LEAP Final Deliverable(s)

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Bookbot

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Executive Summary

Introduction

Literacy is an essential skill in every language. However, access to books and appropriate fluency interventions is needed to achieve high literacy results in Indonesia.

Bookbot addresses the challenge of teaching children to read proficiently through its innovative learn-to-read app. The app offers a leveled, phonics-based library of books, allowing children to read aloud while receiving natural text-to-speech feedback on their pronunciation and fluency through on-device speech recognition.

With Bookbot, children can monitor their reading skills progress and see how close they are to achieving proficiency. The app also sets goals and offers incentives for reading, rewarding children with a choice of virtual avatars or real-world awards determined by parents and teachers. Designed to be lightweight and efficient, the Bookbot app features a speech recognition and synthesis system that operates smoothly even on low-performance devices without internet access. While the app works offline, it stores data on reading time, fluency, and accuracy in a cloud database, enabling teachers to access and review this information.

Joining LEAP brings Bookbot closer to achieving their vision: that every child has the opportunity to develop their reading, writing and communication skills to live a happy and successful life.

Organization's role and strength

Literacy is fundamental, not only for our personal and social development but also for our ability to function effectively in society. Bookbot's vision is that every child should have the opportunity to develop their reading, writing and communication skills to create a happy and successful life. Bookbot's mission is to deliver tools that use machine learning to advance human learning. The Bookbot app combines speech recognition and a reading program for school children to achieve greater literacy outcomes. Bookbot provides better tools for educators to monitor a child's reading progress and provide incentives for growth.

Need summary

Bookbot wants to correctly monitor and evaluate its impact and grow its evidence base. Bookbot has articulated the following objectives:

1. Identifying gaps in available data
2. Prioritize additional data collection

3. Providing a structure for data analysis and reporting
4. Develop key evaluation questions
5. Identify key indicators for monitoring

Solution summary and next steps

Following a few discovery sessions with Bookbot and reviewing their organizational objectives, we suggested the following:

Deliverable 1: Strategic problem-solving framework
Deliverable 2: Theoretical evidence framework
Deliverable 3: Documented code
Deliverable 4: Teacher's Guide
Deliverable 5: Recommendations for the future

Regardless of the direction Bookbot is taking in the future, building a solid evidence base provides strong foundations for Bookbot to excel, so most deliverables relate to this. The first deliverable's suggestion came about after learning that Bookbot often faces complex problems involving team members across different cultures.

Bookbot Objectives	Deliverable 1: Strategic problem solving framework	Deliverable 2: Theoretical evidence framework	Deliverable 3: Documented Code	Deliverable 4: Teacher's Guide	Deliverable 5: Future recommendations
Identifying gaps in available data		✓	✓		
Prioritizing additional data collection			✓		✓
Providing a structure for data analysis and reporting			✓		✓
Developing key evaluation questions			✓	✓	
Identifying key indicators for monitoring		✓	✓		✓

Figure 1: How Bookbot objectives align with deliverables

Deliverable 1- Strategic Problem Solving Framework

Introduction

Organizations such as Bookbot often have competing priorities and have to solve complex problems. In order to make strategic decisions aligned with the company's vision, a simple prioritization matrix can be used. However, to solve more complex problems, a strategic problem-solving framework[1] can be useful.

Overview of the problem solving framework

1. **Defining the problem**
2. **Setting the overall objective**
3. **Conducting a root cause analysis**
4. **Generating alternative solutions**
5. **Performing comparative analysis of alternatives**
6. **Selecting the best solution**
7. **Implementing the solution**
8. **Evaluating the solution**

◈LEAP

These steps are briefly explained below.

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[1] Framework has been adapted based on work from the Global Health Leadership Initiative https://ysph.yale.edu/ghli/ and is based on the work of Rakich, J. S., & Krigline, A. B. (1996). Problem solving in health services organizations. Hospital Topics, 74(2), 21-27. DOI: 10.1080/00185868.1996.11736053

Step 1- Defining the problem

Define the problem in a way that allows you to find solutions. Good problem statements have the following characteristics:

- Focus on a single problem, rather than getting lost in a tangle of multiple problems.
- Address problems that are feasibly solved.
- Keep it short and simple.
- Find statements that are shared widely by key stakeholders: To gain support for your solutions, key players must all believe that this problem exists and is important.
- Do not include solutions themselves (this comes later).

Weak Problem Statement	Suggestions for Improvement	Strong Problem Statement
"We need more mobile phones within the school community."	Focus on a problem, rather than the solution. In this case: "Why do we need more mobile phones?"	"Access to electronic devices within the school community is limited."
"Due to understaffing, teachers are overworked."	Focus on a single problem, rather than the cause of the problem.	"Teachers are overworked."
"Teachers are not sure how to operate zoom, let alone how to clear space on their phones to download the app."	Focus on a single problem and keep the problem statement short.	"Teachers are not very digital literate."

Step 2 - Setting the overall objective

Translate the problem statement into an overall, clear objective or goal. Good overall objectives address the problem statement and are SMART:

- Specific: What exactly are we going to do; with or for whom?
- Measurable: Is it measurable and can we measure it?
- Achievable: Can we get it done in time? Under these circumstances? With these resources?
- Relevant: Will achieving this objective bring us closer to accomplishing our big vision?
- Timely: When do we expect to have achieved our objective?

Step 3 - Conducting a root cause analysis

A root cause analysis will help identify the factors that are actually causing the problem. Focus on root causes that have a large impact, are things you can feasibly address, and that can have a lasting effect without causing new problems. There are several management tools which help leaders find the root causes of the problem, including Fishbone diagrams, or cost-benefit analysis.

Step 4 - Generating alternative solutions

Start generating solutions.
Example problem: Teachers are not very digital literate.

Potential solutions:
- Develop and run a digital skills workshop
- Partner with another organization that provides digital skills training
- Develop a digital literacy handbook for teachers

Step 5 - Performing comparative analysis of alternatives

Rate your alternatives in a table to evaluate the best option.

Evaluative Criteria				
	Impact	Expense	Control over content	Time required
1: Own workshop	High	High	High	2 months
2: Partner	Medium- High	Low	Low	1 year
3: Written manual	Medium	Medium	High	1 month

Step 6 - Selecting the best solution
Based on the comparative analysis, select the best solution.

Step 7 - Implementing the solution

- Identify tasks to be completed to meet specific objectives, including who is responsible for what, what resources are needed etc.
- Use a tool such as a GANTT chart to assign responsibility and a timeline for accomplishing objectives.
- Specify indicators of success for each specific objective and how data will be measured.
- Include regular monitoring and evaluation.

Step 8 - Evaluating the solution

Determine how you will evaluate the solution. Evaluation creates a transparent process for all stakeholders, assures a consistent process, and can identify resource gaps or training needs.

Consider these questions:
- Who is this data for?
- How will it be used?
- What data do you want?
- When do you want it?
- Who will collect the data?
- Who will analyze and report the data?

Process indicators measure progress toward objectives and monitor changes.
Example: Number of teachers who have downloaded the app and are using it every week.

Outcome indicators measure the outcome of a project.
Example: Percentage of teachers who have reported an increase in reading fluency.

Practical application for Bookbot

In order to move the above framework beyond a theoretical exercise for the Bookbot team, we arranged a workshop where we worked through a scenario on how the framework can help generate solutions. We also created a slideshow explaining the framework in detail as a reference document for Bookbot to use on an ongoing basis.

> **APPLY**
>
> If you are an ***organization*** that has a lot of complex problems to solve, this framework can help you evaluate and prioritize solutions.

Deliverable 2- Theoretical evidence framework

Introduction

Reading is a complex cognitive ability which includes several components. As Bookbot aims to train reading fluency, it is important to provide an in-depth theoretical framework for how this component fits within the validated theoretical models for reading. Hence, the developers of reading interventions can recognize the gaps and the appropriate trajectory for reading development. It will also allow a more precise adaptation of the program for children with different reading levels.

This section will introduce the reader to the science behind reading and give an overview of what our brains do when we read. Reading is complex, so we will dissect those complexities and illustrate them via graphs for easy comprehension. We will then relate the science to Bookbot and recommend future steps for Bookbot based on the underlying frameworks.

ENHANCE
What does "evidence-based" mean and why is it important? For a product to be an **evidence-based** product, your organization needs to be demonstrating the effectiveness of a solution and accelerating its impact through a stronger connection to scientific evidence—in an educational context this is most commonly achieved through educational research and metrics of school, teacher, and student performance assessed in an appropriate study design that rules out confounding explanations as much as possible.

The theoretical and scientific background for reading

Reading development

Reading, the translation of abstract shapes to sounds in spoken language, is a relatively new human cognitive ability that has existed for approximately 5000 years. Together with language and visual processing, this process demands attention and memory sources. Reading accurately is not the only important factor, but also performing it in a timely manner, i.e. automatically. Reading in a timely manner is referred to as "fluent reading".

1. Hence, to be able to read, our brain had to "recycle" regions and networks that were not originally evolutionary, aimed for this purpose (Dehaene, 2009; Freedman, 2020)[2] [3].

2. The neurobiological regions recruited to enable reading are also related to the basic abilities reading relies on, which include language (or auditory) processing, visual processing, attention, other executive functions, and articulation (speech). See Figure 1 for this information.

The precise timing in the engagement of these brain regions and networks is related to intact reading fluency which will then be related to reading comprehension abilities (Breznitz, 2006)[4].

Next, this document will explain the developmental process of reading fluency and comprehension by two developmental reading models- the Frith model describing the developmental steps required for reading acquisition (Frith, 1985)[5] and the model describing the transition from "learning to read - to reading to learn" (Chall's model, Chall, 1983).[6]

EXPLORE
Science of reading Learn what parts of the brain are involved in reading and how children learn to read and read to learn by checking out the figures in the sections below.

[2] Freedman L, Zivan, M., Farah, R., Horowitz-Kraus, T. Greater functional connectivity within the cingulo-opercular and ventral attention networks is related to better fluent reading: A resting-state functional connectivity study. . *Neuroimage Clinical.* 2020;accepted for publication.

[3] Dehaene S. *Reading in the Brain: The New Science of How We Read.* Penguin Group US; 2009.

[4] Breznitz Z. *Fluency in Reading: Synchronization of Processes.* Mahwah, New Jersey: Lawrence Erlbaum Associates; 2006.

[5] Frith U. *Beneath the surface of developmental dyslexia.* London: Erlbaum.; 1985.

[6] Chall JS. *Stages of reading development.* New York: McGraw-Hill; 1983.

Figure 1. An illustration of brain regions associated with reading.

Left side — Right side

Articulation /semantics/ syntax

Language

Phonological processing

Orthographical processing
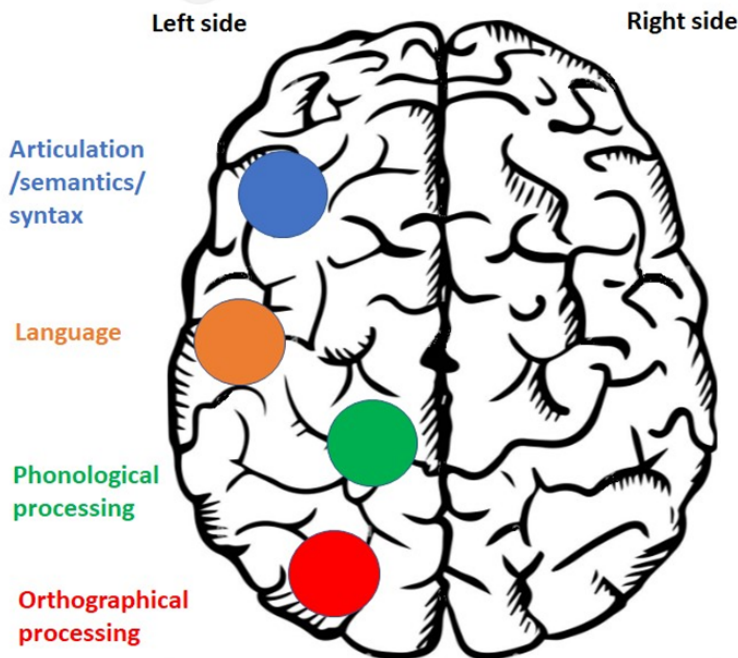
From learning to read to reading to learn

Learning to read

The Frith model (1985)[7] is a Piaget-based model (i.e. a step-by-step model where each step must lead to the other, i.e. a step cannot be bypassed). In this model, in order for learn how to read five critical steps are included:

1. Contextual "reading"
2. Logographic "reading"
3. Partial decoding
4. Full decoding
5. Orthographical processing

The steps listed above also include the sensory and cognitive processes underlying reading which start developing even in the uterus. The awareness that abstract shapes and logos have a meaning in the spoken language (i.e. literacy awareness) starts during the first years of life. These first steps are called the "contextual" and "logographic" phases and are not considered an actual reading (i.e. an awareness and translation to sounds of all the letters in a given word). According to Frith's model, a contextual step is where children who see photos of hamburgers and french fries (or seated in the McDonald's restaurant) with the words (not the logo) for McDonald's will say "McDonald's".

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[7] Frith U. *Beneath the surface of developmental dyslexia.* London: Erlbaum.; 1985.

