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Developing Technology-Enhanced Literacy Learning for LESLLA Learners

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Abstract

Among the reasons why LESLLA learners are less successful than children who learn to read and write in their mother tongue are fewer instructional hours and the lack of individualized instruction. The Digital Literacy Instructor is a European Union–funded Multilateral Lifelong Learning project that is developing software in Dutch, English, Finnish, and German for beginners to learn the grapheme–phoneme correspondences in these four languages. The aim of this software is to give these learners more intensive and extensive practice through clearer, more systematic, and more consistent feedback. What is most innovative is the use of automatic speech recognition (ASR) for providing feedback on words read aloud by the learner while taking into account the specific language background of the learner.

This article also describes the pedagogical ideas that form the basis of the materials and how these ideas are realized in the software. The stepwise work plan of the project is sketched, and the first results are shown in the form of seven exercise types. The software presents 300 words with accompanying audio and photographs along with ASR-based feedback in one and the same exercise type. All stages in literacy learning (direct word recognition, visual and auditory analysis and synthesis) can be practiced with the 300 words.

The Problem

It is generally known that most non-literate adult second-language (L2) learners have difficulty becoming independent readers. In the Netherlands, for instance, the proficiency level that is required for the so-called integration exam and which indicates the start of independent reading—level A2 of the Common European Framework of Reference for Languages—is attained by few students and, even then, after many hundreds of hours of instruction (Kurvers & Stockmann, 2009).

One of the main reasons why LESLLA learners are not as successful as children who learn to read and write in their mother tongue may be that they receive fewer hours of reading instruction; hundreds of hours for these students is less than the thousands of hours that even children in economically developed countries receive. Often, it is also the case that the course material is of a lower quality in the sense that it is not geared to the specific situation of the adult non-literate or low-literate L2 learner. Moreover, materials rarely enable individualization of instruction, which is important in the typical multi-level LESLLA class (see Kurvers & Stockmann, 2009). Adults who learn to read for the first time in their lives in an L2 with a phonological system different from that of their native language and whose social exclusion results in minimal vocabulary need considerable time and patience to build up their vocabularies and to become familiar not only with new sounds or sounds that are slightly different (similar to literate L2 learners), but also with the metalinguistic awareness of linguistic units that is required for reading in an alphabetic script that includes words, graphemes, and phonemes (see, e.g., Kurvers, van Hout, & Vallen, 2007). This is because they do not have native language reading skills to transfer. Moreover, such learners present different learning trajectories and vary in the pace at which they proceed in their acquisition process (Dalderop, 2011). If the classroom is a teacher-fronted one, then learners may listen to sounds in the L2 several times during a lesson. Even under the most favorable conditions, they may pronounce those sounds only once or twice and receive teacher feedback. Then, the learners are expected to practice

the correspondence between grapheme and phoneme on their own, without the feedback of the teacher or another native speaker. This leads to an L2 phoneme's native-language-based pronunciation becoming entrenched and thereby hindering the learning of grapheme–phoneme correspondences that learners who have native language literacy skills to transfer accomplish without great effort. Although there are learning tools (DVDs, for instance) with words and individual sounds pronounced for L2 learners available to LESLLA learners, the project discussed below has created materials for augmenting practice through more *intensive* practice (always with feedback) and more *extensive* practice (for a longer time and more often). The Digital Literacy Instructor project is designed to increase practice time and the speed of learning basic grapheme–phoneme correspondences of 300 words in the four project languages: Dutch, English, Finnish, and German.

A Solution

Feedback that is systematic, consistent, intensive, clear, and at the learner's current level increases the quantity and also the quality of practice time, since learners can move at their own pace. Such feedback can realistically only be provided by an "artificial instructor" who is virtually present inside and outside the classroom at any moment when the learner wants to practice. In the project described below, this takes the form of a Computer Assisted Language Learning (CALL) application. CALL offers potentially enormous advantages compared to teacher-fronted classes: learners can practice as much as they want at their own pace in any environment they wish, all the while receiving individualized, adaptive feedback from the computer. This is particularly important for adult L2 learners who lack the basic literacy skills to be able to work on many existing materials outside the classroom, without the support of a teacher. Learning that can and should be individualized releases the teacher so that he or she can do what only a teacher can do: for example, involve learners in interaction with other learners.

