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RISING ACADEMY NETWORK

WORKING PAPER

Dialling up Learning

Testing the impact of delivering educational content via Interactive Voice Recognition to students and teachers in Ghana

Date October 2021

Authors Edmund Afoakwah
Francisco Carballo
Alex Caro
Samantha D'Cunha
Stephanie Dobrowolski
Alexandra Fallon

DOI 10.53832/edtechhub.0051

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Recommended citation

Afoakwah, E., Carballo, F., Caro, A., D'Cunha, S., Dobrowolski, S., Fallon, A. (2021). *Dialling up Learning: Testing the Impact of Delivering Educational Content via Interactive Voice Response to Students and Teachers in Ghana*. Working Paper 39. https://doi.org/10.53832/edtechhub.0051. Available at https://docs.edtechhub.org/lib/P22BR78B. Available under Creative Commons Attribution 4.0 International, https://creativecommons.org/licenses/by/4.0/.

Notes

EdTech Hub is supported by UK aid and the World Bank; however, the views expressed in this document do not necessarily reflect the views of the UK Government or the World Bank.

Acknowledgements

The authors would like to thank the team at Viamo, especially Rabiu Alhassan, for their collaboration. A special thanks to all school leaders who helped with the implementation and to parents for their time and efforts to support their children's education. We also thank the EdTech Hub team for their support and feedback throughout the study, as well as for their final review and copy-editing.

Reviewers

Dr Miriam Mason-Sesay, Dr Taskeen Adam, Dr Katy Jordan, Kate Jefferies, Chris McBurnie

Abstract

This study explores the potential impact of interactive audio content for students and teachers delivered via Interactive Voice Response (IVR) in Ghana following the reopening of schools. The content for the lessons was drawn from the Rising On Air (ROA) audio library, a 20-week programme developed by Rising Academies to support student learning over the radio during Covid-19 pandemic-related school closures. Rising Academies' 30 low-cost private primary schools, known as Omega schools, were included in a randomised controlled trial. Half of the schools were randomised to receive the student intervention and the other half to receive the teacher intervention. Of the total sample of 1,359 students, 719 students in Grades 4, 5 and 6 received daily audio lessons that focused on foundational numeracy skills. Of the total sample of 333 teachers, 160 teachers received weekly professional development sessions focused on the instruction of foundational reading. In the student intervention, no significant effect was found on students' math skills and although the majority of students reported liking the intervention and wanting it to continue, engagement was a significant challenge. Results from the teacher intervention indicated an improvement in teachers' understanding of phonemic awareness, phonics, and morphology. Teachers' beliefs about their ability to improve student learning in the areas of reading and engagement also increased, but the potential impact on student outcomes was not measured. Differences between the student and teacher interventions suggest some important considerations for future interventions delivered via IVR and highlight some of the challenges as well as potential opportunities for more effective low-tech solutions.

Contents

Abbreviations and acronyms

GLRRP	Ghana Learning Radio and Reading Programme
IRI	Interactive Radio Instruction
IVR	Interactive Voice Response
ROA	Rising On Air
TIMSS	Trends in International Mathematics and Science Study
TSES	Tschannen-Moran's Teacher Sense of Efficacy Scale

Executive summary

Background and context

With the outbreak of Covid-19, there was a sudden need for effective remote learning solutions on an unprecedented scale. The disruptions had a severe impact on student engagement in educational activities and opportunities for learning, and in countries like Ghana, Sierra Leone, and Liberia, exacerbated an already serious crisis in education (↑World Bank, 2018). Teachers were also affected and it was difficult to find meaningful and effective opportunities to engage and support teachers remotely. In an effort to ensure improved preparedness in future, this study sought to explore the potential impact of remote learning interventions for students and teachers delivered via Interactive Voice Response (IVR).

The implementation and evaluation of the student and teacher interventions in this study were carried out by Rising Academies. Rising Academies is a quality-focused network of schools in Africa and a Certified B Corp®. To support national education response efforts in Sierra Leone and Liberia, Rising Academies leveraged its structured curriculum content to develop the Rising On Air (ROA) programme. Rising On Air is a 20-week programme of ready-to-air radio scripts that focuses on foundational literacy and numeracy from pre-primary to senior secondary school. It also includes teacher professional development content focusing on classroom management skills as well as grade-level and subject-specific knowledge, including the instruction of foundational reading. The programme content was provided freely to global partners and governments on Rising's web portal via a creative commons licence. Its lessons reached over 10 million children in 25 countries across Africa and Asia (↑Lamba & Reimers, 2020).

For the purposes of this study, Rising Academies delivered pre-existing ROA audio content that was recorded and broadcast in Sierra Leone. The student intervention targeted foundational skills for upper primary grades. For the teacher intervention, the content focused on the instruction of foundational reading. For both the student and teacher interventions, quiz questions were developed and included as a follow up to each ROA lesson.

Purpose

The purpose of this study was to explore the potential impact of interactive audio content delivered via Interactive Voice Response (IVR) to students and teachers following the reopening of schools in Ghana. Given the challenges with evaluating interactive radio programmes, especially in out-of-school settings, this study sought to test the potential impact of interactive audio

recordings delivered via IVR to students and teachers, in addition to regular schooling. The focus was on foundational numeracy skills development for students and the instruction of foundational literacy skills for teachers, as well as programme engagement and feedback.

Method

The study was designed as a randomised controlled trial and included Rising Academies' 30 low-cost private primary schools in Ghana, known as Omega schools. Schools were randomly assigned to receive either the student IVR programme (15 schools) or the teacher IVR programme (15 schools). To measure the potential impact of the interventions, baseline and endline assessments for students and teachers were developed by adapting existing tools, including Grade 4 Trends in International Mathematics and Science Study (TIMSS) assessment items (↑TIMSS, 2013), ETS Praxis' Teaching Reading: Elementary test (↑ETS Praxis, 2021) and Tschannen-Moran's Teacher Sense of Efficacy Scale (TSES) Short Form (↑Tschannen-Moran & Hoy, 2001). Lastly, students and teachers in the intervention group were also asked for their feedback on several aspects of the programme.

Key findings

The student intervention did not find significant differences in the foundational numeracy skills of students who participated in the 12-week IVR-delivered intervention compared to those who did not. Student engagement was a significant challenge. The majority of students failed to complete the lessons, which were approximately 10 minutes long, and the two follow up quiz questions. In response to student engagement data, lesson length was reduced by half during the intervention implementation. The change did not result in a meaningful increase in student engagement. Student feedback provided some helpful insights, highlighting their enjoyment of the quiz questions and individual preferences for specific content topics. Overall, the student intervention highlights the challenges of encouraging and sustaining sufficiently high levels of engagement in remote learning solutions and suggests some potential design considerations, such as more direct and frequent interaction.

In the teacher intervention, teachers who received one interactive audio session per week and participated in a weekly in-person discussion session with their colleagues improved their understanding of phonemic awareness, phonics, and morphology. Teachers' beliefs about their ability to improve student learning in the areas of reading and engagement also increased. Feedback from teachers was generally positive, with the majority of teachers recommending that Rising Academies should continue to develop more

phone-based approaches to training in future. The majority of teachers also reported that the audio sessions were interesting and convenient. Overall the teacher intervention suggests the potential for well-targeted and clearly structured professional development audio content delivered via IVR, with opportunities to build on these early-stage results.

1. Introduction

This section presents the background to the study, the purpose, aims, and research questions, and also considers the contributions to the literature.

1.1. Background to the study

Covid-19 school closures

Around the world, 1.6 billion children were affected by school closures due to Covid-19 (↑UNESCO, 2020). In Ghana, over 25,000 primary schools closed nationwide and millions of students were out of school from March 2020 until January 2021 (↑Warren & Wagner, 2020).

The abrupt transition to remote learning had a severe impact on the time children spent engaged in educational activities. A survey of students in Ghana, Sierra Leone, and Liberia carried out by IDinsight, an advisory and research organisation, found that children spent 5.7 fewer hours per weekday in educational activities during the pandemic. This is nearly the equivalent of a full school day, meaning that children were engaging in little to no learning activities while schools were closed (↑Caballero et al., 2021). Concerningly, this loss of engagement in learning was in the context of already low attainment levels. In Ghana, according to the 2018 National Education Assessment, the average English and maths scores for students in Grade 4 and Grade 6 were less than 50% (↑Ministry of Education et al., 2018). Further, 92% of young women who have completed six years of primary education cannot read a simple Grade 2 level sentence (↑Pritchett & Sandefur, 2017). Covid-19 school closures, therefore, exacerbated what was already considered a crisis in education (↑World Bank, 2018).

Students were not the only group who were disconnected from school and educational opportunities during this time. A key challenge faced by governments and education service providers, like Rising Academies, was how to stay connected with teachers and engage them in educational activities while they were being kept out of school. In many countries, these challenges were experienced in the context of existing teacher workforce challenges and constraints. In Ghana, less than two-thirds of primary school teachers are trained and qualified to teach (↑World Bank, 2021a).

Rising Academy Network

This study was conducted by Rising Academy Network, including both programme implementation and evaluation. Rising Academies is a quality-focused network of schools in Africa and a Certified B Corp®. Rising Academies uses high-quality curriculum content, intensive teacher coaching,

and rapid feedback loops to bring quality education to every classroom. This academic model is developed and refined through schools that Rising Academies owns and operates on a low-cost private school basis. They then take these learnings and work with governments and other partners to improve the quality of their schools at scale. Rising Academy Network works across 157 schools in Sierra Leone, Liberia, and Ghana serving nearly 50,000 students. This study includes Rising Academies' network of low-cost private schools in Ghana, known as Omega schools.

Rising On Air (ROA)

During the Covid-19 pandemic, many countries implemented national radio programmes to support distance learning. In Ghana, the government launched the Ghana Learning Radio and Reading Programme (GLRRP) supported by USAID, UNICEF and other partners (↑Ghana Ministry of Education, 2020). The programme incorporated storytelling and play-based activities aimed at improving reading, writing, and imaginative skills among lower primary learners, and provided distance learning in English and the 11 official Ghanaian languages of instruction (↑Agbe & Sefa-Nyarko, 2020). In Sierra Leone, the experiences and existing infrastructure from the Ebola crisis were leveraged to rapidly deploy the national Radio Teaching programme, which drew on support from organisations like Rising Academies and EducAid to develop and record radio lessons (↑World Bank, 2021b).

With a clear need for educational radio content to support government response efforts, Rising Academies leveraged its high-quality structured curriculum to develop the Rising On Air (ROA) programme. The 20-week programme of ready-to-air radio scripts focuses on foundational literacy and numeracy at five different levels from pre-primary to senior secondary school. Radio scripts were developed in English, French, and Arabic. In addition to supporting students, Rising Academies recognised the need for teachers to feel connected and have access to professional development opportunities during the pandemic. Rising Academies' radio teacher professional development content focuses on core, high-leverage classroom management skills as well as grade-level and subject-specific knowledge, including the instruction of foundational reading. The ROA content was made freely available to global partners and governments on Rising's web portal via a creative commons licence. The ROA lessons reached over 10 million children in 25 countries across Africa and Asia (↑Lamba & Reimers, 2020).