Following this step comes the logographical step. An example of the logographic phase is when children look at the word McDonald's in the same "shape" and colors of McDonald's logo, and say "McDonald's" (even when they are not exposed to it in the actual restaurant). Although, in both steps, children name the word "McDonald's"correctly, these are not considered as "true" reading as children did not use actual decoding, i.e., translating the letters into their corresponding sounds, to read. However, these steps are essential literacy awareness steps, critical for the two next decoding steps: the partial and complete decoding stages. In the partial step, the reader decodes some of the letters and matches them to their corresponding sounds, whereas, in the complete decoding stages, there is a full match of all letters to their corresponding sounds.

However, the entire decoding stage is not the final step in reading acquisition as reading still needs to be accurate, automatic and fast (i.e.fluent). Reading fluency (or the orthographical step) is the final stage in this process, where the reader recognizes the words holistically, automatically, and effortlessly, which is considered "fluent reading". However, this model suggested by Frith[8] does not relate to the overall "end goal" of reading. This "end goal" includes reading comprehension, gaining new knowledge, and constructing ideas and opinions based on this gained information, i.e. reading to learn.

From "Learning to read" to "Reading to learn"

Chall's model from 1983[9] elaborates on the different stages in development following the technical stages of reading acquisition. The researcher breaks the reading process into two parts: 1) learning to read and 2) reading to learn.

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[8] Frith U. *Beneath the surface of developmental dyslexia.* London: Erlbaum.; 1985.
[9] Chall JS. *Stages of reading development.* New York: McGraw-Hill; 1983.

Figure 2. Chall's reading acquisition model[10], includes the learning to read (blue) and reading to learn (grey) stages.
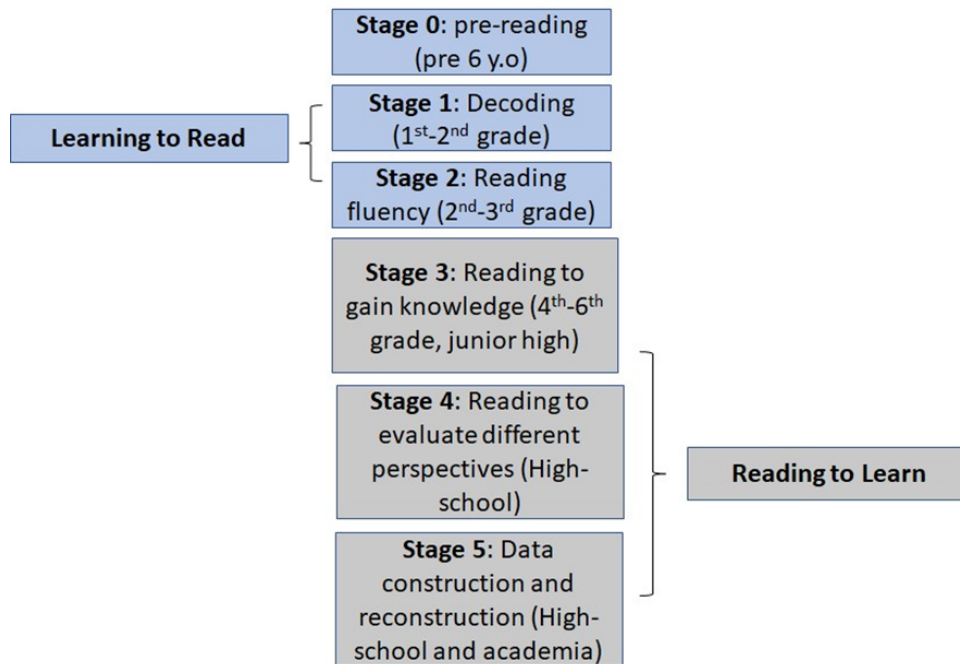
The first part is very similar, in principle, to the stages outlined in Frith's model[11], starting at the pre-reading stage, which includes the awareness to print (i.e. literacy awareness step), decoding, and reading fluency. Uniquely, this model also has the "purpose" of the reading process: reading comprehension. Once reading mastery (i.e. fluency) is reached, reading comprehension, per Chall's model[10], is broken into several critical phases: the first and primary one is to gain new knowledge (4th-6th grade and during junior high). The other two stages (stages 4 and 5) occurring in high school and academia focus on the ability to construct and reconstruct knowledge based on information gained from the text (see Figure 2). In other words, as stated in Samules and Laberge's model (1974),[12] once reading becomes automatic and fluent, the brain can focus on comprehending the written materials on the basic level (stage 3) and then also in a deep-level mode involving higher level processing. Both these models explain the ultimate goals of reading (reading comprehension) but do not provide deeper mechanistic information regarding the fundamental components underlying reading which is explained next in the Simple View of Reading basic and extended models.

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[10] Chall JS. *Stages of reading development.* New York: McGraw-Hill; 1983.
[11] Frith U. *Beneath the surface of developmental dyslexia.* London: Erlbaum.; 1985.
[12] LaBerge D, Samuels SJ. Toward a theory of automatic information processing in reading. *Cognitive Psychology.* 1974;6(2):293-323.

What components underlie reading comprehension?

This part presents the overview of several models aimed to explain the components which underlie reading.

The Simple View of Reading model

As explained earlier, the foundation for reading acquisition is established prior to reading age. The Simple View of Reading model, suggested by Gough (1986),[13] proposes that reading comprehension, the ultimate goal of reading, is achieved by two main components, which can also be viewed from a longitudinal perspective. First, language processing, i.e. vocabulary, phonological awareness and listening comprehension, are developed. This process occurs from birth onward. Secondly, decoding, including letter-sound correspondence and orthographic word reading, is acquired. The model suggests that these two components, together, enable reading comprehension, as can be seen in Figure 3. This model was used to explain reading difficulties among children, as the claim was that reading comprehension could be affected by impairments in the linguistic component, the decoding component, or both.

Figure 3. The Simple View of Reading model adapted from Gough (1986)[13]. Colors in the left scheme match the cognitive/linguistic/sensory processing regions listed in Figure 1.
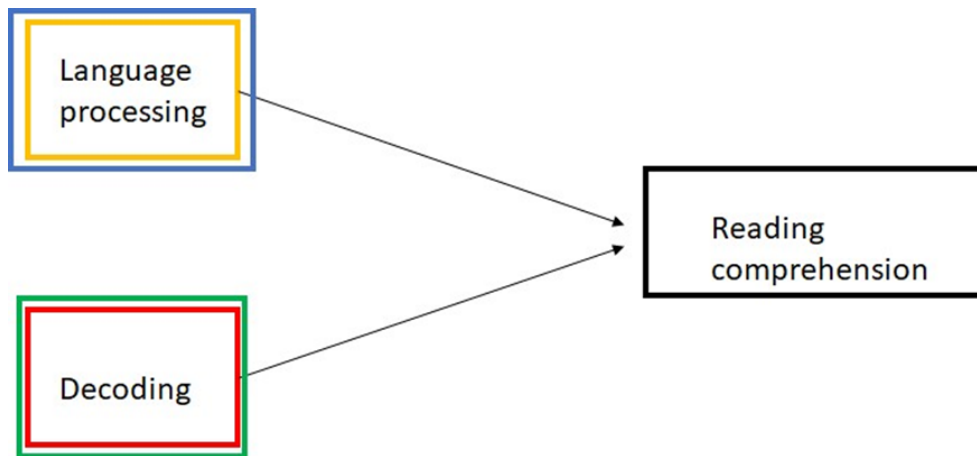
However, the original Simple View of Reading model failed to include an important component- reading fluency- the ability to read words and text automatically and accurately (Breznitz, 2006).[14] As explained earlier, the ability to read fluently allows freeing attention and cognitive resources to comprehend the written material (LaBerge & Samuels,1974).[15]

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[13] Gough P. B. TWE. Decoding, reading, and reading disability RASE. *Remedial and Special Education* 1986;7(1):6–10.

[14] Breznitz Z. *Fluency in Reading: Synchronization of Processes.* Mahwah, New Jersey: Lawrence Erlbaum Associates; 2006.

[15] LaBerge D, Samuels SJ. Toward a theory of automatic information processing in reading. *Cognitive Psychology.* 1974;6(2):293-323.

Hence, Silverman's work (2013),[16] expanding the Simple View of Reading also to include reading fluency, is not surprising. This model suggested that once individuals are able to decode letters to their matching sounds, then they are able to master it automatically (i.e. read fluently), which then enables them to comprehend their reading. See Figure 4.

Figure 4. The extended Simple View of Reading model, including the Fluency component, was suggested by Silverman (2013).[16] Colors correspond to the linguistic/cognitive abilities outlined in Figure 1.
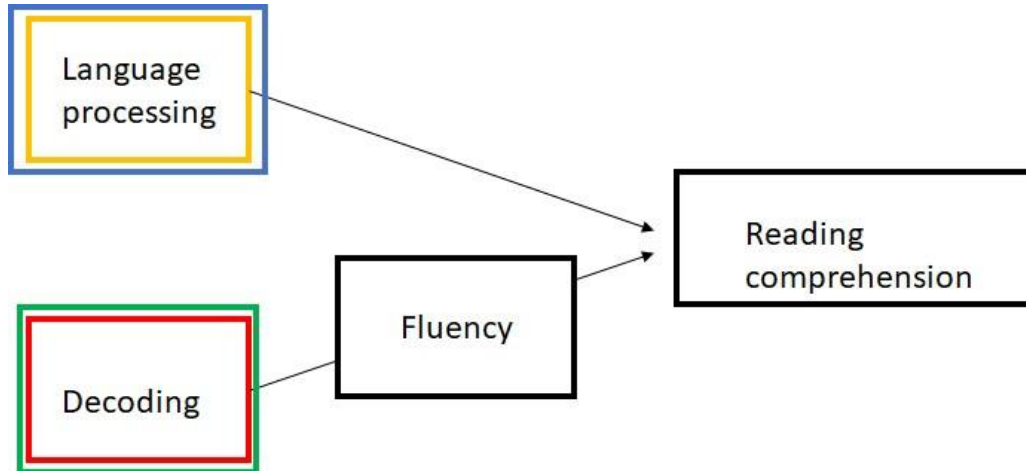
Attempts to provide additional information regarding the interaction between the components as part of the simple view of reading resulted in the Rope model of Reading (Scarborough, 2001).[17] This model suggests that the two components, language processing and decoding, are not separated in their influence on reading comprehension, but, similarly to two ropes, they are combined to achieve reading comprehension as well as fluent reading. The sub-components of language comprehension and word reading components in this model are similar to those presented in the simple view of reading and include the following: 1)language comprehension- vocabulary and literacy knowledge and 2) word recognition- decoding, orthographical processing (the ability to recognize words holistically), and phonological awareness. See Figure 5 for this model.

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[16] Silverman RD, Speece DL, Harring JR, Ritchey KD. Fluency has a role in the simple view of reading. *Scientific Studies of Reading.* 2013;17(2):108-133.
[17] Scarborough HS. Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In: S.B. Neuman and D.K. Dickinson (Eds.), ed. *Handbook of Early Literacy Research (Vol. 1, p. 98), .* New York, NY: : Guilford. Copyright 2001 by The Guilford Press.; 2001.

Figure 5. The Rope model of Reading adapted from Scarborough (2001)[18].
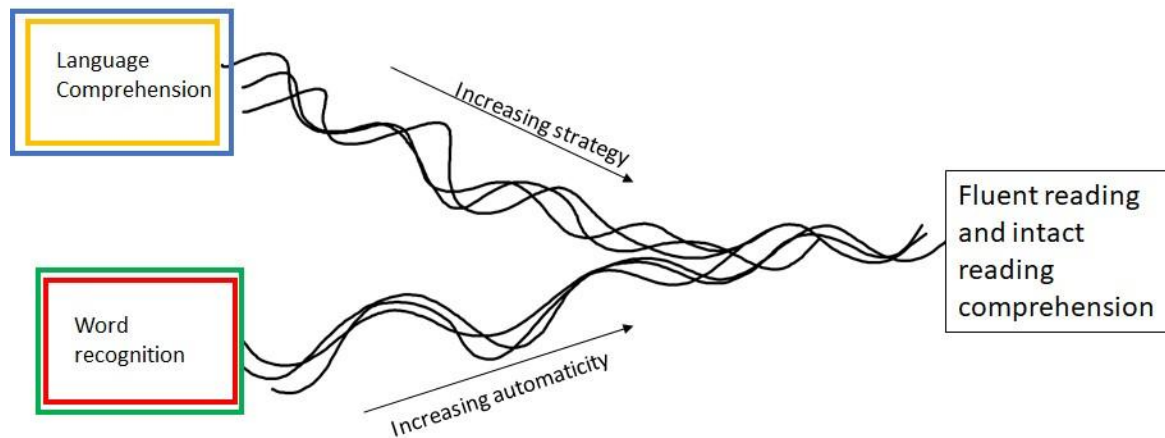
The combined, elaborated, Simple View of Reading model

In recent years, the attempts to combine previous models for reading development generated the suggested elaborated Simple View of Reading model (Kim, 2020).[19] This model, outlined in Figure 6, is related to the reading process as a house with basic building blocks and a roof. The model positioned reading comprehension as the top outcome of the reading process and added cognitive abilities or executive functions such as working memory, the ability to inhibit responses, and shifting, as the underlying basis for reading. The model also includes the basic components listed in the original simple view of reading model and the rope model of reading (e.g. word reading and language/listening comprehension components), however; it suggested the critical role of reading fluency and the ability that relies on these two components and set the basis for reading comprehension. See Figure 6.