In the project described here, feedback techniques are enhanced: well-known ways of providing feedback in the classroom are individualized, digitalized, and extended with ASR feedback, which automatically detects errors when learners read aloud. Below, we describe the organization of the project, the steps that have been completed thus far, the steps the project will take on this work in progress, and the pedagogical ideas underlying the software. Next, we present various types of feedback and explain why we have chosen explicit and immediate forms of feedback for this group of learners. Finally, we show how the feedback is integrated into the system's seven exercise types, and we close with an example of how corrective feedback at the word level is presented to the learner.

The Digital Literacy Instructor Project (http://diglin.eu)

The European Union's Grundtvig-funded Lifelong Learning Multilateral Project Digital Literacy Instructor (DigLin) aims to provide concrete solutions for adult literacy students by developing L2 literacy learning materials in Finnish, Dutch, German, and English (listed here in order of transparency of their orthography). The five project partners in four countries are departments at universities and an institution for vocational education (Friesland College). All have contacts or collaborate with teachers and education centers where adult L2 literacy students take courses. The five collaborating partners are the Netherlands: Radboud University, Nijmegen (lead and automatic speech recognition); Friesland College (software creation); Germany: Herder Institute, University of Vienna; United Kingdom: Newcastle University; and Finland: University of Jyväskylä.

The DigLin project combines the system of existing reading instruction materials for non-literate and low-literate L2 learners developed at Friesland College (FC-Sprint[2]) with ASR. The former provides the software for the exercises; the latter is used to recognize what the learners say as they read aloud, to diagnose errors, and to extend practice and feedback.

Steps involved in creating the DigLin software. Creating literacy software for four languages with different orthographies and pedagogical approaches to literacy instruction over the course of only four face-to-face meetings and fortnightly Skype meetings is a complicated and challenging task. Elaborate discussions preceded the final selection of the content, i.e., which words, sounds, and photos to accompany words; the level of support for learners; etc. Here, we outline the steps we have taken and will take to create seven exercise sets. In chronological order, the steps are as follows:

11. Gather facts about each language's phonology, orthography, and approaches to teaching reading to (children and) LESLLA learners.

The irregularity of English orthography has been and still is the cause of much debate on how children and adults should be taught to read. Teachers in the United Kingdom are currently directed to use a synthetic phonics approach alongside sight word reading. In the other three countries (whose orthographies are more transparent), reading instruction for children and LESLLA learners initially focuses solely on cracking the alphabetic code simply by analysing of the word in phonemes and graphemes and by blending these into a word. It turned out to be difficult to make the much more opaque English orthography fit the model used for the exercises.

12. Agree on selection criteria for words for the software.

In a pure phonics approach, the choice of basic words is primarily determined by those words' usefulness to literacy instruction. Relevance of words for adult immigrants and frequency of words selected are of

secondary importance. For this project, words were selected according to their degree of simplicity. For the most basic words, the choice was twofold:

- monosyllabic CV or CVC words
- words with phonemes that are affected as little as possible by neighboring sounds and which therefore contribute to the categorization of a specific phoneme in the L2

As we were dealing with L2 learners unfamiliar with the phonemic inventory and allophonic rules of the L2 and for whom all the graphemes were new and (almost) equally difficult, it seemed better to start with phonological simplicity, that is:

- typologically frequent (i.e., unmarked) phonemes
- graphemes representing less allophonic variation
- regular orthography

There were also technical requirements for the selection of words depending on the possibilities of the software. Therefore, we had to do the following:

- select words that could be supported by photos (not drawings, because these are less well understood by non-literates)
- restrict the number of new elements (graphemes or allophones) within one set of 20 words to be used for a series of seven exercises in each exercise set

13. Create a "sound bar" for each language for use with exercises in each set.

The sound bar is a tool for the learner to use as support in most of the seven exercises. In the sound bar, the user can see and listen to all of the single graphemes, digraphs, and trigraphs that are used in the software. For Finnish, Dutch, and German, these are almost all the letters of the alphabet; this is not the case for English, as we can see

when we compare the sound bar for Finnish and (British/Received Pronunciation) English in Figure 1.

Figure 1: The sound bar for Finnish (above) and English (below). The pale graphemes (*c, q, w, x,* and *z*) for Finnish are not used in the exercises. The grey buttons in the English sound bar indicate that we are dealing with more than one correspondence for that grapheme. When the learner clicks on the square, the basic (most common/regular) phoneme can be heard; when clicking on the grey button, the less common/regular allograph can be heard.