For the purposes of this study, Rising Academies leveraged pre-existing ROA audio content that the organisation had recorded and broadcast in Sierra Leone. The student intervention in this study specifically focused on upper primary numeracy lessons, which were then edited for delivery via IVR. For the teacher intervention, pre-existing ROA audio content was not available,

therefore, the ROA radio scripts were used to record audio content in Ghana. The focus of the teacher intervention was the ROA teacher professional development series targeting the instruction of foundational reading. For both the student and teacher interventions, quiz questions were developed, recorded, and included as a follow up to each ROA lesson.

Return to school

Schools reopened in Sierra Leone, Liberia, and Ghana in late 2020 and early 2021. Despite concerns around the potential risk of students not returning to school, particularly given the experiences following the Ebola crisis, 97% of students in Sierra Leone, Liberia, and Ghana who had been enrolled pre-Covid re-enrolled when schools reopened (↑Caballero et al., 2021). However, in many countries around the world, disruptions to the academic calendar have become the current reality.

With the risk of future school closures, it is important to continue building on the experiences and lessons learnt during the first 12–18 months of the Covid-19 crisis. This will help ensure that governments and education providers are better prepared to meet sudden demands in future. Further, the well-established gap in foundational skills for both students and teachers continues to drive the need for innovative solutions that can be complementary and additive to in-school education. Consistent with feedback from caregivers concerning their preference for low-tech solutions (↑Fall et al., 2021), this study explores the potential impact of educational audio content delivered via IVR to students and teachers following the reopening of schools in Ghana.

1.2 Purpose, aims, and research questions

The purpose of this study was to test the impact of interactive audio content delivered via IVR on student and teacher outcomes in Ghana. In addition, it also explored the engagement of students and teachers and collected feedback on their perceptions of the IVR-delivered interventions.

The study focused on the following research questions:

- Does listening to numeracy lessons delivered via IVR improve student learning outcomes?
- How often do students listen to IVR-delivered numeracy lessons, for how long, and what are their perceptions of the lessons and the method of delivery?
- Does listening to teacher professional development lessons delivered via IVR improve teacher knowledge and self-efficacy?

- How often do teachers listen to IVR-delivered professional development lessons focused on teaching foundational reading, for how long and what are their perceptions of the lessons and the method of delivery?

1.3. What this paper adds to the knowledge base

This study builds on the existing literature by exploring the potential impact of a low-tech remote learning solution for students and teachers through a randomised study design. Evaluating national radio programming is inherently difficult given the inability to randomise participants into the intervention condition and a 'no listenership' control condition. It is also very difficult to track listenership. This study, therefore, uses IVR as a low-tech mode of delivery that allows for the evaluation of the potential impact of interactive audio content through a more rigorous research design.

From a research perspective, the use of IVR to deliver audio content has the advantage over radio of allowing for the randomisation of participants to an intervention group and a 'no intervention' control group. Only participants in the intervention group have contact numbers that are active in the IVR system. Control group participants do not receive calls nor can they call into the platform. Through the IVR platform, it is also possible to track individual listenership, which is not possible via radio programming. For each participant, it is possible to track their listenership over the course of the intervention to determine how many lessons they completed. It is also possible to determine at which point in the lesson sequence listeners dropped off. The delivery of audio content via IVR also ensures that participants listen to the content in sequence. With radio, listeners must listen at the scheduled time and do not typically have the option of listening to lessons they have missed unless they are re-broadcast. With IVR, participants pick up the content where they left off and have the flexibility of accessing the content at any time of day. The use of IVR as the method of delivery of audio content nationwide, therefore, provides the opportunity for a more rigorous research design and evaluation of its impact on student and teacher outcomes, a richer dataset to explore participant listening and engagement patterns, and ensures that listeners engage with the content sequentially.

The study also builds on the existing research by exploring the experiences of students and teachers and considers the supports and barriers to engagement in an IVR-delivered intervention. Feedback from students and teachers contributes to an improved understanding of the potential of IVR as a low-tech solution to reach children and teachers outside of school. In this study, the interventions are additive to regular in-school education, but the results also have implications for fully remote learning solutions in the event of future school closures.

1.4 Structure of the report

The structure of this paper is as follows:

- Section 2 — Literature review
- Section 3 — Methodology
- Section 4 — Results
- Section 5 — Policy Implications
- Section 6 — Conclusion

2. Literature review

The following literature review explores low-tech learning solutions, including educational radio programmes and insights from Interactive Radio Instruction (IRI). It also considers the evidence for blended and remote teacher professional development programmes, as well as the potential for innovative low-tech solutions.

2.1. Low-tech remote learning solutions

Over 90% of the world's children were out of school due to the Covid-19 pandemic (↑UNICEF, 2020). The sudden closure of schools called for immediate distance learning solutions on an unprecedented scale. In a recent UNESCO report, it was found that over 60% of national distance learning alternatives relied exclusively on online platforms. However, as many as 465 million learners in these countries do not have access to the internet at home (↑Giannini, 2020). A recent survey of Rising Academies' private school students in Ghana found that only 12% of students have a computer or tablet, and only 8% of students participated in online learning (↑Fall et al., 2021). Distance learning programmes, therefore, raise important concerns around the equitability of access and the need to consider low-tech solutions.

In Ghana, Sierra Leone, and Liberia, governments turned to radio as a key solution for remote learning on a national scale. Educational radio programming can be a cost-effective approach for large-scale remote learning, particularly in the context of existing infrastructure, stakeholder support, and a large number of listeners (↑Damani & Mitchell, 2020). Building on their experience and existing infrastructure from the Ebola crisis that also resulted in nationwide school closures, Sierra Leone and Liberia launched national radio teaching programmes soon after the closure of schools due to Covid-19. In Ghana, the GLRRP was launched in June 2020 and focused on foundational learning for lower primary students, particularly through storytelling and play-based activities designed to engage younger learners (↑Agbe & Sefa-Nyarko, 2020). To support wider distribution, the GLRRP was broadcast by regional radio networks of the Ghana Broadcasting Corporation and on local radio stations with instruction in English and in Ghanian local languages.

Across these three West African countries, radio-based programming was the primary low-tech solution for the national education response during the Covid-19 closures. The evidence for educational radio programming in out-of-school contexts, however, is limited (↑Damani & Mitchell, 2020). Despite these limitations, ↑Damani & Mitchell's (2020) rapid evidence review of radio-based education programmes highlighted that the key characteristics of

educational radio approaches in the classroom can still be relevant to learning outside of the classroom. As discussed in more detail below, the importance of interactive, student-centred approaches was identified as a key learning to consider for educational radio programming in out-of-school contexts (ibid).

2.2. Interactive Radio Instruction

Interactive Radio Instruction (IRI) is an instructional approach designed to deliver active learning by radio (↑Ho & Thukral, 2009). According to a World Bank toolkit published in 2005, IRI combines radio broadcasts with active learning, meaning that teachers and students are required to respond verbally and physically to the questions and learning activities included in the radio programme (↑Anzalone & Bosch, 2005). There is good evidence for the effectiveness of IRI to improve student learning outcomes, even in more challenging learning environments (↑Ho & Thukral, 2009). Reviews also note that IRI can effectively support teachers with facilitating more child-centred and interactive classrooms, especially for teachers who have limited access to training opportunities (ibid; ↑Trucano, 2010). Research points to the importance of the interactive nature of IRI, which prompts engagement and actions from both students and teachers, and highlights the key difference with more conventional radio broadcasts.

In an effort to build on the existing evidence from IRI programmes, Rising Academies developed its ROA educational radio scripts to be engaging and interactive for students and teachers. Lessons are not lectures but rather interactive exchanges between teacher and student voices, including questions and responses, prompts for specific actions, and involve activities for students to complete. They also incorporate the role of a 'helper', like a caregiver or an older sibling, to support the student. But without the ability to randomise students to participate in national educational radio broadcasts and the difficulties with accurately tracking listenership, it was very difficult to explore the potential impact of Rising Academies' more interactive approach to educational radio programming during the Covid-19 school closures.

During the Covid-19 crisis in Liberia, RTI's Read Liberia programme supported the Ministry of Education to develop and record language arts lessons for grades 1 and 2, which were broadcast nationally as part of Liberia's Teach by Radio program. Rising Academies was also a key partner and contributed ROA scripts and recordings. Similar to Rising's ROA lessons, the non-profit research institute, RTI, repurposed their content for radio and designed their lessons to involve the active participation of families through singing, writing, and other actions to encourage active listening and learning (↑Bulat, 2020). RTI's follow-up research found that of those parents they interviewed, who reported listening to the Teach by Radio programme, 95% reported that someone in the

household listened with the child. Of the parents, 86% also thought that their child had learnt from the radio lessons, although this was only parents' perception of learning (ibid).

RTI's research in Liberia highlights another potential limitation with interactive radio-based education programmes for out-of-school learning: Of the parents they interviewed, 52% did not have a radio (↑Bulat, 2020). Although radio is certainly more accessible than online learning opportunities, it may not necessarily be as widely accessible as one might assume. In Ghana, a national survey in 2018 reported that 57% of households owned a radio, whereas only 15% of households had a computer and 22% had access to the internet in their home (↑Ghana Statistical Survey & UNICEF, 2018). Mobile phone penetration however was much higher, with 93% of households owning a mobile phone. Of the households, 60% also reported owning a television (ibid).

Similarly, a recent survey of Rising Academies' government and private school students in Sierra Leone, Liberia, and Ghana found that only 24% had access to radio on a weekly basis (↑Fall et al., 2021). This varied from 28% of the homes of private school students in Ghana and 38% of the homes of government school students in Liberia to 52% of the homes of government school students and 67% of the homes of private school students in Sierra Leone. Conversely, in this same survey, it was found that 46% of children had access to basic handsets and an additional 36% had access to smartphones with data. As would be expected, access to technology varied by household income level (↑Fall et al., 2021). When determining the modes of delivery for remote learning solutions, it is important to bear in mind household access to technology even in the case of low-tech options like radio-based learning.

2.3. Remote teacher professional development

National education responses during the Covid-19 crisis focused first on reaching students kept out of school but soon recognised the need to connect with teachers as well. Technology-enabled solutions for remote and blended approaches to support teacher professional development is a relatively new area of practice and research in low- and middle-income countries. Recent reviews suggest the potential for positive results, including improved teacher knowledge and skills (↑Education Endowment Foundation, 2020). However, there is a limited number of studies on the effectiveness of different modes of delivery and approaches, and little evidence for the effects of teacher professional development on student outcomes (↑Perry et al., 2020). Despite the limitations, the literature highlights some consistent learnings.

