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HIBOU: an eBook to improve Text Comprehension and Reading Fluency for Beginning Readers of French

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Abstract

In this paper, we present HIBOU, an eBook application initially developed for iOS, displaying adapted texts (i.e. simplified), and proposing text comprehension activities. The application has been used in six elementary schools in France to evaluate and train reading fluency and comprehension skills on beginning readers of French. HIBOU displays two versions of French literary and documentary texts from the ALECTOR corpus, the ‘original’, and a simplified version. Text simplifications have been manually performed at the lexical, syntactic, and discursive levels. The child can read in autonomy and has access to different games on word identification. HIBOU is at present being developed to be online in a platform that will be available at elementary schools in France.

Keywords: reading practice, educational device, French L1, text adaptation, text comprehension activities.

1. Introduction

Becoming a fluent reader who easily understands a written text is a major societal issue. Comprehension of a text requires rapid progress from word recognition to the development of a mental representation of the text, based on linguistic analyses and ideas from the text, in connection with knowledge of the world.

1.1 Acquiring reading skills at the early years

Studying the development of children’s general reading skills between the ages of 7 and 9 is of utmost importance because it is a decisive phase for the acquisition of automatic word recognition and text comprehension skills. Indeed, it is during this period that children enter the phase of self-teaching (Share, 1995; Ziegler et al., 2014, 2020) and develop automatic reading and text comprehension strategies (Bianco & Lima, 2017; Willingham, 2006). The virtuous circle of self-teaching is initiated when the child starts to use basic spelling-to-sound correspondences to decode novel words. Successful decoding of words (i.e., finding a match in phonological and semantic memory) reinforces the decoding mechanism, and generates an orthographic representation of the word (see Ziegler et al., 2014, 2020 for a computational account of this process). Over time, thanks to repetition, the decoding process becomes more and more efficient, allowing a more rapid transformation of the orthographic to the phonological form of words, thus reducing the cognitive cost of decoding. The child will be able to progressively free cognitive resources for understanding what he or she reads rather than for decoding (Sprenger-Charolles & Ziegler, 2019). Comprehension requires many resources such as language knowledge, cultural knowledge, and cognitive efficiencies (memory, attention, reasoning, executive functions, visual abilities) (Bianco, 2015).

1.2 Reading difficulties

Although most children learn to read during early elementary school, some of them fail to benefit from regular classroom instruction. Some reasons have been put forward in the literature. Vernon-Feagans and collaborators (2010, p. 183) distinguish two groups of struggling readers: “The first group comes to school with adequate oral language skills but has trouble with the processes involved in the relationship between oral language and the printed word. The second, larger group is characterized by problems in both oral language/vocabulary and print related/phonological knowledge. This latter group is composed mostly of low-income children who come to school without the prerequisite experiences in emergent literacy to allow them to profit from most whole class instructional practices”.

Failing at the early years of reading instruction creates a gap between struggling readers and their peers, a gap that grows over the years. Three-quarters of students who are poor readers in grade 3 will remain poor readers in high school (Foorman et al., 1997).

In this context, the main contribution of our work is the proposition of an application for beginning readers of French, based on reading practice through simplified versions of literary and documentary texts (see section 4 for more details on text simplification). The tool can be easily used by children during classroom instruction or in autonomy at home (it has already been tested in six French schools from 2017 to 2019, see section 3.1 for details).

The paper is organized as follows. Section 2 reports on research studies related to reading difficulties of beginning readers in France. In the following sections, 3 to 5, we present the eBook HIBOU, the corpus, and the learning activities. To conclude, in section 6 we discuss on developments and evolutions of the eBook.

2. Beginning readers in France: an overview

In France, the CEDRE report (2015) that evaluates if the national educational curriculum at primary school has been achieved, shows that 11 % of children at the end of grade 5 fail to understand a text, i.e. they are unable to extract and analyze explicit and even less implicit information¹.

The international program PIRLS (Progress in International Reading Literacy) suggests that 10 out of 60 countries, in which reading comprehension has been tested with fourth-grade children, show alarmingly low average scores (Mullis et al., 2017). The situation seems particularly problematic in France: 6% of the students (4% in Europe) have a standard score below 400, which is taken as an indicator that they do not master elementary reading and comprehension skills (Mullis et al., 2017). Since the first PIRLS evaluation in 2001, the performance in reading comprehension of French students has dropped year after year, especially for complex reading comprehension skills (e.g., inference) and informative texts (e.g., scientific or documentary texts).