14. Use the Learning Company (Leerbedrijf) of Friesland College's FC-Sprint² technology to create 15 exercise sets for each language.

Five different types of exercises, adapted from FC-Sprint², are implemented in the course material for each of the four languages. In each of these, subskills of the reading process are practiced, as shown in Table 1. The series is supplemented by exercises 6 and 7, in which reading aloud can be practiced. (This requires integration of ASR technology, which the project is only now developing.)

Number and name of the exercise	Focus
1. Presentation	The meaning and form of a word
2. From letters to words	Making grapheme-phoneme correspondences (analysis)
3. Dragging words 1	Recognizing whole words
4. Dragging words 2	Recognizing strings of phonemes (synthesis/blending)
5. Dictation	Automatizing grapheme-phoneme correspondences
6. Reading with help	Reading with sound bar
7. Reading: Test yourself	Reading without help

Table 1: Overview of the Exercises and Their Focus in DigLin

15. Collect data from nonnative speakers of these four languages for training and testing the ASR engine and the error-detection algorithms.

Developing the ASR technology required for the oral production exercises is not an easy task, given the relatively low language proficiency and variation in native language background of the target group and the difficulties these imply for ASR and error detection (Van Doremalen, Cucchiarini, & Strik, 2010). For this reason, the project team collected speech data and corresponding orthographic annotations at the various locations. These data are being used to train and test the ASR engine and the error-detection algorithms. Speakers use the native languages of the major groups of literacy learners in the four countries, i.e., Arabic (Moroccan and other dialects), Tarifit Berber, Somali, Kurdish, and Bengali (Sylheti dialect).

16. Test the software with LESLLA learners in classrooms for 50 hours as they work with the software.

All technical components will be tested in isolation and then improved. As soon as the new CALL/ASR course material is ready, the teachers of the experimental literacy classes will familiarize themselves with relevant digital pedagogy and the newly developed software. At one-day workshops at each project site, they will be instructed on how to use the DigLin course materials. Then, their students will start working with the materials.

17. Evaluate results and reactions of the students to the software after 10, 25, and 50 hours of working with the software. Teachers will be interviewed at the end of the testing period.

The evaluation is twofold: pedagogical and technical. Both dimensions are integrated into interview questions regarding students:

- How do learners use the DigLin materials?
- How does DigLin contribute to achieving learner goals and increasing motivation?

and regarding teachers:

- Which components of the material do L2 literacy teachers rate as more or less conducive to learning how to read?
- Which suggestions do they have for improving the materials?

Digital questionnaires and an interview manual are currently being developed for these purposes. To evaluate technical aspects, the interactions between the system and learners' responses will be logged. The accuracy of the system in recognizing learners' responses and identifying the errors made in reading will be measured.

18. Disseminate results and expand DigLin.

Dissemination is not the final step, but it has already started, by means of a website that presents gradually increasing information about the project, through presentations at national and international conferences, and by way of academic publications in conference proceedings and journals.

At the time of writing (1.5 years into the three-year project), we are working on steps 4 and 5. The field testing is planned to take place halfway through the second year.

The FC-Sprint² Concept

Since the DigLin system makes use of the learner system of FC-Sprint² materials, we include here an introduction to the basic pedagogical ideas underlying FC-Sprint². The name comes from Friesland College, a school for advanced vocational education in the Netherlands, where this pedagogical concept has been implemented. This name suggests the speed and motivation that the idea promotes.

The concept of FC-Sprint² rests on two cornerstone ideas.

1. **An approach to learners by teachers under which control moves from the teacher to the learners.** FC-Sprint² starts with high expectations. Learners are not told what they should do. Instead, they are asked what they can show the teacher, who then conveys to them the idea that they will impress the teacher. Then, the learners are asked to present to their classmates what they have learned. This requires learners to work with the resources the teacher has made available, which range from books to audio recordings; classmates can also be resources. The teacher is the last resort. That is, if the required knowledge is really not available from any of these resources, then the teacher acts as a resource. This is a radical departure from many LESLLA classes, in which the learners are heavily dependent on the teacher.
2. **Providing students with resources so that they can become more autonomous learners.** Students require the right resources, a large part of which are being built by advanced students and teachers at Friesland College who are part of the Application Development and Media Design tracks. Together, they build small programs so that other students—in this case, adult L2 literacy learners from the education department where literacy for first-time L2 Dutch readers is being taught—can autonomously find the information needed for discovering how reading works, instead of relying on the teacher.