Similar to the evidence from IRI programmes for students, the research on fully remote or blended teacher professional development programmes points to the importance of interactive content and opportunities for

collaboration amongst peers (↑Education Endowment Foundation, 2020). More interactive content was associated with better completion rates, knowledge and skill acquisition. Collaboration between peers seemed to encourage more reflective practice amongst teachers. Ensuring the opportunities for peer collaboration are meaningful and connect teachers to each other and their practice can be difficult, particularly during school closures when engagement is entirely remote (↑Allier-Gagneur et al., 2020). But peer collaboration is important to support teacher reflection, learning and improvement and can help reduce feelings of isolation, which is particularly relevant in the context of school closures (↑Education Endowment Foundation, 2020).

A potential benefit of remote or blended approaches to teacher professional development is the flexibility they can afford teachers (↑Perry et al., 2020). Teachers can engage with online platforms and other remote learning opportunities at a time that is convenient for them. Alongside this potential benefit, the literature also points to possible concerns with open-endedness or lack of structure. Although flexibility can be beneficial, ensuring programmes have clear structure is key. The purpose and expectations for professional development must be clear and well-understood by teachers to ensure active participation over time (↑Perry et al., 2020).

In addition to the need for clear programme structure, research also suggests the importance of supportive conditions, particularly in terms of the enabling environment for teachers to access and participate in remote professional development activities (↑Education Endowment Foundation, 2020). For example, ensuring teachers have access to the necessary technology, as well as the training and support needed to utilise the technology effectively, is essential. Removing practical constraints, like the cost of airtime or data to access online learning and forums for discussion, is also important to consider.

Whether as a blended learning programme during the academic year or a fully remote intervention during school closures, these key insights from the existing literature are important to consider when designing and implementing teacher professional development programmes. The literature notes the promising nature of remote and blended approaches to teacher education and highlights the considerable potential for growth in this area (↑Education Endowment Foundation, 2020).

2.4. IVR-based interventions

Given widespread access to basic handsets, IVR is an alternative low-tech solution with the potential to reach students and teachers on a large scale. With IVR, the participant either receives a call or directly dials into the IVR

system, typically using a toll-free number. The caller is then guided through an interactive computer-operated phone system, which allows the caller to interact either through the use of speech recognition or via the keypad on the phone. IVR systems respond with pre-recorded or computer-generated audio content to further engage the caller through a progression of sequenced information or audio content. With remote learning in mind, IVR presents a potential low-tech solution through which the learner, whether a student or teacher, could listen to educational content and progress at their own pace. Unlike radio broadcasts, wherein all listeners engage with the same content and progress at the same pace regardless of their learning level, IVR has the potential to allow the learner to select content and progress independently. Moreover, callers can dial into IVR systems at any time, offering the flexibility that scheduled radio broadcasts cannot provide.

A systematic review and meta-analysis of the effectiveness of IVR-based interventions to promote health-related behaviour changes found positive results, including improved medication adherence and physical activity (↑Tsoli et al., 2018). The review notes that although there are a number of promising interventions, more research is needed to understand what makes IVR interventions more effective. In the education sector, research on the effectiveness of IVR-based interventions, either for students or for teachers, is limited.

In Malawi, RTI partnered with the global social enterprise called Viamo to deliver teacher training to over 17,000 instructional leaders via IVR when their in-person training plans were disrupted due to Covid-19 (↑Carrol, 2020). A number of key learnings were highlighted, including:

a. logistical considerations, like the time needed to prepare for the IVR programme launch and the importance of collaborating with telecom companies;

b. design considerations, like varying the content format and the importance of simple, clear questions for IVR;

c. participation considerations, like the importance of call-backs, using multiple channels to increase engagement, and the role that government stakeholders can play to increase participation.

Although the IVR-based training was not delivered within an evaluation design, the RTI team concluded that IVR has the potential to support large-scale remote training needs (↑Carrol, 2020). Results from an evaluation of an educational IVR-based intervention for students in Bangladesh are forthcoming.

2.5. Need for innovative, low-tech solutions

The Covid-19 pandemic disrupted student and teacher learning and raised concerns with equitable access to remote learning opportunities. Results from a survey of caregivers in Ghana, Sierra Leone, and Liberia found that children engaged in little to no educational activities during that time (↑Caballero et al., 2021). Although children are now back in school, it is known that many are not learning. Across Africa, 88% of children are in schools where, by Grade 9, they have not learnt how to read, write, or do basic mathematics (↑UNESCO & UIS, 2017). This is despite education spending rising by nearly 70% over the last decade in lower- and lower-middle-income countries, reaching more than $330 billion in 2018–19 (↑Al-Samarrai et al., 2021). There is an urgent need for scalable, cost-effective solutions that can accelerate student learning, whether this is in addition to their regular schooling or in the event of future school closures. There is also a clear need to support teachers to improve the quality of their teaching through effective professional development opportunities.

This study builds on existing evidence to explore the potential impact of interactive ROA audio content delivered via IVR to improve foundational numeracy skills for upper-primary-grade students, in addition to schooling as usual. It also explores the potential impact of interactive ROA audio content for teachers delivered via IVR to improve teacher understanding of foundational literacy skills development.

3. Methodology

3.1 Research questions

The study focused on the following research questions:

- Does listening to ROA numeracy lessons delivered via IVR improve student learning outcomes?
- How often do students listen to IVR-delivered numeracy lessons, for how long and what are their perceptions of the lessons and the method of delivery?
- Does listening to ROA teacher professional development lessons delivered via IVR improve teacher knowledge and self-efficacy?
- How often do teachers listen to IVR-delivered professional development lessons focused on teaching foundational reading, for how long and what are their perceptions of the lessons and the method of delivery?

3.2 Interventions

3.2.1. IVR platform and audio recordings

To deliver the intervention using an existing IVR platform, Rising Academies partnered with Viamo. Viamo uses low-tech solutions for data collection and the distribution of information via mobile phones. They utilise a network of relationships with telecommunications providers throughout the continent of Africa and elsewhere to provide mobile engagement solutions to organisations seeking to provide interactive campaigns to customers.

Rising Academies worked with Viamo to clarify the student and teacher intervention programme design, including audio content and reminder SMS texts, ensuring student and teacher audio content was prepared and distributed according to the agreed schedule. Viamo loaded Rising's audio content onto their platform and scheduled regular calls to students and teachers to deliver the content.

This study used pre-existing ROA audio content for students that was originally recorded in Sierra Leone during the Covid-19 school closures. Student quiz questions, the additional content needed for the IVR programme (e.g., intro messages), and all audio content for the teacher professional development intervention was recorded by Rising Academies in Ghana. The editing of all student and teacher audio content was done by Rising

Academies. Audio files were uploaded into a shared space with Viamo for them to then upload into their system.

Rising Academies coordinated with Viamo regularly through a shared communications channel and held weekly meetings to ensure the successful implementation of the project according to the programme schedule.

3.2.2. Student intervention

The focus of the student intervention was foundational numeracy skills development. In-school programmes across all study schools focus on foundational literacy skills, so it was decided to avoid potential overlap with existing programming. The ROA upper primary numeracy lessons were used and included audio lessons that focused on numbers within 1,000, and addition and subtraction within 1,000. These topics were selected based on the learning needs of students in upper primary grades determined through internal assessments. All participants in Grades 4, 5, and 6 received the same content through the IVR lessons.

During the programme, the IVR system automatically called students every day at 7:00 pm. If students answered the call, the IVR lesson started and students were guided through it (intro session, narrative, and quizzes). If students did not answer the call at that time, they had the option to call into the system at any time. The IVR system would recognise the phone number that was calling in so that students would continue from where they left off in the previous lesson. Students also received regular SMS throughout the week, reminding them of their lessons at 7:00 pm, as well as the possibility of calling back into the system if they missed a lesson, at no cost.

Every student lesson finished with two quiz questions. Students replied to the quiz questions by typing on their keypad. If incorrect, the system informed them that the answer was incorrect, and gave them a chance to reply again. If the answer was incorrect again, the system skipped to the next quiz question.

The student intervention was delivered in two phases, outlined below.

Phase 1: Weeks 1–5

- Students received one 10–12 minute lesson per day. Each week covered 5 lessons.
- Each lesson started with an intro message and ended with two quiz questions.
- Students could not progress from one lesson to the next until they had completed the lesson, including both quiz questions.

- Each week-long block of 5 lessons was new, meaning that every student would start the week on the same lesson regardless of where they had progressed to the week prior. The intention was for students to progress through the programme at a steady and consistent weekly pace.

Phase 2: Weeks 6–12

- To reduce the length of each IVR session, each lesson was divided into Part 1 and Part 2. Students had the option to complete Part 1 on one day and Part 2 the next day or to complete both Parts on the same day.
- Students progressed through the content at their own pace. At a minimum, students were expected to complete 2 full lessons, or 4 lesson segments, every week.
- Two new lessons, or 4 lesson segments, were added to the system each week.

As outlined above, the first phase delivered one lesson per day, 5 days per week. Student engagement was reviewed weekly. After the first few weeks of programme implementation, it was clear that student engagement overall was lower than expected. There was a declining pattern of engagement both within the week (i.e., listenership decreased from Monday to Friday), and from week to week (i.e., in each subsequent week, fewer students were listening). The majority of students were failing to complete each lesson. Although Viamo's experience with IVR programmes typically focuses on public messaging campaigns, it was their view from the outset that lesson segments should be much shorter in length. Their recommendation was a maximum of 2–3 minutes per lesson. At the same time, a concurrent study in Bangladesh exploring the use of IVR for student learning was delivering audio lessons that were approximately twice as long, at about 20 minutes per lesson.

In the absence of prior research and with mixed recommendations, the focus was on the decreasing patterns of student engagement to inform the decision to shorten lessons. Audio lessons for students were shortened by half and the requirement to finish lessons within a certain time frame was removed. Although this removed some of the intended structure of the programme, it ensured that students could progress at their own pace. In the second phase, which started in week 6 of the intervention, students received a phone call 4 days a week and would be prompted to continue wherever they left off. Access to 4 new lesson segments, equivalent to 2 full lessons from Phase 1, was provided each week.

Table A1 in the Annex outlines the lessons covered each week in Phase 1 and Phase 2 of the intervention and the general topic. A detailed overview of the learning objective for each lesson is included in Table A2 in the Annex.

3.2.3. Teacher intervention

The teacher intervention delivered one professional development session per week for 15 weeks (the first session was an introduction to the IVR programme). The focus of the sessions was foundational literacy and how children learn to read. This topic was selected based on the well-established importance of foundational reading skills, the challenges with teaching foundational English reading, and feedback from teachers.