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[18] Scarborough HS. Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In: S.B. Neuman and D.K. Dickinson (Eds.), ed. *Handbook of Early Literacy Research (Vol. 1, p. 98), .* New York, NY: : Guilford. Copyright 2001 by The Guilford Press.; 2001.

[19] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

Figure 6. The "Simple but not simplistic" View of Reading model[20]. The colors in the figure match the cognitive/linguistic/sensory processing brain regions listed in Figure 1.
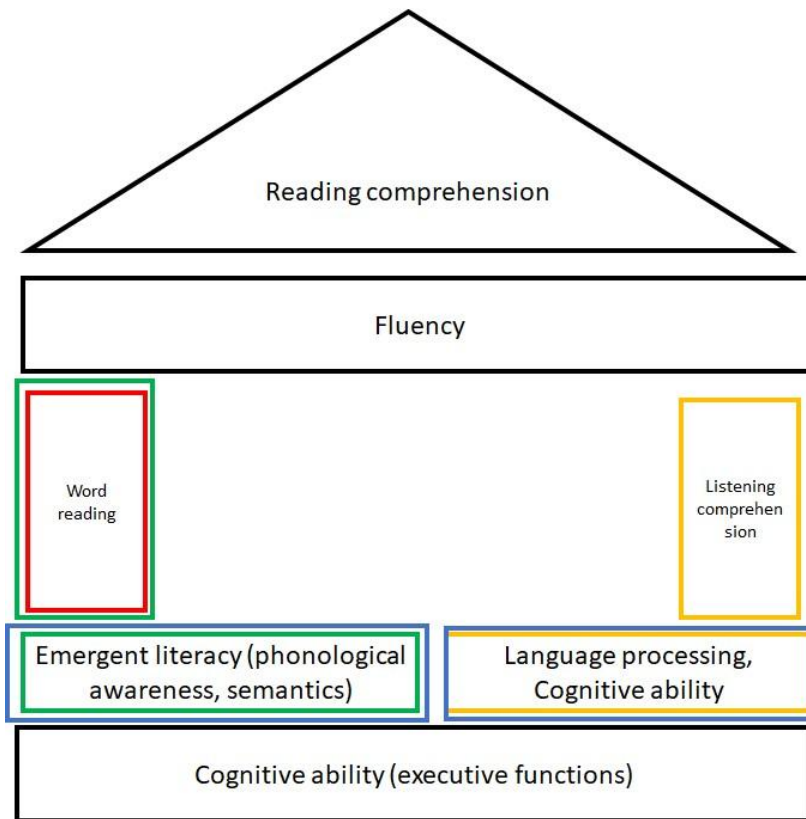
The importance of reading fluency

Reading fluency is defined as the ability to read accurately and automatically while comprehending the written language (Breznitz, 2006)[21]. It is also related to speed of information processing and more basic cognitive abilities, which are part of executive functions (such as working memory, inhibition and attention) (Breznitz, 2006)[21]. Neurobiologically, it was suggested that a timely synchronization between the visual (letters) and auditory (sounds) processes determines the level of reading fluency. The critical position of reading fluency as the component underlying reading comprehension in the extended Simple View of Reading model outlined in Figure 6 is due to the fact that when the components below- processing linguistic information and word decoding are automatic and additional executive functions are intact- then fluency is achieved, and reading comprehension is also intact. Reading will not be fluent and reading comprehension will not be successful if some fundamental components are not active or display impairments, such as when the vocabulary is low and the child does not

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[20] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

[21] Breznitz Z. *Fluency in Reading: Synchronization of Processes.* Mahwah, New Jersey: Lawrence Erlbaum Associates; 2006.

understand the words read, when decoding and word recognition are not automatic, or when executive functions are not functioning properly because of attention issues or other disorders/difficulties.

Reading components and Bookbot

The Bookbot application, presenting text for children, allows them to repeat words or segments of words while presenting them with images representing the written stories. There are several themes in the books and the child can choose them based on their interest level. There are also several levels for the books that are matched to the child based on the child's choice, from basic level to more advanced ones.

These basic training principles of reading have the potential to allow monitoring reading accuracy and speed. It can also potentially train the decoding/word and reading fluency parts during reading. The components that can be potentially trained by Bookbot as part of the Extended simple View of Reading are presented in Figure 7.

Figure 7. The components Bookbot can be potentially trained by Bookbot as part of the Simple but not simplistic View of Reading model (components are marked with asterisks).[22]

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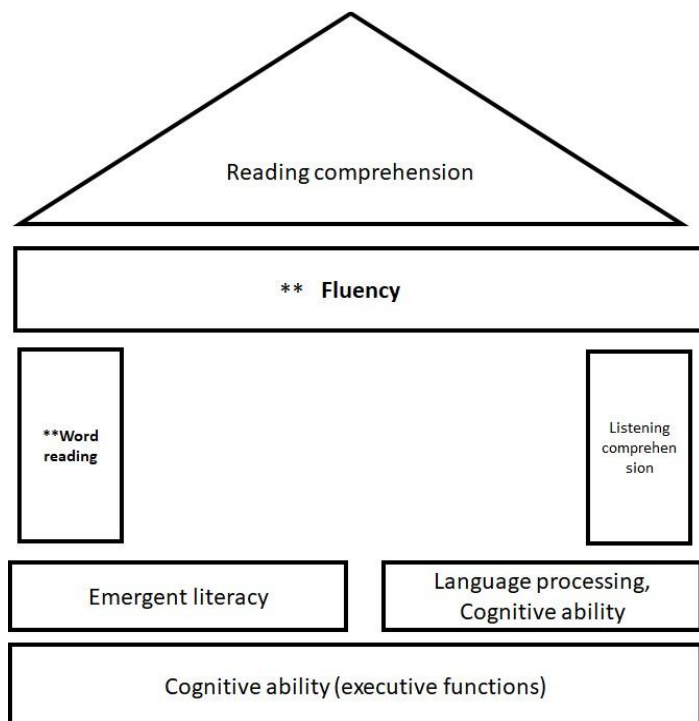
[22] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

Takeaways and Recommendations

Based on the above literature and existing features of Bookbot, we recommend the following to make Bookbot more evidence-based.

1. Include the theoretical background in Teachers' Guides and pitch decks to demonstrate the tight theoretical basis for Bookbot. The video attached to this deliverable can be used to provide this theoretical background.
2. Share this theoretical background with the Bookbot team at large (from the technical to the content level personnel). The video attached to this deliverable can be used to provide this theoretical background.
3. Testing the effect of Bookbot training on the word reading and reading fluency components noted in Figure 7 to validate the effect of training on these components. A diagram outlining this in more detail can be found under Deliverable 5 further below.
4. Adding a reading expert to the team as an advisor.
5. Adding the following components to Bookbot, so the overarching goal to improve reading comprehension is achieved:
   a. Reading comprehension: add features either within the application or as a supplement provided to teachers to also evaluate and improve the children's reading comprehension.
   b. Language processing component (in the word vocabulary level). See Figure 8 below with these items highlighted as part of the extended Simple view of Reading model suggested by Kim, 2020.[23]
   c. Reading fluency: make sure children understand the words they read which will then allow mastering reading fluency.
6. A careful choice of the chosen written materials: When adding these components, careful attention needs to be made for choosing the appropriate stimuli (frequency, length of words etc) and designing the appropriate tests to evaluate the effect of training on these abilities. More information on the process and the needed personnel can be found in Deliverable 5.

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[23] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

Figure 8. Suggestions for possible components which Bookbot can expand into (marked using asterisks).
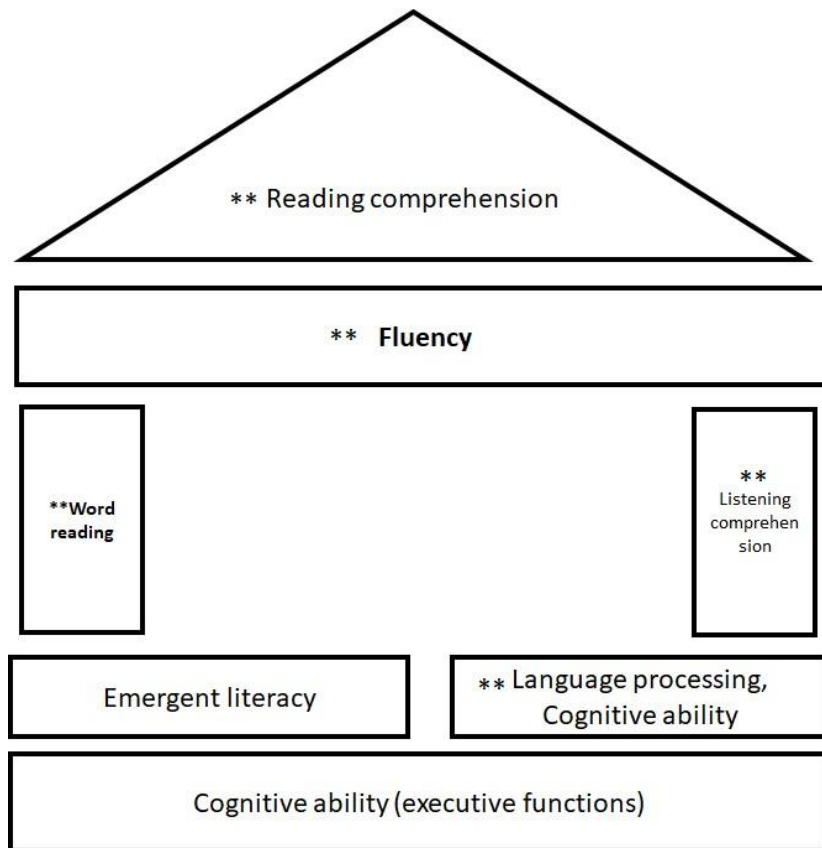
Deliverable 3 - Documented code

Introduction

Bookbot has been collecting a lot of data via its app but the team wanted to identify any gaps in the available data and understand what additional data would need to be collected.
 The purpose of this deliverable is to:

1. Highlight the use of already collected data by guiding Bookbot through how a researcher would run a data analysis (incl. data preparation and data cleaning)
2. Link the theoretical framework (from Deliverable 2) to empirical evidence, and
3. Make the collected data more meaningful and test the validity and other measurement properties.

This deliverable consists of a documented piece of code Bookbot can use in a data analysis environment such as RStudio (offline) or Kaggle (online) to analyze existing data. Bookbot can adjust the delivered piece of code to any new questions.

The documented code that can be adopted and run by Bookbot, is meant as an example of how a data analyst would approach the problem of extracting relevant information from the data. We also used it to understand how the data is structured (in order to be able to make suggestions on how to structure it in a better way) and to identify gaps in the data (in order to suggest how these gaps could be filled). The analyses presented are very basic and probably offer more insights into a data analyst's thinking than into the data itself. We therefore extended this documented data analysis with some exemplary results from more advanced modeling. These results, summarized at the end of this section and represented by three figures, are meant to indicate potential insights that could be gained from the data if one would apply serious statistical modeling to it. <u>These results should not be cited as evidence for anything, because they have been conducted rather as an illustration of possibilities and not as a rigorous test of a scientific hypothesis.</u>

But let us return to the first steps. When researchers conduct a data analysis, they follow the following steps:

1. Recognize the knowledge gap (based on the literature review).
2. Have an overall goal ("What is the overarching problem they want to provide a solution to").
3. Come up with aims ("We are aiming to determine the effect of X on Y or "We aim to determine the role of X in Y")
4. Come up with the hypothesis that you want to test ("We hypothesize that X will have a positive/negative effect on Y in a way that it will result in a higher gain in W")

5. Define the measures in your data that will help you verify your hypothesis (a measure representing "X", 'Y" and "W")
6. Identify the appropriate statistical test (and program) to run this analysis on (i.e. t-test, ANOVA etc.).

Each of these steps will be explained below and related to Bookbot.

Measurements for assessing interventions

Pre (before training/use of Bookbot) vs post (or after training/use of Bookbot):
In order to quantify the effectiveness of educational training, collecting measures reflecting reading speed, accuracy and comprehension is recommended (see the *Important measures relevant to reading fluency section* for the needed measurements). The appropriate statistical tests are needed (it is recommended to consult with a statistician with a background in education). Including a relatively homogeneous group in the testing is also essential due to changes in cognitive development along age (especially during reading acquisition age) or at least control for age, the use of normalized tests (i.e. tests with norms for the appropriate age) for the evaluation of the program is critical.

Progress within a session
Testing the reading accuracy, speed and comprehension within a single session are also important. This can point out a child's difficulty to start a session (children who share challenges to start the training) or monitoring the attention level of the child within each training session.

Progress between sessions
Testing the progress along the intervention/training can also be helpful. It can provide information on the change in performance over time, point at fluctuations in performance, and provide an in-depth understanding of factors associated with success/failure during training itself (such as noise and interruptions during training, which may impact the child's performance).

Control group
Having a control group of children who are waiting to receive the training (i.e. "waiting list') or children who are using a different training or using Bookbot without the actual feedback components (i.e an "active control group") will help strengthening the effect of Bookbot training on the child's reading. Participating in a training involves motivational components which may affect the outcomes of training, and to be able to ensure the effect observed is related to the actual training- a control group should be included.