Under the FC-Sprint² approach, learners are not directed to specific materials (resources) that they should use at a particular moment in the learning process. Rather, all the material is provided at once. Learners are then guided (by the teacher, but also by the program itself) to first discover which resources they can use to reach a target set. Learners are expected to negotiate these teacher-set targets and come up with what they themselves want to learn. The teacher is thus the guardian of the learner's education. If a learner comes up with a target independently, then the teacher has to decide whether it is an appropriate target. If so, the teacher then defines the target based on the learner's input. This involves high expectations. Learning materials are built in such a way

that there is a top layer (e.g., the exercise shown on the computer screen) with information underneath, which a learner can access if needed. The idea behind using the former is that the learner is in charge and is not led by the computer. However, there is immediate feedback so that a learner does not repeat errors only to find out at the end (with a "check the answers" button) that errors were made. Such a "check the answers" button at the end of an exercise constitutes a summative test (e.g., exercise type 7) and are not an effective learning exercise.

At first sight, this seems contradictory to the need for systematic and sequential instruction, a main characteristic of the phonics approach. Although the digital material has been organized very systematically, it allows the learner to follow more than one system. There is a carefully designed sequence of increasing difficulty in the selection of phonemes and graphemes (see step 2) and in the exercises within a set of words (see Table 1). The learner has to discover that order independently and determine if using it makes sense for the given circumstance. When it comes to digital resources, these are structured so that a learner can dig deeper to find more information. For example, when a learner needs to know how a word sounds, he or she can click on a button to hear it.

Feedback

Research indicates the overall effectiveness of corrective feedback (CF) (e.g., Lyster, Saito, & Sato, 2013). A study relevant to users of the DigLin materials, one that compares feedback to learners in language laboratory settings with those in the classroom, indicates that "in the classroom context, there is more distraction, and feedback is often not directed toward individual learners" (Li, 2010, p. 345). Moreover, L2 learners express a preference for receiving CF over having their errors ignored (Plonsky & Mills, 2006). Studies also show that explicit CF on pronunciation is important for improvement (Saito & Lyster, 2012). Because acquisition of phonology is closely linked to LESLLA learners' ability to make accurate grapheme–phoneme correspondences, as noted

above, CF can play an important role. Here, we argue that explicit CF will be more effective than implicit CF techniques; this is because learning to read in an alphabetic script involves conscious awareness of phonemes as linguistic objects.

Adults learning to read and write for the first time in their lives are often entirely dependent on the feedback of their teachers in the classroom, and more so than literate learners. Their lack of transferable native language literacy skills greatly restricts options for independent work, as these are invariably tied to literacy. In a classroom, however, continuous explicit feedback for one and the same learner—although useful—is neither practical nor effective. When the learner experiences negative attention in front of classmates, CF typically results in anxious learners who may decline to participate. Explicit, negative CF does not create the safe environment fundamental to learning for LESLLA learners (see, e.g., Santos & Shandor, 2012). Practitioners and researchers have experimented with materials to create a safe environment while providing opportunities for systematic, consistent, intensive, and clear feedback when learners need it. Paralinguistic signals, both explicit and immediate, contribute to this safe environment and serve to show the learners what they answered correctly and incorrectly. In this way the learners are nonverbally encouraged to find the correct answer. This is replicated in many ways in the FC-Sprint[2] and the DigLin materials.

Types of feedback techniques. In order to operate autonomously, the DigLin learner needs ample opportunities for getting feedback. All feedback techniques provided in DigLin are forms of immediate feedback (except exercise 7, "Test Yourself"). In Ranta and Lyster's (2007) CF taxonomy, this falls under explicit feedback with a paralinguistic signal. In the DigLin exercises, this is a disappointed sound, or an item that refuses to stay in the blank into which it has been dragged. The learner can make repeated attempts, and the system responds each time rather than at the end. This prevents the possibility of the learner's automatizing his or her errors.

CF (when the answer is incorrect) takes a friendly form, as shown in the screenshots in Figures 2–6. Positive feedback is signaled after the learner's successful dragging action by the appearance of a green √, a green button, or an encouraging sound.