To incorporate evidence-based practices, teacher professional development sessions were interactive and followed up with in-person peer discussion and reflection in school. The programme was flexible but with a clear weekly structure and set of learning objectives, and teachers were provided with initial training and support with how to use IVR. The IVR intervention for teachers was designed as one IVR lesson per week plus one in-person peer discussion at the end of every week. It is therefore not possible to single out the effects of the IVR-delivered lessons on their own, without the peer discussion component. Future research exploring the mechanisms through which these programmes impact teacher outcomes should be designed in a way that permits identifying the effects of each component of the programme independently.

The specific structure of each session included an introduction, a narrative segment with the core audio lesson, two interactive quiz questions and a short closing. The core audio was presented in the form of a dialogue between two narrators and lasted approximately 10 minutes per session. Every Friday evening, a new session was made available through the IVR platform and an SMS notification was sent to teachers. If teachers did not complete the lesson in one call, they could call back whenever they preferred to continue from where they had left off. If teachers had not listened by Wednesday afternoon, then they received a second SMS reminder on Wednesday evening. Every Friday after school, teachers would meet together in person to discuss that week's session.

Table A3 in the Annex outlines the content of the 15 teacher professional development sessions.

3.3. Research design and methodology

3.3.1. Sample

A total of 30 schools were included in this study. Rising's Omega network operates 32 schools in Ghana but two of these schools were not included because they offer pre-primary grades only. The student intervention focused on students in Grades 4, 5, and 6, with a particular focus on Grade 5 students.

To inform the target grade selection, upper primary ROA audio content was piloted with students in Grades 3, 4, and 5. Students in Grades 1 and 2 were not considered given challenges with their ability to access and engage with an IVR-delivered programme. The pilot suggested that students in Grade 3 consistently struggled to listen to and understand the upper primary audio content. Students in Grade 4 were mixed, whereas students in Grade 5 seemed most appropriately targeted, both in terms of the level of the content as well as their ability to listen and understand. Grade 6 students were not prioritised given it is their final, exam year of primary school. The priority grade was therefore Grade 5.

In some schools, the number of students in Grade 5 was sufficiently large to meet sample size requirements, which was set at 45 students per school based on power calculations, and implementation and budgetary constraints. In these cases, only Grade 5 students were included. In smaller schools with lower grade-level enrolment, Grade 4 students were the next priority grade, followed by Grade 6 students. Table A4 in the Annex shows the schools, grades, and number of students and teachers that took part in the programme.

Before the start of the programme, parent meetings were held in each of the sample schools to introduce the programme to the families and ask them if they wanted to participate. Phone numbers were collected from parents who opted into the programme. Each of these families shared their contact details and were informed whether they were selected to participate or not after the assignment of schools was completed.

A total of 1,359 students from Grades 4, 5 and 6 across 30 schools were assessed before the programme started, forming our total study sample. Following the random assignment of schools into intervention and control conditions, 719 students from 15 schools participated in the IVR programme.

For the teacher IVR intervention, baseline data was collected from 333 teachers across 30 schools. These teachers were primary and secondary teachers, employed full-time in Omega schools at the time of the baseline. Following the random assignment of schools, 160 teachers from 15 schools (different from the schools selected for the student programme) participated in the IVR programme. Teacher turnover was high and was a challenge in the study. Section 4.2 presents more details about the nature of teacher attrition and how it affects the results.

Collecting detailed data on the socio-economic status of the families who participated in this programme was beyond the scope of this study. However, recent survey statistics collected by IDinsight from a sample of families of the study schools are available. Please note that this study was commissioned

with a potential future school closure scenario in mind, and therefore, some of the answers might not be very representative of families' opinions about after-school and / or extra classes.

Most households in the survey sample (73.7%) were headed by the father / husband, consisted of 4.9 members, and had 2.1 school-age children. Only 5.8% of the households obtained their main income from agriculture, their main occupations being mostly services and trading (↑Caballero et al., 2021). Of the households, 48.5% and 36.5% own a smartphone or a handset, respectively, making IVR a mode of delivery accessible for the majority of the families. Of the families who reported owning a smartphone or a handset, 78.6% and 65.6% (respectively) mentioned that the device is available to their children for schooling purposes. However, only 31.1% agreed that "delivering IVR lessons over the phone was very appropriate and useful." Instead, most families preferred to take home packs and private / group lessons taught by a teacher (↑Caballero et al., 2021).

3.3.2. Randomisation

This study was a randomised controlled trial consisting of an intervention group and a control group for each of the interventions (student and teacher), with randomisation at the school level. Randomising at a school level was deemed appropriate given that it was a grade-focused intervention for students and a whole-school intervention for teachers. There were potential risks with students or teachers in the control group unintentionally receiving the intervention if randomisation occurred at the individual student and teacher level. It was also decided that randomisation at a school level was preferable from an implementation perspective and would simplify the follow-up activities to support student and teacher engagement. Teachers and school leaders could encourage all students within a particular grade to listen to their lessons at home, and school leaders could follow up with all teachers in their school. Furthermore, weekly teacher discussions and reflection sessions would have been more difficult to organise and carry out with only some teachers included within each school.

Randomisation was stratified according to school location, school size, and past school performance.[1]

To keep the programme operationally simple and to avoid confusion within and between the schools, randomisation was carried out only once for the two

[1] Past performance was self-reported by the Managing Director and Academics Manager based on their perceptions. Schools were categorised in three categories: high performance, average performance, under performance.

interventions. For the student intervention, 15 schools were assigned to the intervention group and 15 schools were assigned to the control group. For the teacher intervention, assignments were exchanged. In this manner, 15 schools took part in the student intervention and the other 15 schools took part in the teacher intervention. In other words, the student intervention group served as a control group for the teacher intervention. Similarly, the teacher intervention group served as a control for the student intervention.

A potential concern with this randomisation strategy is the case whereby teachers considerably improve their own teaching skills during the intervention period so that their students benefit from their improved teaching and score better in the student endline assessment. In such a case, the programme impact on student learning outcomes would be overestimated. However, this seemed unlikely given that the focus of the professional development for teachers was foundational reading skills and the focus of the student learning content was foundational numeracy.

In order to estimate the impact of IVR on teacher and student outcomes, the following model was estimated:

$$Y_i = \beta_0 + \beta_1 Treat_i + e_i$$

where Y_i is the outcome variable of interest and β_1 is our coefficient of interest. Clustered standard errors were used at the school level, which was the unit of randomisation.

3.3.3. Data collection

At the inception of the programme, families shared their phone numbers and interest in participating in the IVR programme during the parent meetings. This data was then digitised and cleaned by the data team in Ghana and the information from selected participants was uploaded to the IVR platform.

For teachers phone numbers, Omega has a complete database containing teacher phone numbers and background information. This database was used to select and upload teachers' phone numbers to the IVR platform.

Students' and teachers' assessment data was collected directly at school. For more information on the research tools and data collection methods, please refer to the next section.

During baseline and endline data collection, Rising's Data Team conducted high-frequency checks on teachers' and students' assessment data, as well as random checks where they compared the electronic records with the original papers written by students. Teachers completed their assessments and

surveys in a controlled environment, supervised by the head of school to ensure consistency and fairness.

3.4. Research tools

3.4.1. Student numeracy assessment

The study used a foundational numeracy assessment developed internally by Rising Academies (available upon request). The assessment covers skills taught through the ROA upper primary lessons, including place value and the four operations. Assessment items are similar to released Grade 4 TIMSS assessment items (↑TIMSS, 2013). There were 35 individual problems, of which about half assess procedural fluency with the other half focused on conceptual understanding. The majority of questions were open-response while a smaller number were multiple-choice.

Figure 1. *Example procedural fluency open-response question.*

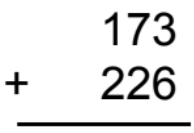


Figure 2. *Example conceptual understanding multiple-choice question.*

In which story is the number of onions equal to 18 x 9?

a. Mohamed buys 18 onions and puts 9 onions in each of 2 bags.
b. Mary buys 18 bags with 9 onions in each bag.
c. James buys 18 onions and gives 9 of the onions away.
d. Mariatu has 18 onions and buys 9 more onions.

3.4.2. Student feedback

At the endline, students in the intervention group also completed a feedback survey. The feedback survey collected information on student perceptions of their own academic improvement from accessing audio lessons via IVR. The survey also collected information on student satisfaction with different aspects of the IVR experience, such as the audio volume, narrator accent, timing of the phone calls, content, and quizzes. Students also had an opportunity to share an open response on the best and worst aspects of the IVR audio lessons.

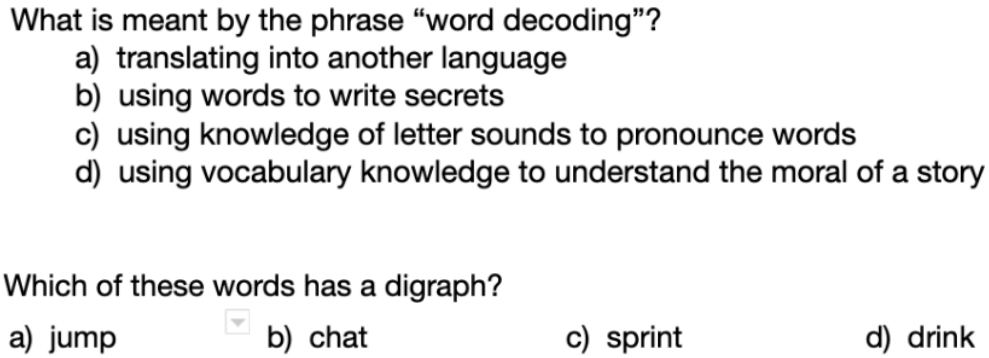
3.4.3. Student assessment administration

Student assessments were printed and distributed to each of the 30 schools in the study. Assessments were administered in groups by grade level with supervision from school staff and the leader of the school. At the baseline, teachers entered the raw student answers into a Kobo data collection app. At the endline, the paper tests were collected at Rising Academies' head office and data entry was conducted by a team of four contractors supervised by Omega's Data Manager. At the endline, the student feedback survey was included in the assessment paper for the intervention schools and filled out by students on paper. These data were also entered by a team of contractors.

3.4.4. Teacher knowledge

The study used a Teacher Knowledge assessment that assessed early literacy knowledge (available upon request). This assessment was developed with reference to the ETS Praxis assessment Teaching Reading: Elementary (↑ETS Praxis, 2021). The assessment includes information on phonological awareness, phonemic awareness, and phonics that supports teachers to improve their ability to teach children to read in English. The assessment consisted of 30 multiple-choice questions.

Figure 3. *Example teacher knowledge questions.*



3.4.5. Teacher self-efficacy

The study used a modified version of Tschannen-Moran's Teacher Sense of Efficacy Scale (TSES) Short Form (↑Tschannen-Moran & Hoy, 2001). The TSES assesses teachers' own beliefs about their ability to make a difference in student learning in three key areas: classroom management, student engagement, and instructional strategies. The version of the TSES used for this study adapted the instructional strategy statements to be more specific to the teaching of reading rather than teaching more broadly.