In recent national assessments, in which 4 837 students at grade 2 in France were tested on reading fluency and comprehension (Andreu et al., 2021), it was found that 15.3% had problems in comprehending a text when it was read on their own and 26.9% had difficulties reading aloud. This situation highlights the importance of providing early intervention programs and resources.

One of such intervention programs might be developing reading activities with a resource with simplified texts and playful exercises. As showed by Javourey–Drevet and collaborators (2022), reading training through adapted (i.e. simplified) versions of texts improves fluency and comprehension: children find it easier to get to the meaning of a text, which in turn, might encourage exposure to more written texts. Reading simplified texts helps poor readers and children with weaker cognitive skills (nonverbal intelligence, memory). This solution might also be relevant as a motivational and inclusive strategy in a classroom with all kinds of reader profiles: all children read the same text (in terms of contents), but while regular readers have the original text, struggling readers read an adapted version to achieve the same objectives. The eBook that we present in this paper has been developed to address this issue. In addition to a variety of texts in original or simplified versions, the tool provides several lexical games to allow children to enhance their vocabulary skills.

3. HIBOU: eBook for reading and learning

HIBOU aims at training reading comprehension and fluency.

3.1 Genesis of the project

The project was initiated by the Laboratoire de Psychologie Cognitive (UMR 7290) and the Laboratoire Parole et Langage (UMR 7309) in collaboration with a school district in the South of France (Var) and the regional authority (Communauté d'Agglomération Sud Sainte Baume). HIBOU is an electronic book in Apple format (eBook). This kind of solution was suited for a research project on studying the development of children's general

reading skills between the ages of 7 and 9. For several years, we followed the evolution of the reading skills of children in grades 2 to 4.

The research project has now come to an end, but we have decided to make the eBook live beyond the project. We have improved it, we gave it a name, HIBOU, we enriched it with some iconography (see Figure 1) and we made it available for download² (right now only for the Apple ecosystem, but an open-access web platform is currently being developed, cf. section 6.2).

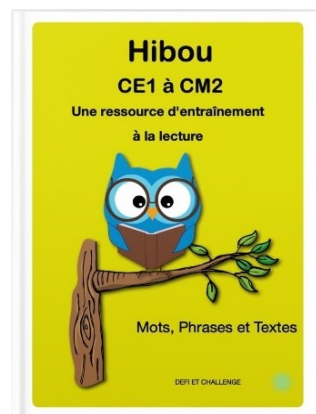


Figure 1: HIBOU Logo.

HIBOU has been developed on iPads to initially assess the effects of text simplification in beginning readers of French all profiles combined: regular readers, low-readers, dyslexic readers, etc. Since the eBook has been well received by the teachers, who could use it at different moments in the classrooms, we would like now to enhance the use of HIBOU through an open access web-platform, and to enrich the eBook with more advanced devices (i.e. adaptive learning to consider individual differences and profiles, see section 6.2).

3.2 Assessing the effects of text simplification for improving reading fluency and comprehension

HIBOU has been used in six primary schools in the south of France for three years (2017-2019) to analyze the effects of text simplification in beginning readers of French (Javourey-Drevet, 2021; Javourey-Drevet et al., 2022). It allowed to collect information on reading times during the three years for about 165 children per year. Each participant in each grade (from 2 to 4) read 20 texts (10 literary and 10 documentary, for each category 5 original versions and 5 simplified versions were available). The choice of an adapted version was randomly proposed. After reading a given text, the participant had to answer to a multiple-choice quiz. Besides the reading and comprehension task, ten tests were used to assess the individual cognitive and language profile, proposed in the same order to each participant.

The results of the reading tests showed that text simplification was beneficial for fluency ($F = 81.327$, $P = .000$, $\eta^2 = .373$) and comprehension ($F = 32.020$, $p = .000$, $\eta^2 = .189$) over the three years for most students and for both types of texts (Javourey-Drevet, 2021). This suggests that simplification can be effective across the elementary

¹ Grade 5 is called 'Cours Moyen' 2 (CM2) in France.

² <https://lpc.univ-amu.fr/fr/hibou-livre-interactif>

school curriculum. Text simplification does not directly affect text comprehension but rather impacts factors that influence comprehension, such as word recognition, vocabulary, inferences or morphosyntax.