The feedback techniques in FC-Sprint[2] can be divided into two main types:

Feedback created by the system. When there is a certain action, for instance when the learner drags, reads, or types a word or grapheme, the system reacts with immediate feedback (correct or incorrect).

Feedback created by the learner independently by clicking on buttons, hovering over buttons, comparing sounds, listening to sounds and words, and looking at photos (necessary to understand why an answer is incorrect). This type of feedback can be compared to the use of a dictionary by literate learners.

Exercises

The exercises are constructed in such way that non-literates are challenged to do something: to touch (with a mouse) colored buttons, to listen and look, and to do so time and again. The DigLin course materials consist of 15 sets of 20 words for each language. In these exercises, clicking a mouse on the leftmost green button activates the audio for that word, and the next, smaller button activates a photo of the word. For Finnish, German, and Dutch, the basic orthography for each language is involved in this selection; for English, more sets of 20 words would be needed to cover all grapheme–phoneme correspondences. Although learners can start with any set of words they choose, the exercises within a set are presented in a specific order (see Table 1) that reflects the pedagogical steps in a phonics-based method aiming at associating specific sounds (phonemes) with specific letters (graphemes). This is done on the basis of a whole word, which is visually and auditorily divided into smaller units (analysis). Traditionally, this is done with a sheet of paper when

a teacher's voice clearly shows the sub-lexical structure of a word (the analysis) and supports the blending of the sounds into words (synthesis).

In computer-aided systems like FC-Sprint[2] and DigLin, these processes are taken over by the visual and auditory form of the exercise shown in Figure 2. The visual form shows a written word as a composite unit of separate elements. The squares with graphemes can be activated to play the specific vowel or consonant sound. In this way, both the visual and the auditory character of the word can be realized as often as needed for systematically developing letter–sound associations. The computer program takes over not only word analysis, but also synthesis, to a certain extent. That is to say, a learner can understand what the result of the synthesis is (the entire word played by the green button to the left) without being challenged to read it aloud. DigLin will add this possibility to the five exercise types taken from FC-Sprint[2] in the form of ASR's providing assessment of the read word. Here, pronunciation plays a role as well.

The presentation exercise (Figure 2), in Dutch, is meant as an orientation for the learner. In the German exercise called "From Letters to Words" (see Figure 3), the learner is challenged to fill in the blanks with the correct graphemes.

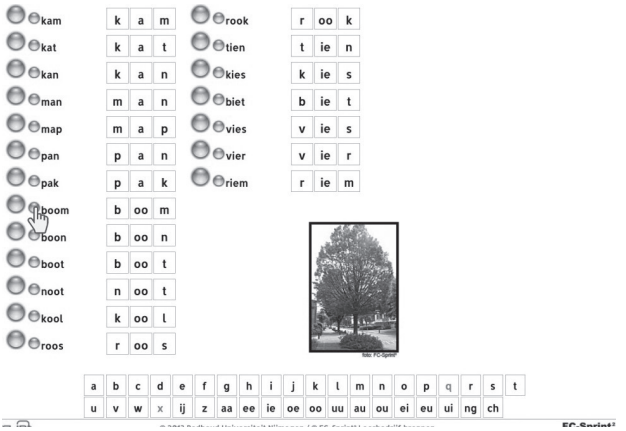

Figure 2. Presentation of 20 Dutch words with the sound bar at the bottom. The meaning of the word *boom* is activated by the learner and shown on the screen.

The learner whose screen is shown in Figure 3 has followed a strategy of finding out where to place the first letter of the alphabet. She has found all blanks for the *a* at this point, since the block with *a* in the alphabet is no longer grey. By the end of this exercise, all grey blocks in the alphabet will have become white. Other learners may follow different strategies, for instance, first filling in all the blanks of the first word.

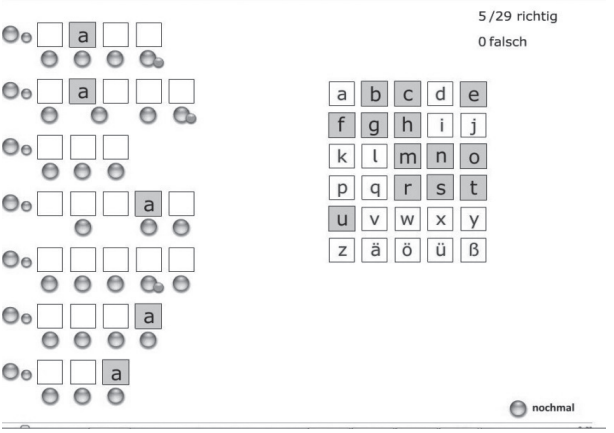

Figure 3. From Letters to Words (German version)

In Figure 4, words are dragged and dropped. There are two rows of words and two rows of blanks.