Important measures relevant to reading fluency

It is recommended that several important measures will be collected before and after training, within a single session, and along training (during each session):

1. Speed*: Reading speed, i.e. how long it takes the user to read a single word, is essential. It is recommended that a measure of the average reading time per word (or milliseconds per word) for words read correctly and for words read erroneously should be extracted per book and session. In addition, having such information per book page would allow for investigating the dynamics within a reading session (and not only between reading sessions). Note that such information should control for the words' length (how many letters) and frequency. This measure should be given in two levels:
   a. Word level
   b. Sentence/context level

2. Accuracy*: Level of reading accuracy (how many words are read correctly out of the overall number of words read by the child). It is recommended that a measure of the average reading accuracy for words read correctly and words read erroneously should be extracted per book and session. In addition, having such information per book page would allow for investigating the dynamics in a reading session. Note that such information should control for the words' length (how many letters) and frequency. Measurement units should be indicated in terms of "percentage accuracy". This measure should be given in two levels:
   a. Word level
   b. Sentence level

*Note: it is important to make sure that the words read fast and accurately have a semantic meaning for the reader (i.e. the reader knows the meaning of the words).

3. Reading comprehension (speed and accuracy):
   a. Speed: reading comprehension speed, i.e. how long it takes to provide correct and erroneous responses to a given question (separately). This should be noted per text difficulty level.
   b. Accuracy: Level of reading comprehension accuracy (how many questions were answered correctly and how many erroneously). It is recommended that a measure of average reading comprehension accuracy per book and per session.

Description of how the data is currently organized

There are two aspects to the issue of how the data is currently organized. The first relates to the structure and the second to the content. The structure is not easily accessible to the average data analyst. Data is provided in a nested JSON format that needs to be transformed

into a format where each data row represents one observation and each data represents a variable. As demonstrated in the documented code, this can be done with existing software with a few lines of code, but it requires some expertise in data structure. Also, it works better for some variables than for others. Single variables can be easily "de-nested" while lists within the JSON structure are more complex, especially when they have unequal length (such as lists of words that, of course, differ between books).

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APPLY

Plan your data collection (e.g. content and structure) in a way that makes it accessible for both technical and research purposes. Talk with a data analyst who can advise you on the requirements for data analytic purposes.

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Overall, our impression was that the data structure was more aligned to the technical requirements of the software and less to the needs of data analysts. This observation even more applies to the contents in the data set. There are, for instance, progress variables that are saved in the data for the purpose of displaying progress to the use and not for tracking progress over time. We would have wished to have more information on reading behavior within a session such as the order of words, the order of mistakes, reading speed per word, and all that information that could have been easily collected as process variables. This would have allowed us to get a much deeper insight into the mistakes that children make, for example, how they fare within a session. Instead, we could only take entire sessions as units of analysis, which of course limits the insights that could be gained.

Aims of this demonstration and working hypotheses

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WATCH OUT

All hypotheses, statistical analyzes, and results are meant for demonstrative purposes only! By no means should they be used as evidence for anything because (a) data cleaning and data preparation was not conducted rigorously, (b) there is no study design allowing to draw very strong conclusions for the data, (c) statistical analyses were performed having in mind to show what would be possible, and (d) results have not been double checked or verified by an independent method. While the material provided should be used for internal purposes, we strongly discourage using this material for purposes such as marketing, acquiring funding etc. It is more likely than not that after a careful review, results would look different than they do now. Having used them for external purposes would then cause more damage to both the company and the research fellows who have provided this information for internal demonstration purposes only.

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Based on the theoretical elaborations framework outlined above, our demonstration was generally guided by the following aims. We were not able to address all of them for different reasons (including finding out that not all data was available to address them), Still, we want to mention all of them to demonstrate how a translation from a theoretical framework (outlined above) to a statistical approach (outlined below) would look like:

Aim 1. To determine the effect of Bookbot training on reading speed and accuracy.

Aim 2. To determine the effect of Bookbot training on reading speed and accuracy per reading profile.

Aim 3. To determine the changes in speed and accuracy between and within sessions per reading profile.

Aim 4. To determine the number of books and breaks per session, per reading age and reading profile.

These aims are designed to examine the following hypotheses:

H1. Faster reading speed (in msec) and more words read per min will be observed following Bookbot use.

The measures we need to address H1:
· Reading speed (per word? per letter?) of words read correctly 1) in the first book 2) in the last book (words need to be normalized for frequency and length)

H2. Faster reading speed (in msec) and more words read per min will be observed following Bookbot use in children in all age groups, with a greater effect in children with reading difficulties.

The measures we need to address H2:
· Reading speed (per word? per letter?) of words read correctly 1) in the first book 2) in the last book (words need to be normalized for frequency and length)
· Age of the participants
· Tagging for reading difficulties

H3. Faster reading speed (in msec) and more words read per min will be observed within each session and between the sessions, especially in those with reading difficulties.

The measures we need to address H3:

- · Reading speed (per word? per letter?) of words read correctly for every session the child trained on (words need to be normalized for frequency and length)
- · Age of the participants
- · Tagging for reading difficulties

H4. More books and fewer breaks between the books will be observed from the beginning of training to the last training session across all reading groups.

The measures we need to address H4:

- · Number of books read every day (per date)
- · Number of breaks within each session (per date)
- · Age of the participants
- · Tagging for reading difficulties

Aims we can address using the current data

Currently, we can first of all address questions regarding the validity of the data. Do the measures make sense, are they correlated as expected, do they capture the expected learning progress etc. We can approach these questions in different ways such as running some descriptive analyses, comparing metrics from the first and the last session, see how changes in one metric affect changes in the other and so on. What we cannot do is provide a rigorous test of the effectiveness of the intervention (the Bookbot app), mainly because there is no appropriate study design to do so. We can, however, try to establish whether children using the app more often will also have steeper learning curves. This at least will show that the data is measuring what it is supposed to measure.

Documented Code

Please refer to Appendix 1 for the documented code.

In addition to the documented code, we conducted four exemplary analyses meant to point to the potential already available in the data. We used complex modelling approaches to demonstrate effectiveness evaluation, theoretical analysis, and learning analytics. These are just three sample cases meant as a glimpse into the insights that serious data analyses could provide. *They should not be cited or used for marketing purposes because any one of them would require a more rigorous robustness check*. Still, they are indicative of what would be possible.
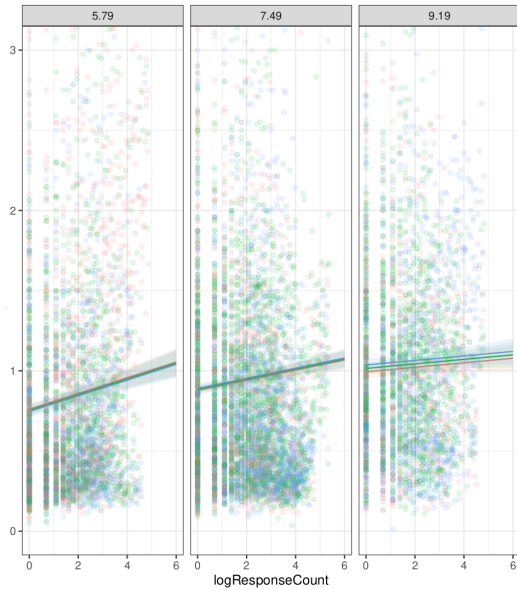
Analysis 1 tried to answer whether more frequent app usage is associated with higher reading speed. We calculated the outcome variable as syllables per second and divided the sample into three age groups. The x-axis in the following figure is the (logarithm) app usage frequency. The number 2 represents approximately seven books read, and the number 4 represents 55 books. The y-axis represents syllables per second as the main outcome variable. The different lines represent different levels of reading accuracy (which had no significant effect).

The more the app usage, the higher the reading speed. This finding is especially true for young children around age 6. For older children around 7 ½ years, the effect gets smaller. Furthermore, for children aged around nine years, the increase is almost non-existent. This dosage-response analysis is an alternative if no true randomized control trial is available. However, of course, self-selection cannot be ruled out here, so these results are not actual evidence of the effectiveness of the app. Still, they indicate that the results are going in the expected and desired direction.
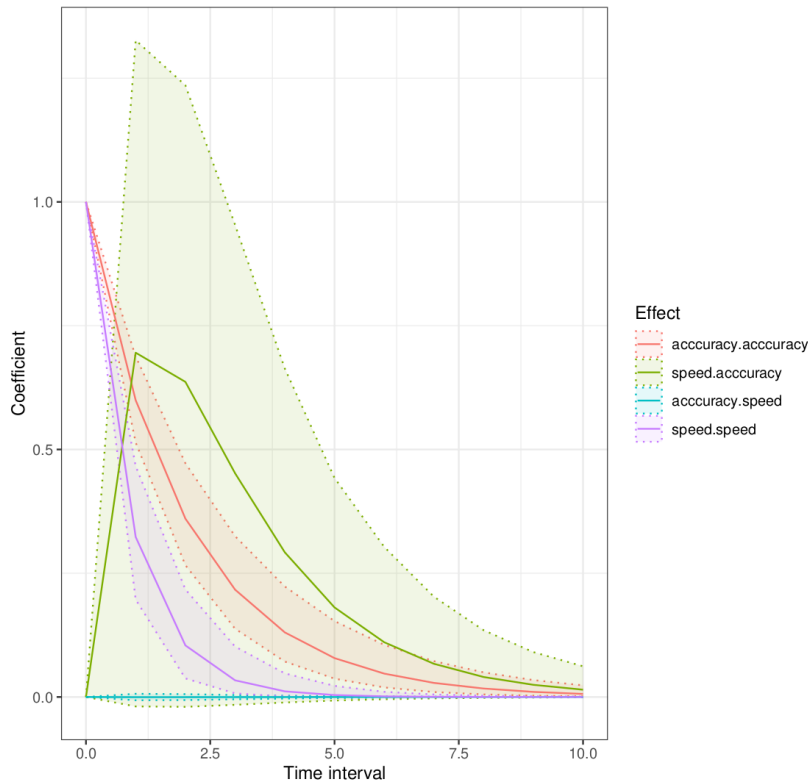
Analysis 2 builds on a complex continuous time dynamic modelling that looks at short-term perturbations on one variable as a function of the perturbation on the other. Driver (2007)[24] developed the software that supported us in these analyses. We looked at the association between speed and accuracy. We calculated speed based on the number of syllables read in the recorded time. For accuracy, we used the variable provided by the system. The figure summarizes the results. The x-axis represents the time interval in terms of sessions (which means that the absolute time interval may vary between single children). The y-axis represents the relative strength of association.

The green line is the most informative. It shows the short-term association between accuracy to speed. Short-term means that we look at associations between single sessions after having statistically removed long-term increases in reading speed. In other words, we are looking at short-term bursts in speed or accuracy and how they relate to each other; and ignore that they occur against the backdrop of more continuous long-term growth.

So what do we see here? If students increase reading accuracy (over and beyond their long-term increase), they also tend to increase reading speed the next time they use the app. Note that the green effect really peaks at $t = 1$, so in the very next sessions. After that, the effect gradually fades away (but is still detectable even 5 sessions later). Interestingly, there is no such effect in the other direction! As the flat petrol-coloured line indicates, increasing speed

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[24] Driver CC, Oud JHL, Voelkle MC. Continuous time structural equation modeling with R package ctsem. *Journal of Statistical Software*. 2017; 77(5):1-15.

in one session does not affect accuracy in the following sessions. Of course, this finding needs to be double-checked and linked to the respective theory. If it turns out to be robust, it could guide the students. The app should focus on training accuracy and provide respective feedback here. Because over time, increased accuracy will translate into higher reading speed (and not vice versa).

Analysis 3 is the most complex and very first demonstration. Single points in this figure represent single observations (e.g. one book), and the lines in the background represent predictions made by the model based on the last 50 observations.

We plotted five individual cases to demonstrate if collecting observations was predictive of the children's learning progress regarding accuracy and speed, which is the case overall. Let us focus on the red dots representing one child and the child's speed depicted in the right part of the figure. The lines behind the dots represent the model predicting learning progress and are updated every 50 observations. After 50 observations, the data predicts the child's progress quite accurately. From the beginning, the "red child" is on a "fast forward" track instead of the purple child. Such predictions provide children with good practising material that is manageable and exciting.