The results of the reading tests for children of grade 2 showed that simplified texts were read faster than original texts ($b=-0.03$, $SD=0.009$, $t=-3.5$), and that scientific texts ($b=0.02$, $SD=0.008$, $t=2.73$) on reaction times were read slower than literary texts. The type of text did not reach significance ($t=1.16$). We also obtained a significant effect of simplification showing that comprehension was better for simplified texts than for original versions ($b=0.55$, $SD=0.09$, $z=6.23$). The gains in simplification (difference between simplified and original texts) were greater for poor readers than for good readers. For comprehension in scientific documentaries, simplification gains were stronger for children with poor non-verbal intelligence and low working memory (Javourey-Drevet et al., 2022).

4. Corpus and reading settings

The texts available in HIBOU are part of the ALECTOR corpus, a collection of 79 original texts in French with their simplified versions (Gala, 2020a). The corpus is already available online³ through a platform that proposes different options for visualizing the texts. It also provides the comprehension questions for each text in the form of multiple-choice questions. Most of the texts from ALECTOR (69) have been integrated in HIBOU. On average, the original versions have about 300 words and the adapted versions 275 (both versions are longer in higher levels, going from grade 2 to grade 4). We focused on grades 2 to 4 because the reading programs and activities are part of the curriculum (we left aside grade 1 where children acquire basic decoding skills).

The corpus presents two kind of texts, narrative (literary) and scientific (documentary). While literary texts often reflect the world view and the sensitivity of its author with a language that emphasizes the aesthetics, the rhythm, etc., documentary texts aim at explaining or describing a scientific or technological causality. Scientific texts are descriptive and explanatory with a logical structure based on scientific reasoning. The texts are extracts taken from websites with stories⁴ or documentaries⁵, selected pieces of magazines (BTJ⁶, WAPITI⁷ for example), and excerpts of books for children (*Chichois de la rue des Mauvestis*, Ciravégna, 1995, to give an example)⁸. The choice of these genres was motivated by our initial project, keeping in mind that the type of text influences comprehension: narrative texts are more easily understood than informative texts whose topics depend on specific world knowledge (Best et al., 2008; McNamara et al., 2017), see section 4.1.

4.1 Text simplification

Simplifying a text renders word recognition and decoding more efficient for poor readers and children with weaker cognitive abilities, which has direct effects in reading fluency and text comprehension (Javourey-Drevet et al., 2022). Decoding, i.e. linking graphemes and phonemes,

must be automated to read words so that he or she can extract the meaning of a sentence and construct an interpretation. Recognizing a written word does not automatically mean comprehending the meaning (Ziegler, Perry & Zorzi, 2014). Comprehension is practiced for both oral and written language. The Simple View of Reading (SVR) model (Gough & Tunmer, 1986) describes reading comprehension as the product of word recognition and oral comprehension. Word identification constrains comprehension, but it is also the cognitive component of the comprehension process that determines the successful development of a mental representation from the text.

Language processing requires complex operations in which memory and different processes of control and manipulation of the information are involved. In this context, text simplification can be a temporary aid for pupils with reading difficulties to continue decoding, reading, and enhancing text comprehension. The idea is to reduce the complexity of a text while preserving its original content (Saggion, 2017). By doing this, the text may be more easily read and understood.

Text simplifications in the ALECTOR corpus were manually carried out by a group of researchers in educational sciences, cognitive psychology, linguistics, and speech therapy. It was decided to keep the simplified text as close as possible to the original version to improve readability and understandability while maintaining the original information content. As the corpus was created having in mind the development of a first automatic text simplification system for French (Todirascu et al., 2022), we considered only linguistic transformations that could be later implemented. For instance, we gave priority to lexical substitutions and coreference chains substitutions (providing the referent to a pronoun), and straightforward reformulations (e.g. deletion of subordinate conjunctions to split a long sentence into two, see Gala et al. 2020b). We deliberately avoided reformulations that would have changed the original texts rather drastically (i.e. summarization).