3.4.6. Teacher feedback

At the endline, teachers in the intervention group also completed a feedback survey. The feedback survey collected information on teacher perceptions of the convenience and effectiveness of the IVR-based training modules. The survey also collected information on teacher satisfaction with aspects of the IVR experience such as relevance of the content and the technical challenges with the IVR system. Teachers also had an opportunity to share an open response on the best and worst aspects of the IVR audio lessons.

3.4.7. Teacher assessment administration

Teacher responses to the Teacher Knowledge Assessment and TSES were entered directly into a mobile data collection tool. Teachers entered their responses into the Kobo form directly. At the endline, the teacher feedback survey was added only for teachers in the intervention group. If more than one submission was received from a teacher, then the first submission was included. Concerns with self-reporting are limited given teachers are responding to questions to assess their knowledge and intentionally seeking teachers' perceptions of their sense of efficacy.

3.5 Stakeholders

Key stakeholders for this study were parents of students attending Rising's Omega schools. Prior to the start of the intervention, parent meetings were held across the 30 schools prior to randomisation. The purpose of the meetings was to explain the intervention, requirements for participation (e.g., a basic handset) and how it would be delivered via IVR (e.g., via a toll-free number). School leaders played an important role in this process, to promote the intervention, engage parents, and encourage them to participate. A training was organised with School Leaders to explain the intervention and prepare them for their parent meetings. Schools were then randomised and parents were informed of their child's opportunity to participate. Once schools were randomised, another set of parent meetings were conducted with the randomised schools to give them a detailed understanding of the IVR project and an opportunity to experience the intervention by listening to a demo of the student audio recording. Parents could then choose whether to have their child participate or not and if they opted in, then they confirmed their contact information and number.

Figure 4. *Parent meeting at Omega school.*

3.6. Ethical considerations

This study was conducted in Rising Academies' Omega schools as a supplementary learning activity outside of the regular school day. The student intervention was therefore additive to regular schooling. Although the focus of the audio content was not tightly aligned with in-school learning on a weekly basis, it was more generally aligned with the learning objectives for upper primary grades. The teacher intervention was also additive to regular teacher training and general professional development. The interventions aimed to provide additional support for students' foundational numeracy skills development and teachers' knowledge about foundational reading. Parents and teachers were informed prior to the start of the programme about the programme details, risks and benefits to participation, and their rights. Their participation was voluntary and they were free to withdraw from the programme at any time. In practice, very few students and families opted out of the programme and none officially withdrew (although some families' interaction with the programme was minimal). We also learnt from the feedback surveys that 75% agreed with the statement "I would like phone lessons to continue."

Risks of the programme are considered to be minimal. Student participants received one SMS and one phone call per day and teacher participants received one call and two reminder SMS texts per week. Calling back into the IVR service was also free of charge and participants could choose to end the call at any time. There are no meaningful risks for non-participants. School leaders, teachers, and parents were informed that the programme was new and part of an initial evaluation to explore the potential benefit. The results and lessons learnt would help inform future programming decisions,

including the possibility of delivering the student and / or teacher intervention across all schools.

Data collection at the baseline and endline was a 30-minute assessment for students during their school time and a 30-minute survey for teachers (to be answered at their convenience). There were no negative outcomes from the data collection process in this study.

4. Results

4.1 Sample descriptives

A total of 1,359 students were part of the study. These students were enrolled in Grades 4, 5, and 6 in the 30 study schools. Table 1 presents a summary of the student group.

Table 1. *Student descriptives by intervention group.*

Student Group	% Males	% Females	Mean age	No. of students
Control	50.6%	49.4%	11.6 years	691
Intervention	53.9%	46.1%	11.6 years	668[2]

Additionally, a total of 333 teachers completed the baseline assessment and were included in the study. Of these, 160 teachers were in the intervention schools and therefore participated in the IVR programme.

Table 2. *Teacher descriptives by intervention group.*

Teacher Group	% Males	% Females	Mean age	Years experience	No. of teachers
Control	47.4%	52.6%	24.6 years	4.1 years	173
Intervention	49.4%	50.6%	27.2 years	5.4 years	160[3]

[2] This number is lower than the total number of students on the platform. It was not possible to collect contact numbers and baseline data for some students who were out of school, had dropped out, or were unreachable. The study sample size is considered as 668 treatment and 691 control students, but engagement data is reported for 719 students whose phone numbers were already set up in the IVR platform.

[3] Similarly, the number of teachers in the sample size for treatment schools is smaller than the number of teachers set up in the IVR platform.

4.2 Attrition

Overall, schools experienced a relatively high number of student dropouts and high rate of staff turnover during the 12–15 week period of programme delivery. Section 4.5 notes many of the challenges that were faced during the implementation phase that may have influenced the validity of the results.

Of the total 1,359 students who were included at the start of the programme, 960 students completed endline assessments. There are multiple reasons for this relatively high rate of student attrition, including students dropping out from school, being absent at the time of assessment, or changing their contact numbers during the programme.

In the teacher intervention, only 195 teachers submitted their endline assessments and feedback surveys. Seventy-five of the missing teachers had resigned and left the school between the baseline and the endline. The remainder were teachers who had changed their phone numbers and / or changed schools, making it challenging to reach them. Table 3 shows the different attrition levels by intervention group.

Table 3. *Attrition by intervention group.*

	Students			Teachers		
	Baseline	Endline	Attrition	Baseline	Endline	Attrition
Control	691	462	33%	173	94	45%
Intervention	668	498	25%	160	101	37%
Total	1,359	960	29%	333	195	41%

4.3 Student intervention results

4.3.1. Student engagement

A total of 719 student phone numbers were registered in the IVR system across 15 intervention schools. The number of participating students and grade levels included varied by school depending on the school size and the number of parents who opted into the programme.

Table 4. *Participating students by grade and gender.*

Gender	Class 4	Class 5	Class 6	Total
Female	106	149	97	352
Male	118	146	103	367
Total	224	295	200	719

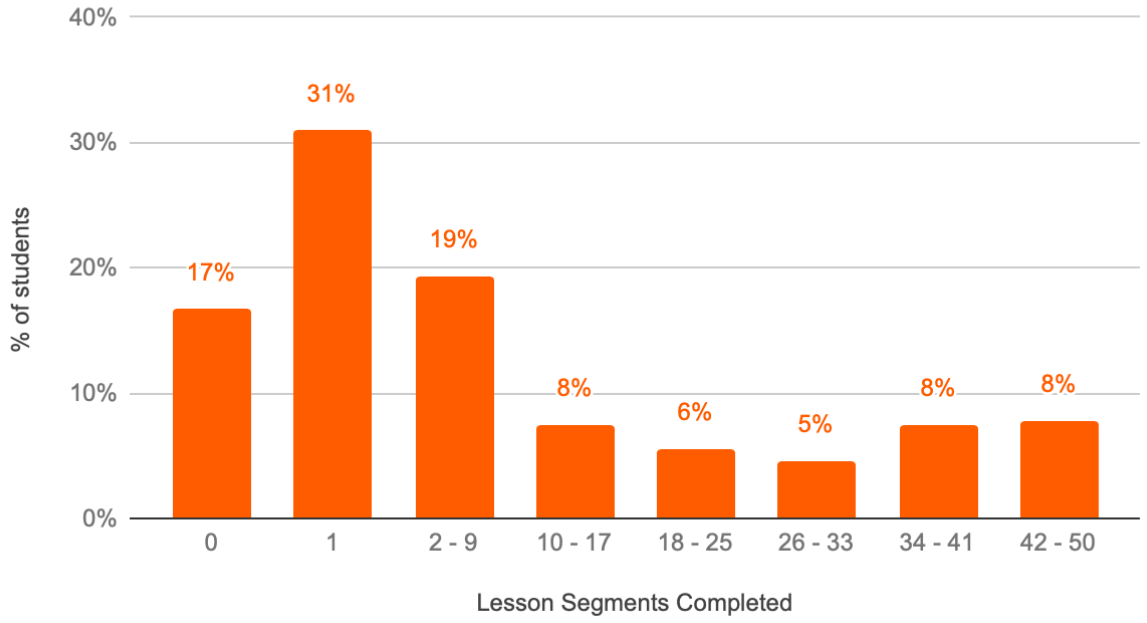
The average student completed 15.4 lesson segments (out of a maximum of 50 segments) during the programme. Lesson segments are the unit of measure to account for the change in lesson length during Phase 2. Lessons from Phase 1 consisted of two lesson segments per call whereas, in Phase 2, there was only one lesson segment per call.

Engagement data from the IVR platform were rich and allowed for further exploration into programme implementation. Participant students called (or received a call from) the IVR system a total of 8,950 times. The average student interacted with the platform 193 times on 13 calls during the programme. Each call lasted for an average of 4.3 minutes and recorded 14 interactions. An interaction was recorded each time a student either completed a designated segment of audio (for example the introduction or the narrative) or completed a quiz question.

Tables A5a, A5b and A5c in the Annex show the breakdown of average lesson segments completed by gender, grade, and school. Anecdotally, schools with the highest lesson completion rates were a mix of schools situated in rural and more challenging communities in Ghana with typically low parent engagement, higher financial constraints, and generally low investment in education. Interestingly, these schools were also schools with highly invested School Leaders who embraced the intervention and regularly encouraged students and parents alike to participate.

Schools with the lowest student engagement appear mixed, with no clear or consistently shared reason for greater challenges with engagement. For example, one school is rural and run by an experienced School Leader but struggles with low student and parent engagement. On the other hand, another school is a school with optimal teacher staffing and higher student attendance but has a struggling School Leader.

Figure 5. *Percentage of students by lesson segment completed.*



A-B testing for content localisation

This study included audio lessons for students that were originally recorded in Sierra Leone for Sierra Leonean students as part of Rising Academies' support for the Covid-19 response efforts. As such, the student audio content included lesson narrators with Sierra Leonean English accents and some localisation. At the outset, the Viamo team recommended re-recording the lessons in English with Ghanaian narrators, however, initial pilots and feedback from students suggested that this might not be required. Towards the end of the programme, in an effort to understand potential reasons for the engagement challenges seen in the student intervention, it was decided that a simple A-B test might provide some initial insights concerning differences with accents and localisation. Two lesson segments were therefore recorded by Ghanaian narrators to use in the A-B testing.

To explore potential differences in student engagement based on localisation of audio content, students were randomised in the IVR system to receive either two lesson segments in a Ghanaian accent (Group A, n = 359) or two lesson segments in the original Sierra Leonean accent (Group B, n = 360). Results were inconclusive. Students in Group A had somewhat higher completion rates for Part 1 but then students in Group B showed somewhat higher completion rates for Part 2. Neither of these differences was statistically significant. It is worth noting that students had already participated in 11 weeks of the intervention at the time of this testing. It is possible that either familiarity or novelty effects could have influenced the results in either direction or intervention fatigue more generally. Although it seems very plausible to assume that the localisation of audio recordings matters, it was

not possible to gain further insights based on this initial test. Further testing would be required.