The (hardly visible) stability of the prediction lines suggests that - although there certainly is much fluctuation between the single reading sessions - the predicted learning growth does not fluctuate a lot. In other words, we can identify and predict individual trajectories quite well, which is the first prerequisite to giving recommendations to learners. Based on the information collected during the first sessions (here it is 50 but one can try how low one can get), one can predict the reading progress of a child and hence provide information to teachers, provide children with the appropriate material and so on. This prediction model is not meant to be the one that we would ultimately suggest, though. But it is meant to demonstrate that there is enough "signal" in the data and that the choses measures have sufficient information to base educational decisions on them. This is not self-evident and speaks for the quality of the data collected.
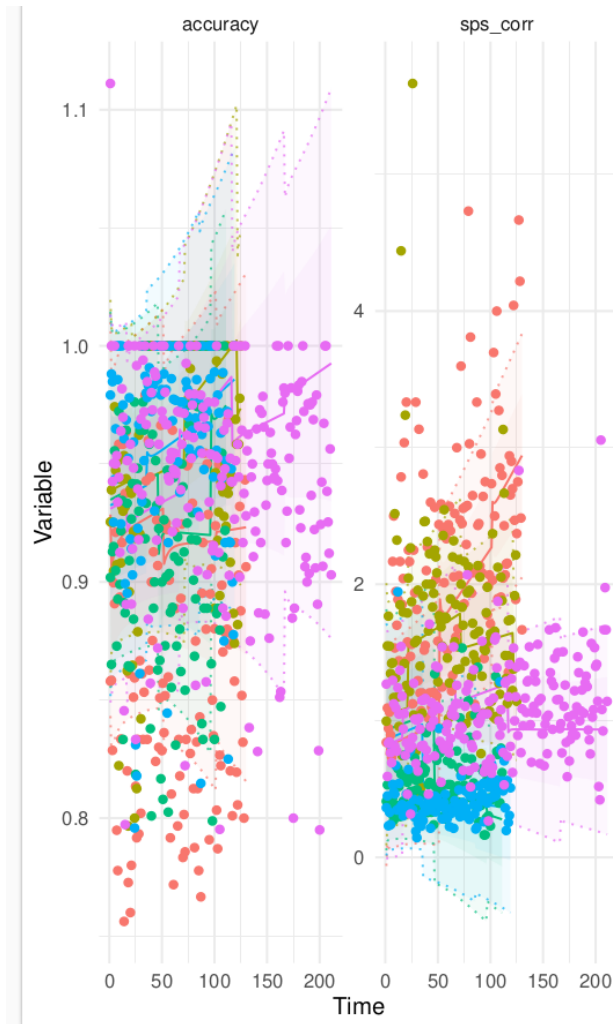
Analysis 4, finally, we looked at the associations between speed and accuracy using a continuous-time dynamic modelling approach. In this approach, we decompose long-term trends (i.e., over months and years of app usage) from short-term fluctuations. Short-term fluctuations are those changes (up or down) in reading performance that cannot be explained by long-term growth. They can occur because a child had a good or bad day, put in more or less effort, read more or less conscientiously and that like. Associations between short-term fluctuation components are depicted in the second figure in this section.

Surprisingly, we find no significant association between the long-term growth components. Hypothesis 3 would have expected that weaker children (at the outset) gain the most in speed (over time). Instead, Reading speed at the outset and gain over time are uncorrelated. In other words, the gain in speed is independent of the speed at the outset.

Insights

1. The fascinating, aggregated and linguistic data is in a way that does not allow in-depth analysis. Words spoken correctly and to which degree of correctness is also needed to allow substantial analyses within one book and not only overall analyses between books. One could collect rich information from the progress within a book that would allow, for instance, analyses of the types of mistakes made or recommendations on which books to read based on the reading progress within single linguistic domains.

2. Thinking about ways of distinguishing data appropriate for answering research questions from invalid, test user data that is currently present in the data set. The current data set seems to be a dump of all data that has been collected, including test users and others. One needs to define a procedure that identifies invalid data. Identifying invalid data is achieved by flagging testing cases, defining what counts as a valid user, and setting up a procedure for adequately cleaning the data set before conducting any analyses.

3. This preprocessing step has been included here for demonstrative purposes. Having a similar look at other variables and defining a procedure that identifies invalid cases is recommended. Such a definition should be consistent across all analyses because only such consistency allows for comparing different results with each other.

Recommendations

4. Collecting data that can be collected without much additional effort, especially within a book.

5. Examining the effect of word frequency/length on reading fluency and comprehension.

6. Having a data analyst on onboard who can make sense of the approaches suggested.

7. Reorganizing the data export to allow data extraction from the first to last training sessions and within sessions.

8. Tagging sentences as sentences and book sheets need to be tagged.

9. Extracting reading errors per letter/phoneme along with training, in the best case having time stamped information during a book session.

10. Sharing data for research purposes that include identifying information carefully. Although the data here is relatively low-risk data, one wants to avoid seeing the user's email addresses, like those in the hands of a data analyst or published by accident, as this could negatively impact the company's reputation.

11. Obtaining some expertise in natural language processing to extract the relevant linguistic features of the books presented and using this information to test some substantial hypotheses about learning to read or for recommendation purposes.

12. Reviewing state of the art in reading research, identifying the common operationalisations, and building the system in a way that allows extracting this information. Otherwise, there will always be only very crude measures, making it more convenient to draw valid conclusions.

13. Looking at means and variances, correlations between variables, trajectories of single cases. It is always recommended to get an understanding of the raw, individual case data before applying sophisticated statistical models to it.

14. Completing primary first analyses with more data points, control variables, and others are more appropriate models for analyzing the data (as demonstrated outside this document) and obtaining expertise in how to set up and interpret appropriate statistical models. The type of data obtained is undoubtedly helpful for drawing meaningful conclusions about children's reading progress, improving the user experience, optimizing the app's effectiveness, and providing evidence-based proof that using Bookbot can be an effective means to support children in learning to read.

15. Collecting more background information about children and the situation in which they are using the app will help to think up and test new hypotheses and obtain new evidence to improve the system even if no randomized controlled trials exist.

16. Collecting valuable data within one reading session (a book) will open up new possibilities for getting evidence on how children interact with the app, which mistakes they make and others.

17. Setting up a randomized control trial with a proper control condition to get solid evidence if this app achieves its promises.

Deliverable 4 - Teacher's guide

Introduction

We wanted to ensure that teachers had access to all pertinent material in one place because teachers are so important to the widespread adoption of Bookbot. Since Bookbot strives to be more evidence-based, we wanted to empower teachers to comprehend the theoretical framework as well. Bookbot already had a basic Teacher's Manual and gathered teacher feedback. We used this as a foundation to create this Teacher's Guide to help teachers get the most out of using the app. The guide will provide educators with all the background information on literacy they require, as well as enable and motivate educators to use the app to help students learn to read.

Deliverable

Bookbot Teacher's Guide

What is this guide about?

To provide step-by-step instructions for installing the app, setting up an account and navigating the Bookbot app.

Bookbot is a learn-to-read app that guides children through becoming proficient readers. The app provides an extensive library of thousands of leveled synthetic phonics books that children can read aloud and receive guidance.

Who is this guide for?

The guide is for teachers, guardians and users who can use the app with little help and supervision.

About Bookbot

Vision

Bookbot's vision is that every child has the opportunity to develop their reading, writing and communication skills to live a happy and successful life.

The team

Based in Jakarta, our team comprises educators, producers, writers, creatives, and software and machine-learning engineers who share a common passion for education and leveraging technology to create a better future for children.

Your main contact person will be Yanti Sitepu. As an accomplished education manager, she brings over a decade of experience in teaching reading and writing to students across preschool, primary, middle, and high school levels. Her extensive expertise covers teacher training, designing education and language programs, managing and supervising teachers, monitoring and evaluating performance, and conducting research on children with dyslexia. Her valuable contributions have been featured in numerous national and international journals.

Installing and setting up Bookbot

What are the device requirements for using Bookbot?

For an optimal experience with Bookbot, we recommend using a smartphone or tablet that meets the following specifications:

- You will need around 500MB of storage space to install and use the app. You'll need Wi-Fi or mobile data during installation, but once you install the app, you can use it offline without an internet connection. In addition, You'll need Wi-Fi or mobile data to sync your progress with the Bookbot Report app.
- For optimal performance, it's recommended that your device has a minimum of 3GB RAM. Devices with less RAM will experience poor app performance.
- The Bookbot app is compatible with Android 6.0 or newer and iOS 11 or more recent for iPadOS and iOS devices. The Bookbot Report app works with Android 5.0 or newer and iOS 9 or newer for iPadOS and iOS devices.
- You'll need an email, Google or Apple account to create a Bookbot account and access the app's features.

How do I check the amount of storage and RAM on Android?

To determine the amount of storage and RAM on your Android phone, follow these general steps:
- Open the "Settings" app on your phone.
- Scroll down and tap "Device Care", "Storage", or "Memory".
- Look for "Storage" and "Memory" to see the available storage and used RAM.

Remember that the steps might differ slightly based on your Android phone's model and

software version.

How do I check the amount of storage on iOS?

To determine the amount of storage on your iOS phone, follow these easy steps:

- Open the "Settings" app on your iPhone.
- Tap "General" to access the general settings.
- Choose "iPhone Storage" (or "iPad Storage" for iPads) to view the available storage space   and the amount used.

How do I install Bookbot from Google Play?

- Open the Google Play app on your Android phone.
- Search for "Bookbot".
- Choose Bookbot Phonics Books for Kids.
- Select "Install".

How do I install Bookbot from the Apple App Store?

- Open the App Store on your Apple phone.
- Search for "Bookbot".
- Choose Bookbot Phonics Books for Kids.
- Select "Install".

How do I install the Report app from Google Play?

- Open the Google Play app on your Android phone.
- Search for "Bookbot".
- Choose Bookbot Reports.
- Select "Install".

How do I install the Report app from the Apple App Store?

- Open the App Store on your Apple phone.
- Search for "Bookbot".
- Choose Bookbot Reports.
- Select "Install".

How can I create an account or log in to Bookbot?

To register or sign in to Bookbot, follow these steps:

- On the main page, tap the button at the top-centre of the screen (it looks like an ID card).
- You'll be taken to the sign-in screen, where you have a couple of options:
- You can quickly sign in using your saved Gmail or Apple ID on your phone.
- Alternatively, type your email address into the provided space.
- If you choose to enter your email, you'll receive a verification code in your inbox. Enter the code on the sign-in screen, and you're ready to use Bookbot!

Why is it important to register my email address?

By registering your email address, you can reap the benefits of saving and monitoring your progress and earning awards and advancing levels. This way, you can pick up where you left off, even if you switch devices or need to reinstall the app.

Why should I register for a Bookbot account?

Registering for a Bookbot account lets you customize your reading experience and fully utilize the app's features. By creating an account, you can:

- Track your progress: Your account lets you monitor your reading progress, including the number of books read, your reading level, and your reading speed.
- Set reading goals: Establish reading goals for yourself and track your progress.
- Access additional features: As we continually update and enhance the app, registered users will gain access to new features and content.

Can I use Bookbot offline?

Yes, you can use Bookbot offline. Upon downloading the app, you'll have access to thousands of books, and the voice recognition feature will also be available offline. Please note that an internet connection is required for the initial download and for signing in or registering an email with the app.

How do I create a new profile?

To create a new profile, follow these steps:

- On the main page, tap the top-centre button (the ID card button).
- You'll be taken to the sign-in screen if you still need to sign in or register. First, connect with an email. You can use your Gmail or Apple ID account or manually enter your email.
- After connecting your email, select whether you're a teacher or a parent.
- Choose and fill in the following information:

- Avatar: Choose a visual representation or icon for the student. This adds a personal touch and makes it more engaging for the child.
- Student's Name: Enter the student's name using Bookbot to learn and practice reading.
- Birthdate: Provide the student's date of birth. This helps Bookbot tailor the learning experience based on the student's age.
- Reading Level: Select the appropriate reading level for the student. This ensures that the app presents material suitable for their current reading abilities.
- Student Goals: This helps us understand the support the student requires.

How do I change my student profile?

You can't modify the student's name, birthdate or set goals directly in their profile. However, you can change the profile and reading level through the library.

To switch profiles:
- Tap the bottom-right button (the book button) on the main page.
- Choose the profile you'd like to switch to.

To change the reading level:
- Go to the library and tap the letter in the center below the book cover.
- This will let you choose the desired level, ranging from beginner to advanced.
- If the current level is too easy or complex, you can switch to another level by tapping the same letter and selecting a new level.

Does the Bookbot application limit the number of students?

No, there is no limit on the number of students using the Bookbot application. We designed the app with the intention of providing flexibility and accessibility to all users. This enables a wide range of students, regardless of group or class size, to take advantage of the valuable reading resources and features offered by Bookbot.

Can I download the reading app on multiple devices?

You can download and use the Bookbot reading app on multiple devices. To ensure your progress is synced across all devices, sign in with the same email account you used to create your account. This way, you can seamlessly continue your reading journey, regardless of your device.

Using Bookbot on multiple devices also means accessing your reading materials wherever possible. For example, you can read on your mobile device while on-the-go or use a tablet or laptop to read at home.

How to use Bookbot

How can students use Bookbot if they and their parents do not have a phone or gadget?

If a student or their parents don't possess a personal device to access Bookbot, several alternative options are available to ensure they can still benefit from the learning resources:

- School-provided devices: Schools may offer shared devices, such as Chromebooks, tablets, or computers, that students can use to access Bookbot during class or designated study sessions.
- Teacher's device: If shared school devices are not available, students may be able to use their teacher's phone or gadget under supervision. This option depends on the teacher's willingness and the availability of their device during appropriate times.

By utilizing these alternatives, students can continue to take advantage of Bookbot's educational resources, even without personal devices.

How can Bookbot be used for large classroom sizes?

Since there is no restriction on the number of students who can use the Bookbot application, it is also suitable for large classrooms. To accommodate multiple students in a class, follow these steps:

- Create individual profiles for each student by tapping the top-center button (the ID card button) on the main page.
- For every student, choose an avatar, enter their name, birth date, and reading level, and set goals for their reading progress.