Within the field of Natural Language Processing (NLP), automatic text simplification (ATS) has been explored from different angles since the late 90s, and especially very recently with the rapid growth of statistical and deep learning techniques. However, although being an active research area (see Al-Thanyyan and Azmi (2021) for a complete survey), when we started the project there was not yet a sufficiently satisfactory state-of-the-art tool for automatically simplifying texts in French. Therefore, manual simplifications, although very time-consuming, were the only option to provide adapted reading materials for struggling readers in elementary schools.

The adaptations were made at four linguistic levels: vocabulary and morphology (lexical adaptations), sentence structures (syntactic adaptations) and pronouns (discourse adaptations). Lexical adaptations, i.e. substitutions of words with simpler synonyms (shorter, more frequent, simpler syllable structure, etc.) were performed based on two standard lexical resources for French: Manulex (Lété

³ <https://corpusalector.huma-num.fr/>

⁴ <https://www.storyplayr.com/blog/le-conte-africain>

⁵ <https://kidiscience.cafe-sciences.org/articles/comment-les-huitres-fabriquent-elles-des-perles/>

⁶ <https://www.icem-vente-en-ligne.org/btj>

⁷ <https://www.wapiti-magazine.com/magazine>

⁸ <https://www.babelio.com/livres/Ciravegna-Chichois-de-la-rue-des-Mauvestis/459091>

et al., 2004) and ReSyf⁹ (Billami et al., 2018). Syntactic and discursive simplifications followed a set of guidelines that we defined to address the specificities of poor and dyslexic children's needs (Gala et al., 2020b; Wilkens & Todirascu, 2020). The guidelines include a total of 29 recommendations: six for typography (e.g., police size, interlinear and character spacing, etc.), five for lexical substitutions (thus characterizing simpler synonym candidates), five for morphology (e.g. frequencies in morphological families, verb-tenses, etc.), nine for syntax (e.g. keeping the SVO order when possible, split complex sentences, avoid negation, etc.), and five for discourse related difficulties (e.g., pronoun substitution with a referent, replacement of certain determinants, etc.). The guidelines are free available on-line in the web-site of the ALECTOR project¹⁰.

The simplification effort was different according to the type of text. The specific vocabulary of documentary texts, often unknown to young readers, was difficult to adapt because of its specialization (Marin et al., 2007). In these cases, we preferred to keep the original word (e.g., although being words with a complex structure -graphemes, complex syllables, etc.- we kept “atmosphere” and “scaphandre”, respectively ‘*atmosphere*’ and ‘*diving suit*’, instead of trying to provide semantic equivalents). In literary texts, vocabulary adaptations were easier to perform thanks to synonymy (e.g. “mousquetaire” replaced by “soldat”, ‘*musketeer*’ by ‘*soldier*’). We choose the closest semantic synonym, knowing that full synonymy is rare, and unstable where it does exist (Murphy, 2003, p. 165).

4.2 Reading settings in the eBook

HIBOU displays ten different pages. The first one contains a web application integrated into the book, the other pages display pedagogical information and the first sentences of the texts to be read. The heart of HIBOU is the web application.

The reader can choose a text depending on his/her level at primary school (beginner = grade 2, intermediate = grade 3, advanced = grades 4 and 5). The complexity of the texts increases according to the level (longer texts, more complex structures, and more specialized vocabulary). There is currently an average of 20 texts per level.

The texts are presented sentence by sentence (it has been shown that presenting texts line by line on electronic devices can improve reading speed and comprehension for struggling readers (Schneps et al., 2013)). The reader can also set up between-character and between-line spacing (Zorzi et al., 2012). The spacing of letters and words allows learners to be less influenced by the presence of neighboring letters and words when reading a word (i.e., crowding).

After choosing the level of a text, from “Beginner” to “Advanced”, the child (or the teacher) chooses among the category “Défi” for texts in the simplified version or “Challenge” for texts in the original version. On the page displaying the texts, an icon corresponds to the theme of the text (see Figure 2). A different color indicates the type of text: green frame for literary texts and red for documentaries.

The application was designed to allow researchers to collect reading times from the readers. By using these data, it was possible to implement an alert message (“*you read too fast!*”, see Figure 3) when the reading time was below the minimum threshold according to the number of words in the sentence.