4.3.2. Student learning

The primary outcome variable of the student intervention was student maths skills. Different maths concepts were measured by the student assessment tool and proxy variables were created for the different topics covered in the assessment (place value, addition and subtraction, and multiplication and division).

Overall, significant positive effects of the IVR intervention were only found on the set of questions for place value. Students in the intervention group scored 5% more points in the place value questions than students in the control group. This effect is small and is only significant at the 10% level.

There was no impact on any of the other outcomes of interest, including addition, subtraction, multiplication, and division. See Table A6 for the complete estimation output.

4.3.3. Student perceptions

A total of 579[4] student responses to the endline survey were received from intervention schools. Open responses were collected to the questions "What was the best part of the phone-based lessons?" and "What was the worst part of the phone-based lessons?" Responses were coded according to similar themes.

Student responses to the question about the best part of the programme are summarised in Table 5 below.

[4] This number is different from the number of participants (719). This is because not all participants filled in the endline survey, and not all of them filled in the 'student perceptions' section.

Table 5. *Response rates and examples of students' responses to what was the best part of the programme.*

Best part	Response rate	Example responses
Quiz question	32%	"I like when it time for the quiz" "The answering is the best part" "Quiz questions" "The best part was the quizzes"
Lesson topic	22%	"Place value chart" "Skip counting" "Adding numbers" "Expanded form and standard form" "Ones, Tens, Hundreds and Thousands"
General positive response	13%	"I liked listening to the lessons" "The phone lessons were interesting" "It helps me to know math" "All were good and amazing"
Type of teaching	9%	"The best part of the phone-based lessons is that they were repeating what they said" "I like when the madam ask questions"
Sense of achievement	6%	"The phone lessons helps me to know maths" "It helps me to learn more" "It makes me know maths, I have become best student"
Unclear	8%	
Other	10%	

Student responses to the question about the worst part of the intervention are summarised in Table 6 below.

Table 6. *Response rates and examples of students' responses to what was the worst part of the programme.*

Worst part	Response rate	Example responses
Non-academic aspect of the lesson	33%	"The language was too fast" "I don't like how they talk" "The phone lessons were boring" "The worst part of the phone-based lessons is that they repeat it again" "Sometimes I don't understand it easily "
Lesson topic	24%	"Finding the missing numbers" "Subtraction" "Place value" "Regrouping numbers" "The division part was the worst part for me"
No worst part	17%	
Technical issues	15%	"It sometimes stop typing the questions" "Sometimes they call me at the wrong time"
Unclear response	6%	
Other	5%	

4.4. Teacher intervention results

4.4.1. Teacher engagement

A total of 185 teacher phone numbers were registered in the IVR system. Among the 185 registered teachers, the average number of completed lesson segments was 5.1 out of 15 lessons or 34% of the total. The most listened to lesson (Lesson 3) had 56% of teachers complete it, whereas the least listened to lesson (Lesson 15) had 14% of teachers complete it. Lesson completion rates peaked in Lesson 3 of the sequence and remained steady through lesson 10 before dipping towards the end of the programme.

Teachers interacted with the IVR platform 13,100 times, for a total of 250 hours. Each call lasted an average of 13 minutes and recorded 11 interactions. Each teacher called an average of 7 times during the programme and interacted 84 times with the IVR platform.

It seems that male teachers may have engaged with the lessons more often than their female counterparts (5.7 and 4.9 completed lessons respectively).

Figure 6. *Percentage of teachers who completed each lesson.*

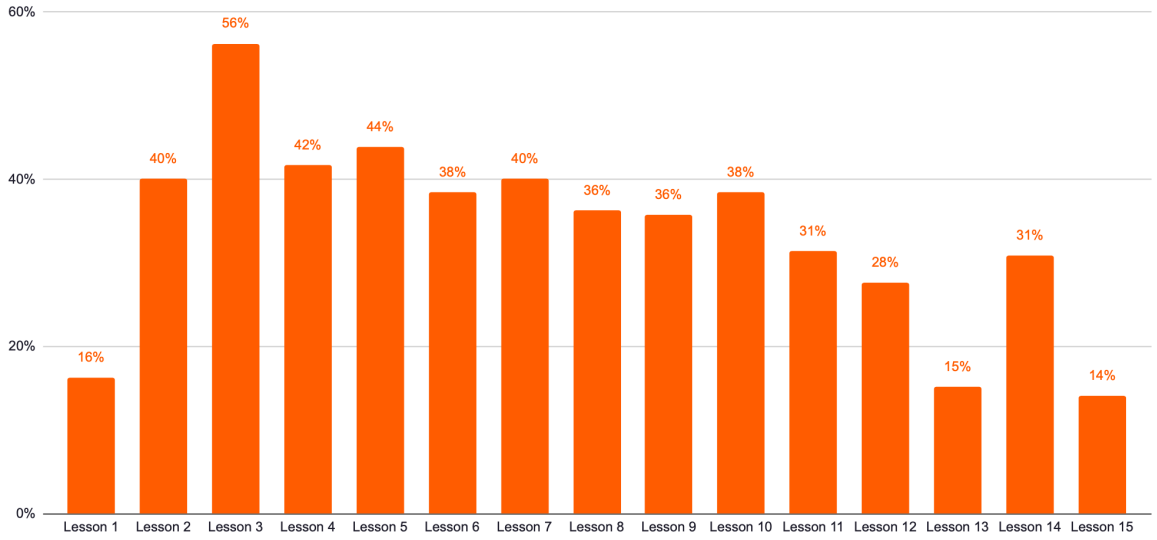
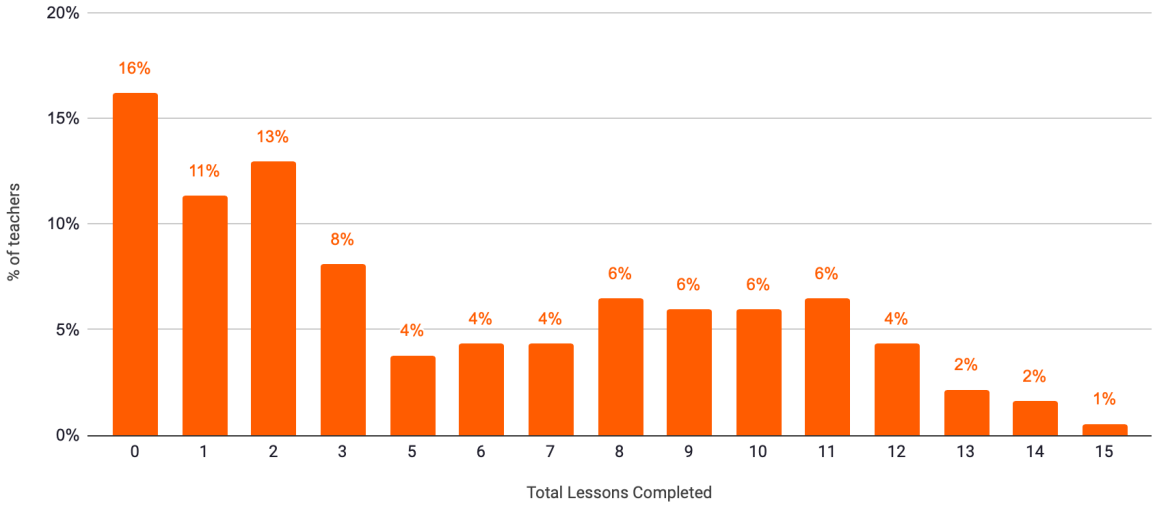


Figure 7. *Percentage of teachers completing each lesson.*



4.4.2. Teacher Knowledge

Teachers in the intervention group scored higher in three of five topics covered in the teacher knowledge assessment than their control counterparts. In particular, teachers in the intervention group scored 13 percentage points higher in phonemic awareness, 11 percentage points higher in phonics knowledge, and 16 percentage points higher in morphology than control teachers. These results are significant at the 1% level.

There were no significant differences on the other two topics covered in the assessment (phonological awareness and simple view of reading). See Table A8 for the full estimation output.

4.4.3. Teacher self-efficacy

Positive effects were also found on the teacher self-efficacy outcomes. Teachers who participated in the IVR programme reported being better at teaching reading (12 percentage points) and more capable of motivating students and engaging families (13 percentage points). Results suggest that teacher perceptions of their ability to manage their classrooms may have increased, but these results are only significant at a 10% level. See Table A9 for the full estimation output.

4.4.4. Teacher perceptions

A total of 96 responses to the feedback survey were received from teachers in intervention schools.

In the final survey, open-ended responses were collected to the questions "What was the best part of the phone-based training?" and "What was the worst part of the phone-based training?"

Teacher responses to the question about the best part of the phone-based intervention are summarised in Table 7 below.

Table 7. *Response rates and examples of teachers' responses to what was the best part of the programme.*

Best part	Response rate	Example responses
Aspect of content	45%	"phonological awareness" "phonological awareness, phonemes, syllables" "the consonant blends" "blending sounds to words"
Lesson format	20%	"correct answers are given even when you get wrong" "questions and answer segments" "how interactive they managed to make it" "when you give your answer and the answer you give is wrong and they correct you"
Sense of achievement	12%	"I learnt about word decoding" "was able to know much on the phonics" "getting more knowledge on things I haven't come across." "lessons improved my teaching"

Unclear response	11%	
Generally positive	8%	
Nothing	2%	
Other	1%	

Teacher responses to the question about the worst part of the phone-based intervention are summarised in Table 8 below.

Table 8. *Response rates and examples of teachers' responses to what was the worst part of the programme.*

Worst part	Response rate	Example responses
Aspect of the content	30%	"it was too lengthy" "the question was some of tricky "the phone-based training will be boring"
No worst part	28%	
Lesson format	19%	"you can't ask question when there is need" "cannot be paused when interrupted" "couldn't hear the audio lessons at a point"
Technical issues	13%	"at times they don't return our calls on time" "when the system was not working" "sometimes we don't receive the lesson" "network failure"
Unclear response	8%	
Other	2%	

4.5 Challenges and limitations

4.5.1. Set up and delivery of an intervention using IVR

Based on their experiences delivering an IVR intervention in Malawi, RTI's insight resonates with the experiences of this study, "Prepare to spend significant time and effort to prepare for the launch of the IVR" (↑Carrol, 2020). One challenge was the time needed to secure a partnership with an existing IVR platform provider. Although the original intention was to implement the

IVR intervention in Sierra Leone, this proved to be unfeasible given the lack of existing IVR platforms. In Ghana, discussions were held with one IVR platform provider at length before eventually determining they were not suitable and Viamo was contracted instead. Relatedly, a second challenge was direct access to the platform. Because Viamo manages their platform for their clients, direct access to the system was not granted. It was not possible to directly manage how and when the intervention was delivered. Initially, delays were experienced given the time needed to coordinate with Viamo. A third challenge was the preparation time required to record and edit audio content for delivery via IVR. Although re-recording all student audio content had originally been considered, only the new quiz questions for students were recorded given the limitations of the study. Because pre-recorded ROA teacher professional development content was not available, the more limited number of teacher professional development sessions and accompanying quiz questions were also recorded. Overall, there was a significant investment of time and resources in the initial setup phase of the interventions. Although a cost-effectiveness analysis was beyond the scope of this study, recurring costs were relatively minimal once interventions were underway, suggesting the potential for cost-effectiveness longer-term.