By creating personalized profiles, you can tailor the learning experience for each student in the class, regardless of its size. This way, Bookbot can effectively support all students' diverse reading needs and progress in a large classroom setting.

Can Bookbot be used on a laptop?

Currently, Bookbot is not designed for desktop installations. However, we have some exciting news to share!

Beginning in May 2023, Bookbot will be available on Chromebooks, providing users with a larger screen for an even better reading experience. Additionally, our development team is working on a Windows version of Bookbot, which is anticipated to launch in June 2023.

We understand the importance of accessibility, and we want to ensure that our platform is accessible to a broad range of users, including those who prefer to use laptops for their learning needs. These upcoming releases aim to deliver an excellent reading experience to a broader range of users and enhance accessibility.

Can Bookbot be used on older phones?

Yes, you can! Just make sure your older phone meets these requirements:

- Bookbot application is compatible with Android 6.0 or newer and iOS 11 or newer for iPadOS and iOS devices.
- The Bookbot Report application is compatible with Android 5.0 or newer and iOS 9 or newer for iPadOS and iOS devices.

Keep in mind that Bookbot might not perform as well on older phones. But don't worry, we're working on finding ways to improve the experience for these devices over time.

How do I change the reading level in a profile?

To change the reading level in a Bookbot profile, follow these steps:

- Go to the library within the Bookbot app.
- Locate and tap the letter icon in the center below the book cover.
- A selection of reading levels will appear, ranging from beginner to advanced. Choose the level that best suits the student's needs.
- If the current level is too easy or challenging, quickly adjust it by tapping the same letter icon and selecting a new level.

By following these steps, you can customize the reading level for each student's profile, ensuring they receive materials tailored to their abilities and progress.

What is the best and most conducive environment for using the bookbot app?

Creating the right environment can positively impact a child's reading experience. Here are some recommended tips for providing an ideal environment for using the Bookbot app:

- Quiet Location: Choose a quiet and peaceful location for the child to read. It should be free from external distractions like loud noises or interruptions.
- Optionally, you can use headphones or earphones to reduce background noise and help the child concentrate on the reading material.
- Comfortable Seating: Ensure the child has a comfortable seating arrangement, such as

a comfy chair and table, or use a phone holder for their device. This will prevent any discomfort and distractions that could impact their ability to concentrate.

Following these simple tips can help create an ideal learning environment for your child to use Bookbot, enhancing their reading experience and learning outcomes.

How do I read in Bookbot?

Here are the steps to begin reading in Bookbot:

- Open the Bookbot app and tap the bottom-right button (the library button) on the main page.
- Select the student who will be reading from the list of profiles.
- You will be directed to the Library screen, which displays various categories of books at the top of the screen.
- Choose the book category you want or use the search button in the bottom-right corner to find a specific book.
- Once you have found a book the student likes, select it to open and start reading.

How do I check an award from my teacher?

Here are the steps to check the award given by your teacher in Bookbot:

- Open the Bookbot app and go to the library by tapping the bottom-right button (the book button) on the main page.
- Look for the button with numbers, which should be on the screen's bottom. Tap on it to access the award screen.
- For example, if your teacher sets the award with five tokens, scroll down to the five avatar award section. Here, you can check the award your teacher has set for you.

By following these simple steps, you can check the awards assigned to you by your teacher in Bookbot. This feature serves as an excellent motivation tool for students, helping to encourage and celebrate their progress in reading.

How do I get new stickers and avatars?

Here's how to earn new stickers and avatars in Bookbot:

- Complete a reading session by reading books in the app.
- As you read, the battery icon on the screen will gradually fill up.
- Once the battery is full, a meme will be revealed, and you will earn one token.
- Collect more tokens by completing additional reading sessions.

● Use the tokens to redeem new avatars and stickers for your profile by tapping the button at the bottom of the screen and selecting "Avatar" or "Stickers."

How do I redeem my token into avatars

Here are the steps to redeem your tokens for avatars in Bookbot:

Open the Bookbot app and tap the bottom-right button (the book button) on the main page to go to the reading room.

Look for the button on the right side of the screen in the middle-bottom section and tap on it to open the store.

Select the "Avatar" option.
● You will see different levels of avatars available, and each level contains unique avatars.
● Choose a level to view the available avatars.
● To unlock new levels, read more books.
● Once you have enough tokens, you can exchange them for new avatars by tapping the avatar you want.

How can I provide feedback on the Bookbot application?

Here are the steps to provide feedback on the Bookbot application:

● Open the Bookbot app and go to the main page.
● Look for the gear icon on the top right corner of the screen and tap on it to open the settings menu
● Choose "Contact Us" from the settings menu.
● Provide your feedback and suggestions to the Bookbot team.
● You can also report any issues or technical problems you encounter while using the app.

The Bookbot team values your input and feedback, which is crucial in improving the application. So, don't hesitate to share your thoughts and opinions with the Bookbot team.

How do I switch my profile if I have more than two profiles?

Here are the steps to switch your profile in Bookbot:

● Open the Bookbot app and go to the library by tapping the bottom-right button (the book button) on the main page.
● Look for the "Switch Profile" button at the screen's bottom left corner and tap on it.

- You will see a list of profiles that you have created. Choose the profile that you want to switch to by tapping on it.
- Once you select the desired profile, you will be directed to the reading room, and all the books associated with that profile will be displayed.

How do I connect my account to an email?

Here are the steps to connect your Bookbot account to an email address:

- Open the Bookbot app and go to the main page.
- Look for the top-centre (ID card) button and tap on it.
- You will be directed to the sign-in screen if you still need to be signed in.
- Choose the "Connect with Email" option.
- You can directly connect with a Gmail or Apple ID account by selecting the appropriate option or manually entering your email address in the provided fields and entering the verification code sent to your email.

Connecting your Bookbot account to an email address allows you to save your progress and access your profile from multiple devices.

Technical issues

What steps should I take if the verification code I entered during sign-in is reported as incorrect?

If the verification code entered during sign-in is reported as incorrect, please double-check your email inbox for a new verification code. There are instances when the code may have expired or been mistyped. In such cases, you can request a new verification code by returning to the previous page and resubmitting the request for a new code.

Why can't I find the reading app in the app store?

Compatibility and Update Issues. One of the most common reasons an app goes missing is simply because your device is no longer compatible. If you're using an older device with an outdated version of Android, iOS, or iPadOS, an app might go missing from the store or be uninstallable

Why is the reading app download taking so long?

Several factors can impact your download speed, including:

- Internet connection speed: The primary factor affecting download time is your internet

connection speed. A slow or unstable connection can cause downloads to take longer than expected. To ensure a faster download, provide a stable, high-speed connection.

- Download size: The app's size also affects the time it takes to complete. In this case, the Bookbot app is around 327MB, which can take some time to download, especially on slower connections.
- Device performance: Your device's performance can also impact the download speed. If your device runs multiple apps or processes simultaneously, it may slow down the download process. Closing unnecessary apps and processes can help free up resources and speed up the download.
- Network congestion: The network may become congested if many users are connected to the same network or downloading large files simultaneously. This can cause slower download speeds for everyone connected. Downloading during off-peak hours or using a less crowded network may help.
- Server-side issues: Sometimes, the issue may be on the server side, where the app is hosted. If the server is experiencing high traffic or technical issues, it may result in slower download speeds. In such cases, you can download the app later when the server is less busy.
- To ensure a faster and smoother download experience, check your internet connection speed, close unnecessary apps and processes on your device, and consider downloading during off-peak hours or using a less congested network.

Why does Bookbot close when I open the app?

- Before downloading or updating Bookbot, please ensure your mobile device has sufficient memory to prevent installation problems or errors. Check your phone's memory here.
- Close all active applications before opening the Bookbot application.
- If all applications have been closed but the issue persists, reinstall the Bookbot application. To do this, uninstall the Bookbot application and install it again.
- If all the above steps have been followed and the issue still occurs, check the phone model, available storage, RAM, and OS, then contact the Bookbot Team.

Why does the app installation fail?

App installation can fail for several reasons, but one common cause is insufficient storage space on your device. Ensure that your device has at least 500MB of free space for a smooth installation. If you lack the required space, the installation may fail when it reaches 100%. To free up space, you can delete unnecessary apps, files, or media or move them to external storage.

Why is the app not compatible with my device?

App compatibility issues can occur if you're using an older device or an outdated version of your device's operating system (Android, iOS, or iPadOS). If you're experiencing app compatibility issues, we recommend updating your device's OS to the latest version if available. This will ensure your device can access the latest features and performance improvements. If an update is not available, consider upgrading to a newer device.

What should I do if I accidentally delete the and want to reinstall it without losing my data?

Register your account in Bookbot to back up information to the internet. This action ensures that your progress and data are saved within your account. If you inadvertently delete the app, download it once more from the app store and sign in using the email address you previously connected to. The app will automatically restore your progress and data, allowing you to continue from where you left off.

How to use the Bookbot Reports for Teachers

Can I use the Bookbot Report offline?

Unfortunately, you cannot use the Bookbot Report offline, as the students' details are synchronized online. An active internet connection is required to access the report and manage student data.

How do I create a class?

Follow these steps to create a class in the Bookbot app:

- Open the app and connect your email to the app. You can directly connect with a Gmail or Apple ID account or manually enter your email.
- After connecting your email, select whether you are a teacher or parent.
- You will be prompted to create a class. Enter the class name and teacher's name, then proceed.
- Your class is now ready. You can start adding students and managing class activities.

How do I create student accounts?

To create student accounts in the Bookbot app, follow these steps:

- From the homepage, select "Add Students."
- Enter the student's first and last name.

- Choose the student's reading level according to their teacher's recommendation.
- Select the desired avatar for the student.
- Enter the student's or parent's email address to link the account.

How can I connect with students using their email accounts?

- To connect with students using their email accounts, follow these steps:
- On the home page, choose the student you want to connect with.
- Input the student's or parent's email address.
- Choose "Update Student" to save the changes and establish a connection.
- Connecting with students through their email accounts allows you to monitor their progress, assign homework, and give awards.

How can I connect with students using Barcode or Printing invitations?

You can establish connections with students using a barcode or printed invitations when using a tablet or iPad. Follow these steps:

- Select the "Invite Family" option on the homepage, represented by a barcode icon.
- Select the student you want to connect with.
- Follow the steps on the page to generate a barcode.
- If you're going to print the barcode, select the printer icon to print the invitation.
- If you prefer to share the barcode via WhatsApp or SMS, select the share button to send the invitation.

How do I track my student's progress?

To track your student's progress in the Bookbot app, follow these steps:

- Ensure you have connected the app to the student's or parent's email. If you still need to do so, refer to the earlier explanation on connecting with students using email.
- Once connected, click on the student's name on the homepage.
- The student's details, progress, and performance will be displayed for you to review and analyze.

How do I assign homework to my students?

To assign homework or reading tasks to your students in the Bookbot app, follow these steps:

- In the Bookbot Report, select the "Reading Room" option.
- You can search for and filter books by category or reading level to find suitable material for your students.

- Choose the book that you would like to assign as a reading task.
- Select the "Set Book" option to designate the book as a reading assignment for the student(s).

How can I monitor the number of books students have read?

To monitor the number of books a student has read, follow these steps:

- On the homepage, select the name of the student whose reading progress you want to view.
- Once on the student's details page, select the "Reading Log" option.
- The details about the books the student has read or listened to, along with the duration they spent on each book, will be displayed.

How are students awarded?

To award students in the Bookbot app, follow these steps:

- In the Bookbot Report, select the "Awards" option to access the awards panel for the entire class.
- Choose the type of award that you want to give to the students.
- Determine the number of tokens needs to acquire to redeem the award.
- Click on the "Give Award" button to distribute the awards to all students in the class.

These awards motivate students to read more books and frequently use the app. To check the award the student redeemed, click here.

Click here to learn how to check an award from the teacher and here to redeem the award for the student.

How can I monitor the avatar and award the student redeemed?

To monitor the number of avatars and award the student has redeemed, follow these steps:
- On the homepage, select the name of the student whose avatar and award you want to view.
- Once on the student's details page, select the "Awards" option.
- The details about the avatar and award your student already redeemed will be displayed here.

How to use the Bookbot Reports for Parents

Can I use the Bookbot Report offline?

Unfortunately, you cannot use the Bookbot Report offline because your children's details are synced online. You need an active internet connection to access the report and manage student data.

How do I create my child's profile?

To create children's accounts in the Bookbot app, follow these steps:

- From the homepage, select "Add New Child."
- Enter the child's first name.
- Choose the student's reading level according to their teacher's recommendation.
- Select the desired avatar for the student.
- Click "Add Child"

How can I connect with my child(ren) using their email accounts?

As a parent, the email you're using for the Bookbot and Reports app is already connected. So you won't have to connect again with your child(ren) email account

How do I track my child's progress?

To track your children's progress in the Bookbot app, follow these steps:

- Click on the children's name on the homepage.
- The student's details, progress, and performance will be displayed for you to review and analyze.

How can I monitor the number of books my child has read?

To monitor the number of books a child has read, follow these steps:

- On the homepage, select the name of the children whose reading progress you want to view.
- Once on the children's details page, select the "Reading Log" option.
- This will display information about the books your child has read or listened to, along with the time spent on each book.

Can I assign a book as reading homework for my child(ren)?

