.1. Summarizes our data sources collected by the team ........................................... 45

6.1. Table summarizing our data sources collected by the team ........................................... 66

7.1. Summarizes the different data collection proposed over the year. The green color indicates work already completed. ........................................... 82

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A.1. Table summarizing our code book from questions ........................................... 110
Appendix

**Fig. A.1.:** Storyboard 1: Here the chatbot is helping Teacher Eric with an activity to implement a pedagogical program.

**Fig. A.2.:** Storyboard 2: Here, the chatbot supports an advisor to monitor the teachers in the region using a quiz.
Tab. A.1.: Table summarizing our code book from questions

<table>
<thead>
<tr>
<th>Subject/Classroom Teaching</th>
<th>31 (28%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geography</td>
<td>11</td>
</tr>
<tr>
<td>History</td>
<td>6</td>
</tr>
<tr>
<td>Math</td>
<td>4</td>
</tr>
<tr>
<td>Ivorian Administration</td>
<td>4</td>
</tr>
<tr>
<td>Grammar</td>
<td>3</td>
</tr>
<tr>
<td>Science</td>
<td>2</td>
</tr>
<tr>
<td>Teaching method</td>
<td>1</td>
</tr>
<tr>
<td>NewMethod</td>
<td>25 (23%)</td>
</tr>
<tr>
<td>NewMethod info</td>
<td>11</td>
</tr>
<tr>
<td>NewMethod implementation</td>
<td>11</td>
</tr>
<tr>
<td>NewMethod resource</td>
<td>3</td>
</tr>
<tr>
<td>Feedback</td>
<td>24 (22%)</td>
</tr>
<tr>
<td>Clarification</td>
<td>17</td>
</tr>
<tr>
<td>Greetings</td>
<td>5</td>
</tr>
<tr>
<td>Feedback</td>
<td>2</td>
</tr>
<tr>
<td>COVID</td>
<td>10 (9%)</td>
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<td>Covid news</td>
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</tr>
<tr>
<td>Covid treatment</td>
<td>1</td>
</tr>
<tr>
<td>Covid symptoms</td>
<td>1</td>
</tr>
<tr>
<td>Covid forward</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>9 (8%)</td>
</tr>
<tr>
<td>Sport</td>
<td>5</td>
</tr>
<tr>
<td>News</td>
<td>4</td>
</tr>
<tr>
<td>Personal</td>
<td>6 (6%)</td>
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<tr>
<td>Business advice</td>
<td>4</td>
</tr>
<tr>
<td>Sexual Health</td>
<td>2</td>
</tr>
<tr>
<td>NewMethod logistics</td>
<td>4 (4%)</td>
</tr>
<tr>
<td>NewMethod logistics</td>
<td>3</td>
</tr>
<tr>
<td>NewMethod implementation</td>
<td>1</td>
</tr>
<tr>
<td>Text</td>
<td>Translated text</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>Quels sont les états membres de la CEDEAO</td>
<td>WHAT ARE THE ECOWAS Member States</td>
</tr>
<tr>
<td>l'Union Africaine comprend combien de pays</td>
<td>The African Union includes how many countries</td>
</tr>
<tr>
<td>À quel moment utilise-t-on voici où vola ?</td>
<td>When it is used here are it?</td>
</tr>
<tr>
<td>Conjuguer le verbe plevoir au présent simple de l'indicatif</td>
<td>Conjugate the verb rain to the present simple indicative</td>
</tr>
<tr>
<td>Que signifie PEC</td>
<td>What does PEC mean</td>
</tr>
</tbody>
</table>

**Fig. A.3.:** Analysis of questions