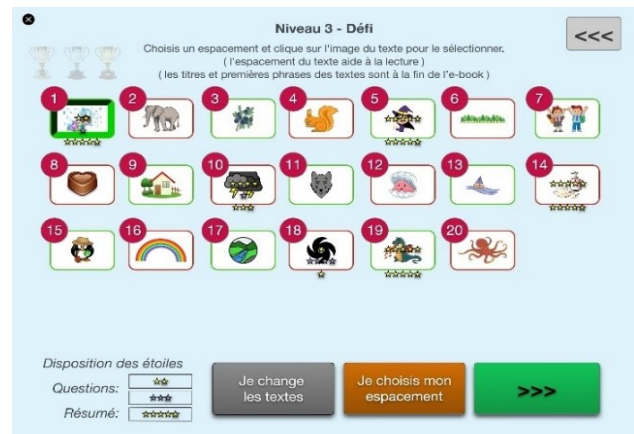


Figure 2: HIBOU interface for choosing the texts.



Figure 3: HIBOU interface for reading sentence after sentence, and error message.

5. Learning activities

In addition to the reading activities, using HIBOU the child can improve his/her comprehension of the texts and work on his/her vocabulary through different word-games.

5.1 Multiple choice questions

After reading a text, a **multiple-choice questionnaire** is presented: five questions are asked to the child and for each of them three or four possible answers are proposed. The five questions are based on essential elements or events that are present within the whole text. They are displayed following the chronological order in which they appear in the text. The questions allow the child to consider the overall understanding of the text, sometimes by doing inferences. The proposed answers to each question are all plausible and related to the subject of the text.

For levels 2 and 3, a **gap-fill summary** is also provided (see Figure 4). Five words must be put in the right place in the text. For each text, we proposed the same grammatical category for statements, e.g. only nouns or only verbs. We also balanced the different grammatical categories between literary and scientific texts.

⁹ <https://cental.uclouvain.be/resyf/>

¹⁰ https://alectorsite.files.wordpress.com/2020/11/guidelines-linguistiques_alector_final.pdf

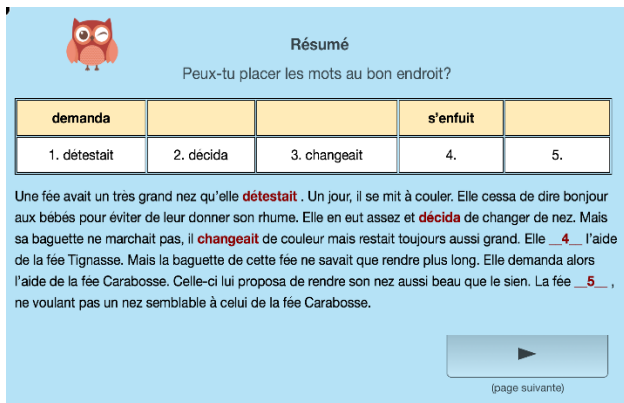


Figure 4: HIBOU interface for gap-fill summary.

The comprehension activity has been imagined as a game enabling to get awards. Correct answers to the quiz and the gap-fill summary give the child gold or silver stars which are displayed on the text selection page. Golden stars are proposed for correct answers; silver stars for inaccurate answers (one or more elements are present in the text). If the answer is totally incorrect, no reward is offered. For the gap-fill summary activity, each word or group of words correctly positioned provides a gold star (see Figure 5).

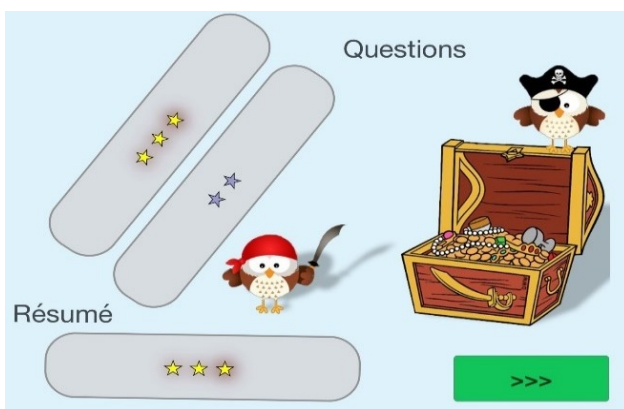


Figure 5: HIBOU interface for individual rewards after reading a text.



Figure 6: HIBOU interface for overall rewards.

Children can read a text several times before doing the questionnaire. They can also redo the assessment if they are not satisfied with their performance, but only after rereading the text.