4.5.2. Student engagement

This study is one of the first to explore the potential use of IVR to deliver interactive audio content to students to improve learning outcomes. There were therefore many unknowns and limited evidence upon which to draw, particularly concerning details of the intervention design. It was unclear what the weekly expectations should be for the duration and frequency of student engagement. Challenges with engagement data from the IVR platform created additional difficulties with clearly understanding patterns of engagement in real time. Although lesson length was reduced and schools were encouraged to follow up with parents to increase support, student engagement remained low throughout the intervention.

4.5.3. Teacher retention

There was a relatively high rate of teacher turnover in this study. Challenges with teacher attrition and maintaining active participation have been identified in prior research as well (↑Perry et al., 2020), and require thoughtful consideration to address and ensure sufficiently high levels of engagement for a consistent group of teachers. Additional challenges that contributed to limitations with teacher engagement included teachers changing their phone numbers, which made tracking their engagement in the IVR platform more difficult. Anecdotal feedback from schools also suggested that some teachers

listened to the audio lessons together, which would not reflect in the IVR engagement data.

4.5.4. IVR engagement data

IVR systems generate extremely granular data on participant interactions. For a single phone call, the system records when a participant starts and finishes each individual part of a lesson, such as the introduction, the statement of the learning objective, the lesson narrative, and the quiz question. Data are also recorded for every outgoing call that is missed as well as any outgoing SMS messages that are sent. If a participant is interrupted and calls back into the system, there may also be multiple calls recorded on the same day. The data is also extremely dynamic as participants are constantly interacting with the system. Additional analyses could be considered to explore participant engagement and relations with learning outcomes.

4.5.5. Focus on teacher outcomes

In this study, any change in teacher knowledge or self-efficacy was not directly connected to student learning outcomes. This is a limitation within the literature more broadly. "Perhaps surprisingly, there is very little focus on pupil outcomes in the remote and blended teacher education literature, much of which is focused on changes in teacher practices or thinking and / or teacher perceptions of new ways of learning" (↑Perry et al., 2020). Although this study did not address this limitation, it is an early-stage exploration of the potential for IVR to effectively deliver teacher professional development. As a first step, the study sought to determine if an IVR-based intervention can improve teacher knowledge and self-efficacy related to the instruction of foundational literacy before considering any ensuing changes to student learning.

4.5.6. Challenges with data collection

Teachers, school staff, and members of Rising Academies' head office team collected the data for this study. Although Rising Academies' routinely collects data related to ongoing school operations and performance, the collection of data from students and teachers for the purposes of a high-quality randomised controlled trial in addition to ongoing school operations was a challenge. Teachers and school staff were provided with basic training on data collection and tools, but they are also not as experienced as contracted research assistants and enumerators. These challenges, combined with limited access to the IVR platform to manage data directly, resulted in difficulties collecting high-quality data that required additional time to address. The most important implications of this limitation are that we cannot explore the marginal learning gains of additional lessons or whether there are differences between the most active participants and the least engaged.

5. Policy implications

This study was an early-stage exploration into the potential effectiveness of IVR as a low-tech solution to deliver interactive audio content to students and teachers. Despite the study's limitations, there are some potentially helpful insights.

The difference in results between the student and teacher interventions suggests some important considerations related to the target audience for an IVR-based intervention. Low engagement levels in the student intervention may have been due to greater issues with access, although the extent to which this might be the case is not clear. In both the student and the teacher interventions, approximately 15% of participants reported technical problems of some kind, which could have limited the access of both students and teachers. In the student intervention specifically, however, students relied on the use of their caregiver's phone whereas teachers used their personal phones. The need to access their caregiver's phone every evening could have posed some unique difficulties for student engagement. For example, a caregiver might not have made their phone available to their child, a caregiver's phone might not have been charged, or a caregiver might have been out of the house with their phone. Recent survey results showed that only 55% of caregivers reported that their basic handset would be available for their child's learning, with the main reason for refusal being that children would not know how to use the phone (↑Fall et al., 2021). Bearing in mind general barriers to access as well as those that might be unique to the target participants is important, as is aiming to collect the data needed to disentangle issues of access from engagement.

Acknowledging first the potential limitations with access, there then remain concerns with engagement for those students who did answer the IVR calls. Encouraging and maintaining sufficiently high engagement in any learning activity can be a challenge, even in a well-organised classroom, but it is particularly so with remote learning solutions. Providing interactive audio content with quiz questions and SMS text reminders was insufficient to engage the majority of students. At the same time, 75% of student participants said they would like the phone lessons to continue and the same per cent also thought that the lessons helped them with their maths. Positive perceptions from students did not however translate into the level of student engagement required to demonstrate improved learning outcomes. In the context of this study, students were expected to engage with the IVR programme in addition to schooling as usual, so it is possible that the added demand after a regular school day was a challenge. Regardless, some key

takeaways emerge concerning the potential for student-focused interventions.

Firstly, evidence from IRI research points to the importance of the facilitator to encourage and support active verbal and physical engagement in the learning activities. Collecting detailed feedback from caregivers was beyond the scope of this study, so it is difficult to draw conclusions about the extent and type of support that caregivers may or may not have provided to students. Caregivers were invited to attend an initial information and training meeting, they chose to have their child participate in the intervention, and the school actively followed up to encourage caregivers to support their child to access and participate in the audio lessons. But the role of the caregiver or another supportive 'helper' in the home was not more formally structured, supported, or incentivised in this study.

There are clearly many demands on caregiver time and recent caregiver surveys have highlighted the increased financial constraints experienced within the home following the Covid-19 crisis (↑Caballero et al., 2021). Forthcoming results from the evaluation of an IVR-delivered intervention for students in Bangladesh should provide helpful insights concerning the importance of a supporting 'helper'. More generally, however, it is clear that students require appropriate levels of support and there are many reasons why this can be difficult to achieve in practice, particularly in out-of-school or informal contexts. Should education service providers or other large-scale education efforts consider the use of IVR to deliver student programming in the future, it would be important to invest in better understanding what type and degree of support is required for students to achieve a higher level of engagement, depending on their age, ability level, and other contextual factors. Furthermore, consideration for what is both practically and financially feasible to achieve that level of support would also be necessary.

Secondly, in their survey responses, students most commonly reported that the quiz questions were the best part of the lesson. Although the audio content was designed to be interactive, students were not required to interact directly with the IVR platform aside from the quiz questions. Leveraging the potential for direct and more frequent interaction could have the potential to more actively engage students in an IVR-delivered programme. Not only might this increase engagement, but it could serve as a means of delivering more targeted learning content. This study's intervention was not designed to provide students with a choice of lesson content, nor was content provided in response to individualised student learning levels. Student feedback is suggestive of this point because the second most commonly reported area of feedback was related to specific topics in maths. The topics themselves varied between students, with some students expressing a preference for place value whereas others preferred addition or skip counting. Low-tech solutions that

are designed to necessitate and encourage ongoing student interaction and that in doing so, can generate well-targeted content, could have greater potential.

The positive results in the teacher intervention are suggestive of a more feasible and potentially effective approach to achieving gains in learning. Teachers were expected to complete one professional development session per week and completion rates were much higher among teachers than among students. The expectations for teachers appeared more realistic and feasible. It is worth noting that in the final two weeks of the teacher intervention, two audio sessions were delivered each week rather than only one, in an effort to complete the full set of audio content within the allocated time period. Teacher engagement in the second audio session of each week was much lower. Although this was not intentionally carried out to test differences in levels of engagement, it would seem that the expectation of one focused audio session per week was more achievable for teachers. Furthermore, engagement in one audio lesson per week for 14 weeks was sufficient in this study to improve teacher knowledge of a specific set of topics. Understanding the necessary 'dosage' required for future interventions with different groups of teachers and focus areas of learning would be helpful to explore and consider in relation to changes in teacher behaviour as well as teacher knowledge. Finally, the teacher intervention also included one introductory audio message that explained the purpose of the intervention, expectations for teacher engagement in the audio sessions and follow-up in-school discussions, as well as the intended benefits. Again, the value of this introductory session was not explicitly tested, but ensuring the aims and objectives of teacher professional development is clearly essential and this might be one way of ensuring clarity of purpose is achieved. Bearing this in mind in future programming efforts would also be important.

A more general but important consideration is a fuller understanding of the investment required to deliver IVR-based interventions well. Much like the IVR-delivered teacher training in Malawi (↑Carrol, 2020), it is important to emphasise that the delivery of an intervention via IVR takes a significant investment of time and resources to set up and then administer. As described above in Section 4.5 on challenges and limitations, time and resources are required to: engage and contract an IVR platform provider; design, record, edit and upload the audio content for IVR delivery and; understand the available data from the IVR platform and have the systems in place to actively analyse, review, and take action based on key insights. This study explored the potential impact of two IVR-based interventions implemented concurrently, which generated interesting and helpful insights at an early stage in the research but was also challenging to set up and administer.

6. Conclusion

Although the student intervention did not demonstrate significant gains in student learning, the implementation of the student intervention did result in helpful early-stage insights and considerations for future programming decisions. A key challenge to address is student engagement, and how to design low-tech solutions that can support and encourage more active and ongoing student interaction throughout the learning process, while also ensuring that the content is well-targeted to their individual learning needs. New innovations with low-tech solutions, such as interactive chatbots, may provide encouraging directions for future exploration.

Results from the teacher intervention build on the existing evidence to suggest the potential for remote and blended learning approaches to improve teacher knowledge and self-efficacy. The design of the programme, which included one interactive audio session per week followed by an in-person discussion with peers, appeared to be a convenient and realistic set of programme expectations for teachers. It was also sufficient to achieve gains in teachers' understanding of specific topics related to the instruction of foundational reading, including phonemic awareness, phonics and morphology, and improved teachers' belief in their own ability to improve student reading and engagement in learning. Overall, feedback from the teacher intervention was positive and generally suggestive of the potential for blended, low-tech solutions to support teacher professional development.

There is extensive evidence related to the many challenges with delivering tech-enabled solutions to improve learning. The investment required to deliver an intervention using IVR is no exception. Future programmes that might consider IVR as a low-tech solution to deliver educational content should consider the target learner, the intended learning gains and the supports needed to achieve those gains. It is still early days for research and practice in this area but this study provides some initial considerations that can help inform future programme design decisions and related research questions.