Unfortunately, as a parent, you cannot assign book-reading homework to your child(ren) using Bookbot. This feature is designed exclusively for teachers to utilise in their classrooms.

How are children awarded for reading?

Bookbot encourages children to read by offering points for every book they complete. The more children read the more points they earn. These points can be redeemed for awards, such as badges, certificates, or other rewards. Follow these steps:

- In the Bookbot Report, select the "Awards" option to access the awards panel, where you can view all the awards earned by the children in your account.
- Choose the type of award that you want to give to your children.
- Determine the number of tokens needed to acquire to redeem the award.
- Click on the "Give Award" button to distribute the awards to all children in the app.

These awards motivate children to read more books and frequently use the app. To check the award the children redeemed, click here.

Click here to learn how to check an award from the teacher and here to redeem the award for the student and children.

How can I monitor the avatar and award the children redeemed?

To monitor the number of avatars and award the children have redeemed, follow these steps:

- On the homepage, select the name of the children whose avatar and award you want to view.
- Once on the children's details page, select the "Awards" option.
- This will display information about the avatars and awards your child has already redeemed.

Pedagogy

What is the Bookbot Indonesia leveling guide?

The leveling information can be found in our scope and sequence guide.

Will children with speech difficulties, such as the inability to pronounce the letter "R," be able to use the app?

Absolutely! Bookbot's voice recognition technology is specifically designed to recognize words even if a person has difficulty pronouncing certain sounds, such as the letter "R". This feature ensures that individuals with speech disorders or other challenges can still benefit from using the application and improve their reading skills.

Can kindergarten children and grade 1 students use Bookbot?

Bookbot is designed for children aged 5 - 9, providing benefits to sometimes kindergarten and grade 3, but mainly grade 1 and 2 students. However, it's essential to consider each child's abilities and reading levels. These young learners may need guidance from parents or teachers, especially when beginning to read or using digital platforms. As with any educational tool, monitoring progress and ensuring appropriate content and difficulty level is vital for meeting their learning needs.

Which age group can use the Bookbot app?

Although Bookbot is primarily designed for children aged 5 to 9, readers of all ages who enjoy reading can appreciate the app's features and benefits. Thank you for selecting Bookbot to support your child's learning and development!

When can we use Boobot at school?

Bookbot can be utilised at school during scheduled reading sessions, independent study periods, or within a structured literacy program. Teachers can incorporate it into their lesson plans to boost students' reading abilities and encourage engagement with reading materials. It is crucial to consult with school administrators and adhere to any guidelines or policies concerning technology use in the classroom.

Does Bookbot have books that contain numeracy?

Bookbot is primarily designed to improve literacy skills through its extensive range of books. In addition, some of these books also integrate numeracy concepts or elements, offering a more comprehensive learning experience.

What does a student's reading level mean?

A student's reading level refers to their ability to understand and interpret written material. It typically indicates the complexity and challenge of the text a student can effectively read and comprehend. Upon setting up their initial personal profile, each reader is required to choose a starting level. This can be achieved by reading a sample sentence that demonstrates the

difficulty associated with each level within the Units. The app's initial levels correspond with the Units in the Scope and Sequence, where each Unit represents a carefully structured progression of skill complexity.

Can fluent readers use Bookbot?

Bookbot is an excellent resource for fluent readers. The app offers books catering to multiple reading levels and preferences, including content designed explicitly for fluent readers. Engaging with these books can help maintain and improve reading skills, expand vocabulary, and foster a lifelong love for reading.

For optimal experience, fluent readers are advised to disable the speech recognition feature while immersing themselves in the books.

Does Bookbot have books from different languages?

Bookbot primarily specializes in offering books in both English and Indonesian languages. To browse and read our English book selection, download and use the Bookbot English app. Please install and use the Bookbot Indonesian app to access Indonesian language books. These dedicated apps have been developed to ensure an effortless and enjoyable reading experience tailored to your language preferences.

Background for the users: The importance of literacy

**Figure 1. An illustration of brain regions associated with reading.**
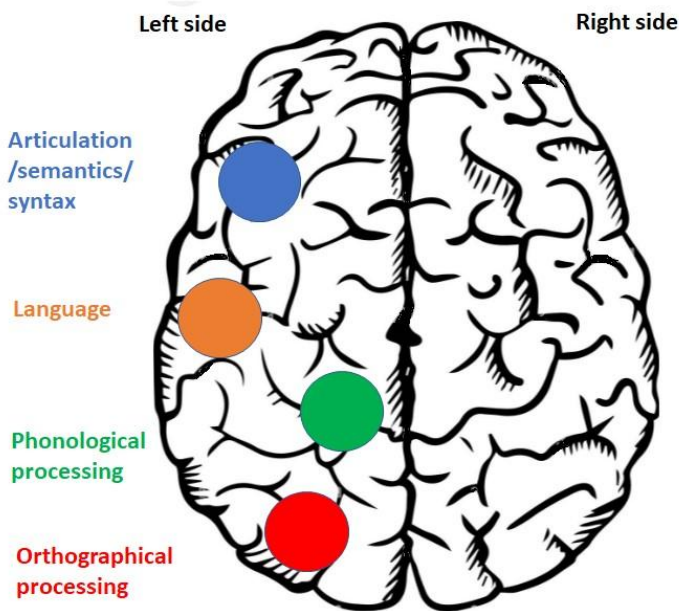
Reading, the translation of abstract shapes to sounds in spoken language, is cognitively demanding, as performing it accurately, is not the only important factor, but also performing it promptly, i.e. automatically. This process is referred to as "fluent reading".

The regions highlighted in Figure.1 enable reading and are also related to the basic abilities reading relies on, which include language (or auditory) processing, visual processing, attention, other executive functions, and articulation (speech).

The precise timing in the engagement of these brain regions and networks is related to intact reading fluency and comprehension.

Chall's reading acquisition model

Figure 2. Chall's reading acquisition model[25], includes the learning to read (blue) and reading to learn (grey) stages.
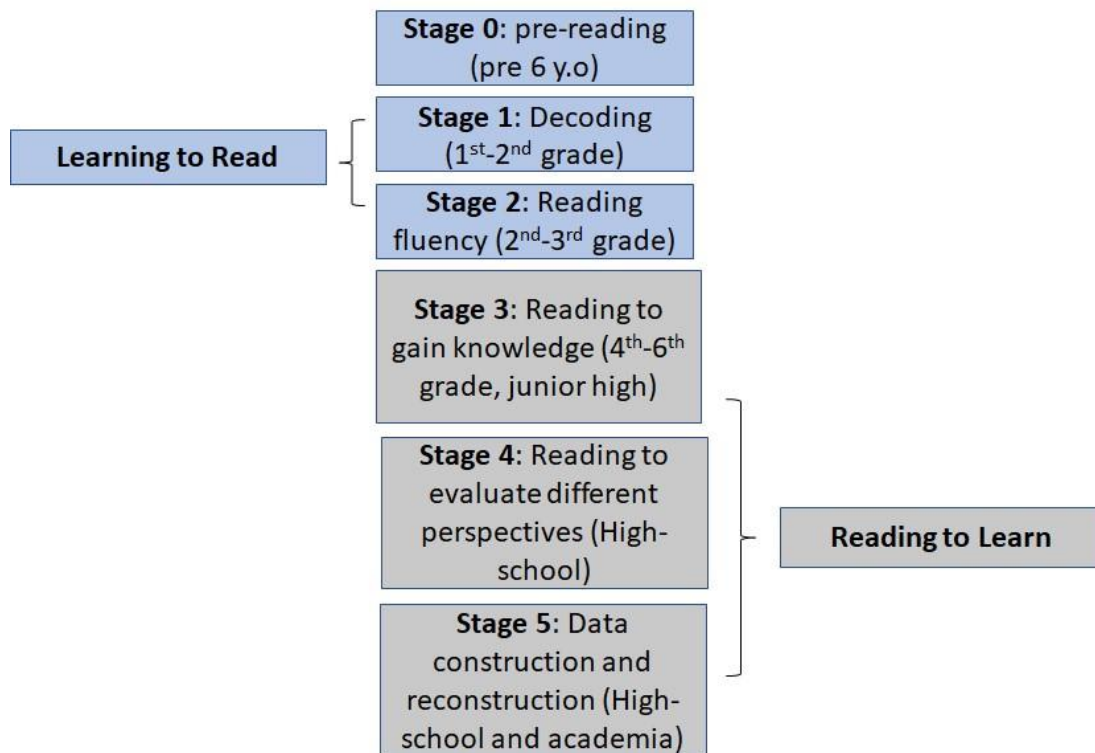
In Chall's model, the researcher breaks the reading process into two parts: 1) learning to read and 2) reading to learn.

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[25] Chall JS. *Stages of reading development.* New York: McGraw-Hill; 1983.

The first part is a step-by-step model where each step leads to the other and cannot be bypassed. The learning-to-reading model results in reading fluency and comprehension.

Once reading fluency and comprehension have been achieved, Chall's model is broken into several critical phases: the first and primary one is to gain new knowledge (4th-6th grade and during junior high). The other two stages (stages 4 and 5) occurring in high school and academia focus on the ability to construct and reconstruct knowledge based on information gained from the text (see Figure 2).

The Simple but not simplistic View of Reading model

Figure 3. The Simple but not simplistic View of Reading model. The colors in the figure match the cognitive/linguistic/sensory processing regions listed in Figure 1.
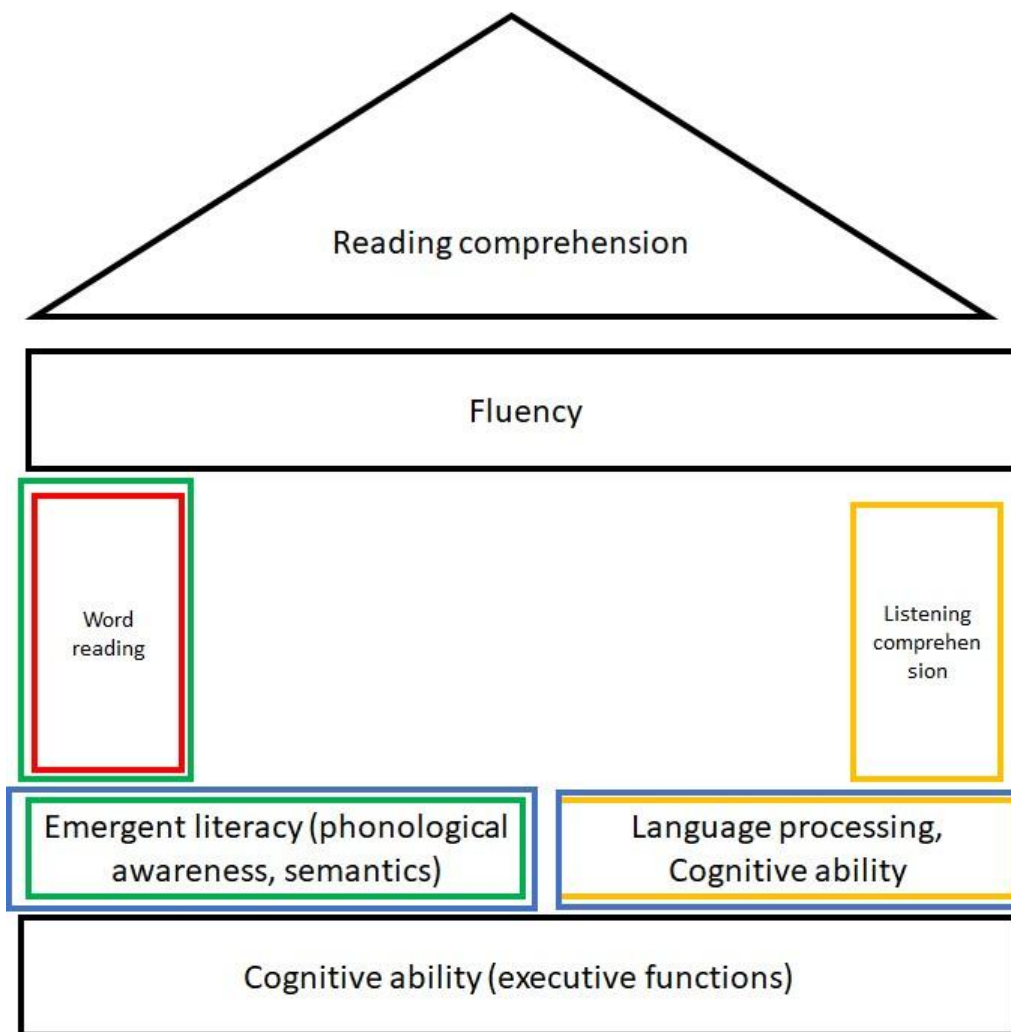

This model positioned reading comprehension as the top outcome of the reading process and added cognitive abilities such as working memory, the ability to inhibit responses, and shifting

as the underlying basis for reading. The model also includes word reading and language/listening comprehension components, however; it suggests the critical role of reading fluency and the ability that relies on these two components and sets the basis for reading comprehension. The colours used in this model correspond to the ones used in Figure 1 and show which parts of the brain are involved.

Components of literacy Bookbot is working on

Figure 4. The components Bookbot aims to train in the context of the expanded Simple View of Reading model (components are marked with asterisks)[26].