Finally, a page allows the child to quickly see the number of texts already read, the score obtained in the questions and summaries (see Figure 6). The number of activities allows the child to win a cup: bronze trophy for 5 texts read, silver trophy for 10 texts read and gold trophy for 15 texts read.

5.2 Word identification

HIBOU proposes three word-games, two on spelling recognition and one focused on syntax and semantics. The games are based on a choice task between two alternatives, which is called lexical decision. The player chooses whether the word or sequence of words, presented in the center of the screen, is correct or not. A sound feedback allows the child to know whether his or her answer is right or wrong, so that he or she only memorizes a correct spelling.

The first word game, *Mots Rigolos* (Funny Words), is intended for readers of all levels. It is based on words from textbooks. The nonwords are constructed so that they do not look like words, for example "pamelut", "mias", "placiter", "nediter", etc.

The second word game, *Pièges piégeux* (Trapping Traps), is intended for good readers. The traps are constructed mainly by changing the spelling of words, for example "exemple", "brôle" ("drôle" *funny*), "ensemfle" ("ensemble" *together*), "doucemen" ("doucement" *slowly*).

The third word game, *Mots Mêlés* (Mixed Words), is a game on sentences or phrases. Here, the trap sequences are utterances where the words have been scrambled (the SVO or syntagmatic order is not maintained). These utterances do not make sense and are not grammatically or syntactically correct, for instance "inquiets se très montrent" for "se montrent très inquiets" (*they are very worried*), "dresse sur il se" for "il se dresse sur" (*he stands upright*), "pas ne copie on" for "on ne copie pas" (*do not copy*), "bateau de son l'arrière" for "l'arrière de son bateau" (*the back of his boat*). The child must reorder the sequence. The players earn coins if they answer quickly and correctly. An overall score is also given at the end of each game, along with a reading speed in words per minute. The score can be improved by playing several times.

6. Implementation and future work

6.1 From iPads to an online application

As previously mentioned, the heart of the eBook is the interactive embedded web application: the reading application is programmed in HTML5 with some API such as Canvas and Web Storage, user interface and interactions are managed by Javascript routines and content of texts, questions and answers are stored in JSON format. HIBOU application can run on all versions of the iPad family, although sounds do not play correctly on iPad2 and earlier versions.

Originally developed as an eBook (Apple standard), the technical specifications of the iPad application make it suitable to be transferred to similar environments such as computers and tablets displaying a standard e-book (EPUB3 international standard). Such a development has recently been carried out by an industrial partner of the original HIBOU project (ISI Inc., France) that publishes electronic books for schools. The new e-book will be

available by the end of 2022 with a tier policy that will make the access to the content free of charge for pupils.

6.2 Future work

Right now HIBOU has been used in six French schools and all the readers performances in the period 2017-2019 have been logged. There is currently work in progress on the analysis on the performances on the different kind of texts (literary vs documentary, original vs simplified) on the tested school levels (2-4).

In future work, we plan to enrich the corpus with more literary and documentary texts, along with their comprehension tasks, particularly for grade 5. As a result, the platform will provide texts addressed to children of all primary levels (grade 2 to 5). While in the long run, part of the simplifications will become semi-automatized by using a text simplification system for French (work in progress), in the short-term, we will train a group of teachers on text simplification to be able to increase the corpus and the associated learning activities.

Finally, we are planning the possibility to include adaptive learning devices thanks to IA, to propose specific texts and vocabulary activities adapted to each individual profile. By collecting individual feedback on how the child browses the texts and activities, the platform will be able to guide the learners by proposing them adapted materials. By doing so, HIBOU will enable weaker readers to progress at their rhythm while reading the same texts than normal readers. It will be able to propose new adapted tasks for training, thus encouraging them to read more.

7. Conclusion

Adapting texts to the needs of struggling readers might be a solution to enhance reading practices and to boost reading comprehension. In this paper, we have proposed HIBOU, and eBook enabling to read and play with words to enhance reading practices and vocabulary skills. While it has been initially developed in the Apple ecosystem, we are now preparing an open access platform that will be freely available to teachers and learners of French.

In future work, we plan to enrich HIBOU with more texts by recruiting and training teachers on text simplification. We are also interested in applying recent advances in automatic text simplification in French to assist the teachers in the work of adapting the texts. Finally, we are foreseeing the possibility to include adaptive learning devices thanks to AI, to propose specific texts and vocabulary activities adapted to each individual profile.

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