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Annex: Tables

Table A1. *Student programme schedule, topics, and lesson segments.*

Phase	Weeks	Lessons covered	Lesson segments	Topic
Phase 1	Week 1	Lessons 1.1 to 1.5	10	Numbers within 1,000
	Week 2	Lessons 2.1 to 2.5	10	
	Week 3	Lessons 3.1 to 3.5	10	Addition and Subtraction within 1,000
	Week 4	Lessons 4.1 to 4.5	10	
	Week 5	Lessons 5.1 to 5.5	10	
Phase 2	Week 6	Lessons 3.1 and 3.2	4	Addition and Subtraction within 1,000
	Week 7	Lessons 3.3 and 3.4	4	
	Week 8	Lessons 3.5 and 4.1	4	
	Week 9	Lessons 4.2 and 4.3	4	
	Week 10	Lessons 4.4 and 4.5	4	
	Week 11	Lessons 5.1 and 5.2	4	
	Week 12	Lessons 5.3 and 5.4	4	

Table A2: *Learning objective for student IVR lessons.*

#	Learning Objective
1.1	Read and write numbers within 1,000
1.2	Represent and read three-digit numbers in expanded form by identifying the value of each digit.
1.3	Add or subtract 10 or 100 from a three-digit number using mental math.
1.4	Compare 2 three-digit numbers
1.5	Order three-digit numbers
2.1	Model numbers with more than 9 tens and ones
2.2	Model numbers with more than 9 tens and ones
2.3	Compare numbers with more than 9 tens and 9 ones
2.4	Compare numbers with more than 9 tens and 9 ones
2.5	Order numbers in different forms
3.1	Add three-digit numbers (no regrouping) using pictures and expanded notation.
3.2	Add three-digit numbers (no regrouping) using the standard algorithm.

3.3	Add three-digit numbers with regrouping in one place using pictures and expanded notation.
3.4	Add three-digit numbers with regrouping in two places using pictures and expanded notation.
3.5	Add three-digit numbers with regrouping using the standard algorithm.
4.1	Add three-digit numbers with regrouping using the standard algorithm.
4.2	Subtract three-digit numbers (no regrouping) using pictures and expanded notation.
4.3	Subtract three-digit numbers (no regrouping) using pictures and expanded notation.
4.4	Subtract three-digit numbers with regrouping in one place using pictures and expanded notation.
4.5	Subtract three-digit numbers with regrouping in two places using pictures and expanded notation.
5.1	Subtract three-digit numbers with regrouping using the standard algorithm.
5.2	Subtract three-digit numbers with regrouping using the standard algorithm.
5.3	Solve three-digit addition and subtraction problems using the standard algorithm.
5.4	Solve three-digit addition and subtraction problems using the standard algorithm.

Table A3: *Content of teacher professional development sessions*

No	Session Title	Session Overview
0	Introduction to teacher professional development program	
1	The components of reading	What are the components of being able to read with understanding?
2	Overview of Phonological Awareness	What is phonological awareness?
3	Hear and Use Words and Syllables	Helping children to hear words and syllables in sentences.
4	Overview of Phonemic Awareness	What is phonemic awareness
5	Blend Sounds to Say Words	Helping children to blend individual sounds together to create words
6	Hear Words and Segment them into Sounds	Helping children hear a word and then break it into sounds
7	Phonics Overview	What is phonics and why is it important for reading?
8	Building block 1: one letter can represent one sound	Helping children learn the simple letter sounds
9	Building block 2: letter sounds blend together to make words (3 letter words)	Helping children make simple 3-letter words with simple letter sounds

10	Building block 2: letter sounds blend together to make words (4+5 letter words)	Helping children make simple 4 and 5 letter words with simple letter sounds (blends)
11	Building block 3: two letters can make one sound (digraphs)	Helping children read digraphs
12	Learn Advanced Code - building blocks 4-6	What is advanced code?
13	Building block 4: letters can sometimes make different sounds (vCe)	Helping children read words with long vowel sounds (vCe)
14	Building block 5: different letters can make the same sound	Helping children read words with different spellings that sound the same (vowel teams)

Table A4: *School information and participants*

School	Group	Region	Grade 4	Grade 5	Grade 6	Students
ABLEKUMA	Student IVR	Greater Accra	-	53	-	53
ASAMANKESE YAYOO	Student IVR	Eastern	12	5	11	28
BORTIANOR	Student IVR	Greater Accra	17	14	12	43
BREKU	Student IVR	Central	9	7	3	19
BRIGADE	Student IVR	Central	26	18	33	77
KASOA CP	Student IVR	Central	26	21	24	71
KAEMEBRE	Student IVR	Central	9	24	25	58
KASOA 94	Student IVR	Central	9	31	19	59
KOKROBITE	Student IVR	Greater Accra	17	28	10	55
LIBERIA CAMP	Student IVR	Central	17	17	13	47
MANKESIM KESSIM	Student IVR	Central	13	22	11	46
MANKESIM MKT	Student IVR	Central	17	18	5	40
NYANYANO	Student IVR	Central	20	12	15	47

PIPE TANK	Student IVR	Central	9	9	5	23
SUHUM	Student IVR	Eastern	23	16	14	53

School	Group	Region	Teachers
AKWELEY	Teacher IVR	Central	7
ASAMANKESE ESTATE	Teacher IVR	Eastern	13
ASEMPA	Teacher IVR	Central	11
ASIKUMA	Teacher IVR	Eastern	14
AYIGBE TOWN	Teacher IVR	Greater Accra	10
BAWJIASE	Teacher IVR	Central	12
GALILEA	Teacher IVR	Greater Accra	10
KASAPA	Teacher IVR	Central	11
OBLOGO	Teacher IVR	Greater Accra	14
ODA	Teacher IVR	Eastern	5
OFAAKOR	Teacher IVR	Central	8
OPEIKUMA	Teacher IVR	Central	11
PEACE TOWN	Teacher IVR	Central	10
YABEM	Teacher IVR	Central	12
KAKRABA	Teacher IVR	Central	13

Table A5a: *Student engagement by gender*

Gender	Average Lesson Segments Completed	% of students who completed at least 2 lesson segments
Female	16.6	53%
Male	14.2	52%

Table A5b: *Student engagement by grade*

Grade	Average Lesson Segments Completed	% of students who completed at least 2 lesson segments

Class 4	13.1	48%
Class 5	17.5	57%
Class 6	15.0	52%

Table A5c: *Student engagement by school*

School ID	Average Lesson Segments Completed	% of students who completed at least 2 lesson segments
Liberia Camp	25.4	68%
Pipe Tank	24.3	78%
Asamankese Yayoo	24.3	61%
Ablekuma	23.3	72%
Breku	18.5	53%
Bortianor	17.1	63%
Kokrobite	15.5	55%
Kasoa 94	15.2	56%
Nyanyano	15.0	49%
Mankesim Mkt	14.7	58%
Suhum	14.6	57%
Kaemebre	11.9	31%
Mankesim Kessim	10.5	54%
Kasoa CP	9.7	32%
Brigade	8.8	40%

Table A6: *Effects on Students' Learning Outcomes*

	(1)	(2)	(3)
	Addition & Subtraction	Place Value	Multiplication & Division
Effect of IVR	0.0394	0.0555*	0.0555
	(0.0396)	(0.0306)	(0.0363)
Observations	960	960	960
Control Mean	0.57	0.60	0.51

Note: Clustered standard errors at school level in parentheses.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table A7a: *Student feedback responses (a)*

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I would like phone lessons to continue.	55%	20%	11%	4%	11%
The phone lessons helped me with math.	52%	23%	11%	4%	10%
I prefer the phone lessons to going to class.	34%	12%	13%	16%	26%
I prefer phone lessons to reading a textbook	28%	20%	17%	16%	19%

Table A7b: *Student feedback responses (b)*

	Always	Often	Some-times	Rarely	Never
I liked completing the phone quizzes.	50%	9%	25%	5%	10%
I liked listening to the phone lessons.	48%	11%	25%	5%	10%
The phone lessons were interesting.	45%	10%	35%	2%	8%
I could easily understand what the teacher said in the phone lessons.	40%	10%	35%	4%	11%
I could easily hear the phone lessons.	37%	11%	37%	4%	11%
The phone lessons came at a convenient time.	33%	11%	35%	5%	16%
The phone lessons were boring	17%	11%	34%	5%	33%
The phone lessons didn't work properly.	16%	10%	31%	6%	37%

Table A8: *Effects on Teachers' Knowledge*

	(1)	(2)	(3)	(4)	(5)
	Phonological Awareness	Phonemic Awareness	Phonics	Morphology	Simple View of reading
Effect of IVR	0.0232	0.134***	0.108***	0.158***	-0.0240
	(0.0333)	(0.0205)	(0.0295)	(0.0481)	(0.0741)
Observations	195	195	195	195	195
Control Mean	0.64	0.41	0.51	0.68	0.54

Note: Clustered standard errors at school level in parentheses.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table A9: *Effects on Teachers' Self-Efficacy*

	(1)	(2)	(3)
	Teaching Reading	Classroom Management	Student Engagement
Effect of IVR	0.123***	0.0718*	0.132***
	(0.0399)	(0.0371)	(0.0363)
Observations	195	195	195
Control Mean	0.37	0.46	0.57

Note: Clustered standard errors at school level in parentheses.

* p < 0.10, ** p < 0.05, *** p < 0.01

Table A10: *Average lessons completed per teacher by school*

School ID	Average Lesson Completed
Ofaakor	10.6
Opeikuma	8.3
Yabem	7.4
Asempa	6.7
Ayigbe Town	6.7
Bawjiase	6.6
Oda	6.4
Asamankese Estate	6.0
Akweley	5.1
Galilea	5.0
Asikuma	4.1
Kasapa	3.3
Oblogo	3.0
Peace Town	1.5
Kakraba	1.2

Table A11: *Teacher feedback responses*

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I recommend that Rising continues to develop more phone-based training systems.	50%	20%	21%	6%	3%
Most teachers I know would benefit from listening to the literacy phone-based training.	46%	24%	18%	4%	7%
The phone-based lessons were interesting.	44%	27%	17%	7%	4%
The phone-based training was convenient for me.	38%	30%	19%	7%	6%
I was able to follow and understand the phone-based training lessons easily	34%	27%	23%	13%	3%
I discussed the phone-based training sessions with my colleagues at school.	31%	35%	16%	12%	6%
I was able to listen to all of the phone-based training sessions.	26%	28%	25%	15%	5%
I prefer phone-based training to in-person training.	21%	24%	20%	15%	20%
I already knew most of the information in the phone-based training.	17%	26%	18%	25%	14%
I experienced many technical challenges with the phone-based training sessions.	14%	34%	23%	17%	13%
The phone-based training was boring.	11%	13%	22%	23%	31%