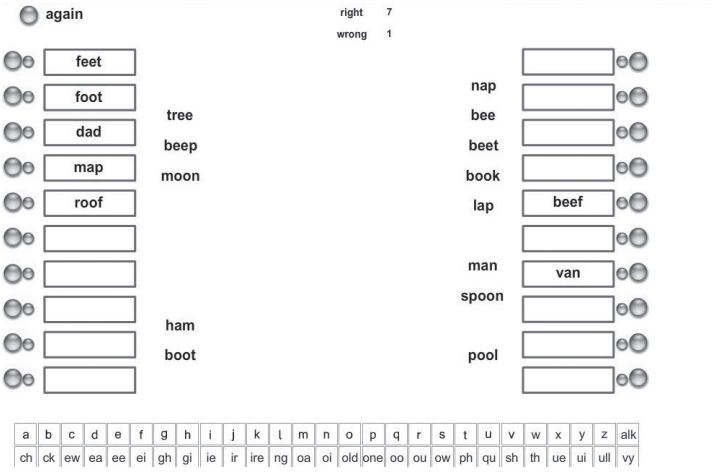

Figure 4. Screenshot of exercise 3: Dragging Words—1 (English version)

The learner needs to drag the listed words to the blanks. The learner whose screen is shown has successfully dragged seven words and dropped them into the correct blanks on the left and the right. This can be seen by the fact that the words remain in the blanks. Words dropped into the wrong blank cannot stay there but jump back to the position where they came from. A learner can use several strategies: (1) visually recognize the word as a unit and connect it the correct photo, or (2) first listen to the word, try to analyze its orthography (with help of the sound bar), or (3) try to recognize the written word on the basis of the first grapheme—or use similar strategies.

Figure 5 also shows a drag-and-drop exercise, this one based on the dragging of individual graphemes in German. This exercise is particularly useful for blending individual phonemes into a word. It requires the learner to first synthesize the phonemes "hidden" under the four buttons to the left of each blank; then, when the learner locates the word *sofa,* he or she must search for it in the list of written words, find it, and drag it to the blank. This learner has successfully dragged and dropped five words to the appropriate blanks (a green button appears at the right of the blank when the action is correct).

This feedback takes the form of being able to check the synthesis of phonemes without reading the word aloud. It is a way of disentangling reading (i.e., synthesis of graphemes to silent word reading) from pronunciation and thus provides evidence that it is possible for even beginner-level learners to practice (and test) their skills without reading aloud, although this is not DigLin's ultimate target. Rather, the aim is that the learner will read aloud at a level which native speakers of the target language are able to understand without great effort.

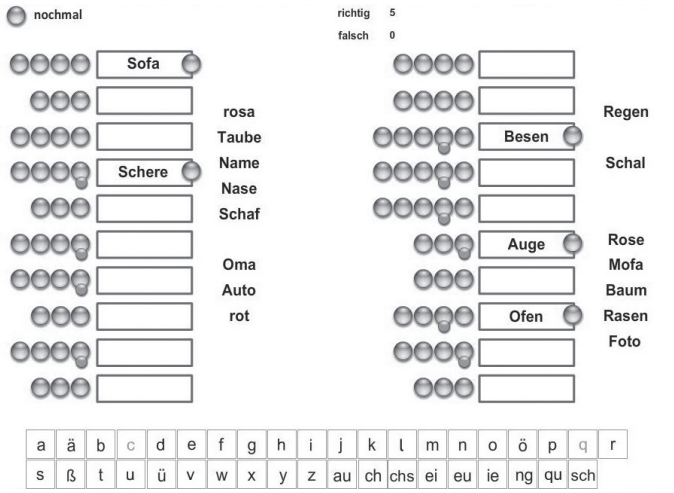

Figure 5. Screenshot of exercise 4: Dragging Words—2 (German version)

In exercise 5, shown in Figure 6 for Finnish, the learner has to type the word he or she hears into the blank. This requires the learner to analyze the spoken word and then to find and type the corresponding graphemes. The sound bar at the bottom can help locate the appropriate graphemes. The screenshot in Figure 6 shows that this student has correctly written 14 words; an incorrect answer simply does not get the green sign (√).