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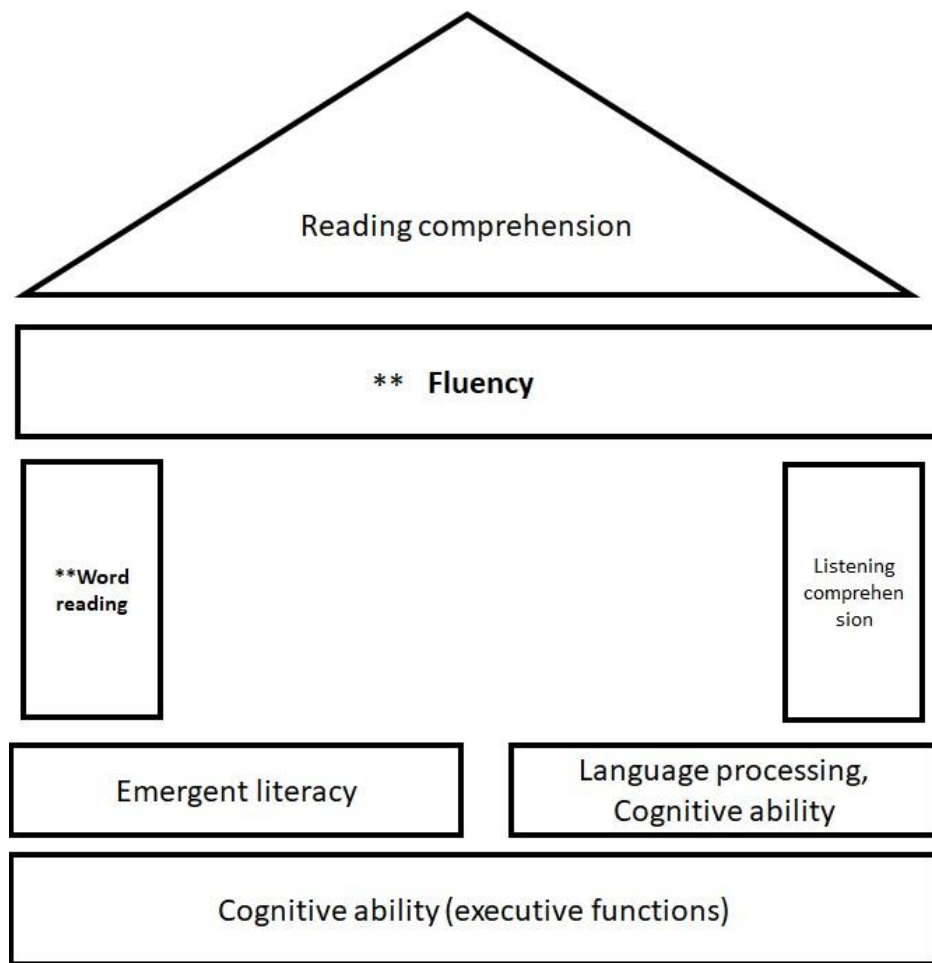
[26] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

Deliverable 5 - Recommendations for the future

Introduction

Bookbot already has a user friendly and engaging app which shows a lot of potential to teach users how to read fluently. In order for Bookbot to grow its impact and its unique value proposition, we recommend that Bookbot strengthens its scientific evidence base. This means every claim Bookbot makes has to be thoroughly tested scientifically so Bookbot's credibility is not undermined. We have prepared some future recommendations with the aim of making Bookbot more attractive to potential investors and funders. Our suggestions are listed in the order that they should be implemented because they build upon one another. If Bookbot wants to become an evidence-based application, the last set of recommendations for expanding the evidence base is essential.

Growing your organizational capability

1. Adding a reading expert to the team as an advisor.
2. Having a data analyst on onboard who can make sense of the approaches suggested.
3. Obtaining some expertise in natural language processing to extract the relevant linguistic features of the books presented and using this information to test some substantial hypotheses about learning to read or for recommendation purposes.

Figure 9: A diagram with recommendations and the needed personnel to help achieve the goals
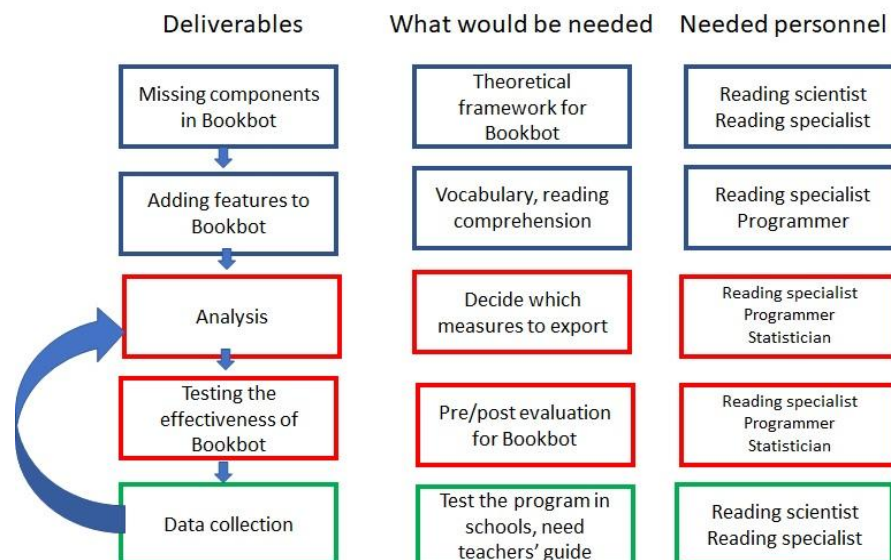
Applying a theoretical perspective

4. Making it a priority to include the theoretical background in Teachers' Guides (as done by Fellows in Deliverable 4) and pitch decks to demonstrate the tight theoretical basis for Bookbot.

5. Sharing this theoretical background (as outlined in Deliverable 2) with the Bookbot team at large (from the technical to the content level personnel), using this video, for example.

6. Reviewing state of the art in reading research, identifying the common operationalisations, and building the system in a way that allows extracting this information. Otherwise, there will always be only very crude measures, making it more convenient to draw valid conclusions.

7. Testing the effect of Bookbot training on the word reading and reading fluency components noted in Figure 7 to validate the effect of training on these components. A diagram outlining this in more detail can be found in Figure 9 below. Note: the user can start with any component separately but we recommend to start with the foundational components of fluency and vocabulary first and then move onto more complex ones such as reading comprehension.

8. Providing reading fluency intervention for children with dyslexia: If Bookbot aims to focus on the dyslexic population, a priority for the product roadmap would be to address phonological processing and ensure that the app provides meaning to the words that children read.
    a. The case of dyslexia: definition and etiology
    b. How can Bookbot be adapted for children with dyslexia?

9. Adding additional criteria for fluency improvements: at the current stage, Bookbot is asking children to repeat words they read incorrectly and breaks the words into syllables for them. Children have to repeat these words and then, Bookbot moves the words from the "incorrect word reading" to the "correct word reading" list. It is recommended that the words read incorrectly will be given in the following book, in a different context. A "successful" fluent reading would be a word that the child failed reading in book 1 but successfully read in book 2 and did it faster (i.e. per the definition for reading fluency).

Running a proper program evaluation

10. Like teachers within a classroom have two types of assessment (formative and summative), there are two types of program evaluation that can be done: The summative assessment is a rigorous and structured process with well defined parameters and control groups. Whereas the formative evaluation is less structured and can be done on a daily basis (e.g. A/B testing with users, user feedback). As a group,

we did not address this in the Sprint, but we would recommend for Bookbot to conduct a full program evaluation in order to get additional insight.[27]

Collecting data and structuring it appropriately

11. Collecting data that can be collected without much additional effort, especially within a book.

12. Adding the following components to Bookbot, so the overarching goal to improve reading comprehension is achieved:

    a. Reading comprehension: add features either within the application or as a supplement provided to teachers to also evaluate and improve the children's reading comprehension.

    b. Language processing component (in the word vocabulary level). See Figure 8 below with these items highlighted as part of the extended Simple view of Reading model suggested by Kim (2020).[28]

13. Reorganizing the data export to allow data extraction from the first to last training sessions and within sessions.

14. Reorganizing the database- All the current data is structured based on technical requirements so Bookbot would benefit from not just collecting different variables but also structuring them so that data analysts and researchers can more easily analyze it.

15. Thinking about ways of distinguishing data appropriate for answering research questions from invalid, test user data that is currently present in the data set. The current data set seems to be a dump of all data that has been collected, including test users and others. One needs to define a procedure that identifies invalid data. Identifying invalid data is achieved by flagging testing cases, defining what counts as a valid user, and setting up a procedure for adequately cleaning the data set before conducting any analyses.

16. This preprocessing step has been included here for demonstrative purposes. Having a similar look at other variables and defining a procedure that identifies invalid cases is recommended. Such a definition should be consistent across all analyses because only such consistency allows for comparing different results with each other.

17. Tagging sentences as sentences and book sheets need to be tagged so progress within and between sessions can be measured.

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[27] The below sources provide some further reading on program evaluations.
https://www.cdc.gov/nccdphp/dch/programs/healthycommunitiesprogram/tools/pdf/eval_planning.pdf
https://bradroseconsulting.com/understanding-different-types-of-program-evaluation/

[28] Kim Y-SG. Simple but not simplistic: The simple view of reading unpacked and expanded. *The Reading League Journal.* 2020;1(2):15-34.

18. Collecting valuable data within one reading session (a book) will open up new possibilities for getting evidence on how children interact with the app, which mistakes they make and others.

19. Collecting more background information about children and the situation in which they are using the app will help to think up and test new hypotheses and obtain new evidence to improve the system even if no randomized controlled trials exist.

20. Extracting reading errors per letter/phoneme along with training, in the best case having time stamped information during a book session.

21. Comparing the effect of Bookbot to another control group:
    a. Comparing it to another intervention (i.e. an active control group)
    b. Having a "waiting list" group of children who are not training on Bookbot but just reading the first story in the series of stories (i.e. book level 1) and then the last book most children read at the end of intervention (i.e. book level "N") and compare the fluency levels of the two groups
    c. Having children train on Bookbot without the "interactive" mode (i.e. without Bookbot correcting the children's reading, for example).

22. Sharing data for research purposes that include identifying information carefully. Although the data here is relatively low-risk data, one wants to avoid seeing the user's email addresses, like those in the hands of a data analyst or published by accident, as this could negatively impact the company's reputation.

Capitalizing on learning analytics

23. Looking at means and variances, correlations between variables, trajectories of single cases. It is always recommended to get an understanding of the raw, individual case data before applying sophisticated statistical models to it.

24. Completing primary first analyses with more data points, control variables, and others are more appropriate models for analyzing the data (as demonstrated outside this document) and obtaining expertise in how to set up and interpret appropriate statistical models. The type of data obtained is undoubtedly helpful for drawing meaningful conclusions about children's reading progress, improving the user experience, optimizing the app's effectiveness, and providing evidence-based proof that using Bookbot can be an effective means to support children in learning to read.

25. The fascinating, aggregated and linguistic data is in a way that does not allow in-depth analysis. Words spelt correctly and to which degree of correctness is also needed to allow substantial analyses within one book and not only overall analyses between books. One could collect rich information from the progress within a book that would allow, for instance, analyses of the types of mistakes made or recommendations on which books to read based on the reading progress within single linguistic domains.

26. Have an evaluation of reading fluency prior to and at the end of the training period.

27. Examining the effect of word frequency/length on reading fluency and comprehension.

Getting strong evidence for the effectiveness

In case the Bookbot team decides that their next goal is to become an evidence-based reading intervention, it is important to take the time to carefully design the data collection, the sample size, the population to be examined and so on. These processes often demand time and should occur prior to data collection, and not afterwards. The following steps are recommended in this case:

28. Setting up a randomized control trial with a proper control condition to get solid evidence if this app achieves its promises.
29. Unlocking different funding opportunities: Once Bookbot is evidence-based, additional opportunities to fund and grow the organization become available from opportunities focusing on collaboration between science and industry such as the Creative Destruction Lab or MIINT

Conclusion- Defining the intrinsic and extrinsic variable

We got the impression that the app's creators had put a lot of effort into making it appealing to children and maximizing their extrinsic motivation to use it. The layout is quite appealing and the gamification features encourage frequent reading. The components that focus on the users' intrinsic motivation, e.g. "Why should I use this application?" are somewhat weak in comparison to this. The reward for an action comes from the action itself, which is known as intrinsic motivation. By giving children the proper level of difficulty for their learning material, one that is neither too easy (and thus uninteresting), nor too difficult (and hence frustrating), we can optimize their drive. The available data can be used to determine the level of difficulty (and ability), but this functionality has not yet been put into place. Giving users a sense of autonomy in their work and encouraging their social connectedness by incorporating non-competitive social components are other factors that promote intrinsic motivation.[29] In order to achieve this intrinsic drive, Bookbot needs measurement and evidence. The Bookbot team needs to be able to measure students reading ability; the difficulty of a book; and Bookbot needs an algorithm to match the two. Once this is achieved, Bookbot will have created an intrinsic motivation tool that is neither boring nor overburdening children and thus, putting Bookbot on the forefront of educational technology that teaches literacy.

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[29] For further reading on intrinsic motivation
https://www.apa.org/members/content/intrinsic-motivation

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Appendix 1

Documented Code