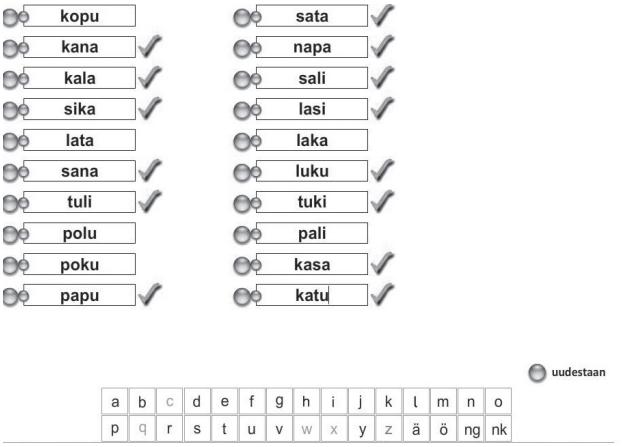

Figure 6: Screenshot of exercise 5: Dictation (Finnish version). The leftmost button provides the spoken word that the student has to type.

ASR-based corrective feedback on read words. Exercises 6 and 7 (not shown here) form the last phase of the beginning reading process (see Table 1) for each set of words. These exercises consist of reading 20 words from a Dutch, English, German, or English set. There are no photos and no opportunities to listen to words. Exercise 6 includes only the 20 written words and the sound bar; exercise 7 is without the sound bar, and the words are in an arbitrary order. This exercise enables the learner to assess the quality of their pronunciation by receiving explicit feedback on words read aloud.

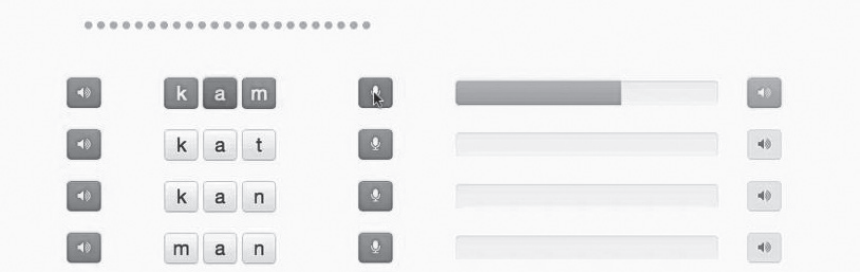

Figure 7: Screenshot of feedback by ASR (Dutch version)

Because this form of feedback is not included in FC-Sprint[2], the DigLin project has been developing additional exercises using ASR-dedicated technology and error-detection algorithms. The application of ASR technology and automatic error detection in the non-literate classroom is innovative and challenging, particularly because we are dealing with the non-native speech of low-proficient learners (van Doremalen et al., 2010). The process in this exercise will work as follows: The learner reads a word aloud and receives detailed feedback after every word. This feedback is gradient rather than absolute; it indicates the degree of correctness. The student in Figure 7 has pronounced <kam> (*comb*), but the pronunciation is not sufficiently close to the target (amber color). The phoneme *a,* which was most incorrect, appears in red. The learner's realization now appears on the screen so the learner can compare this with the target sound and try again.

Conclusion

The concept of learning built into FC-Sprint² might appear to conflict with the systematic and sequential instruction essential to a phonics approach. The Digital Literacy Instructor, however, has the potential to retain the learner autonomy embodied in these features. As seen above, DigLin presents the structure of the word to the learner's eye and ear in a systematic way, while allowing the learner more freedom. It allows individual routes based on native language influences and on individual problems, interests, and learning strategies. Teacher feedback is replaced by DigLin's systematic, consistent (always the same exercises, with always the same feedback), intensive (practice is unlimited), and clear (visual signals) corrective feedback. The teacher supports and encourages the learner by setting high expectations. One might ask if this is really feasible for the non-literate adult L2 learner. In the beginning, the learner might have a hard time; however, our experience with non-literate students at Friesland College, elsewhere in the Netherlands, and in Denmark at Lower Dansk has shown that this approach is successful (see Koot, van Binsbergen, van der Burg, & Gerbenzon, 2011). Learners become more active and explore on their own how to solve problems they encounter. As a consequence, their motivation increases. Can non-literate adult learners even work with the computer without first receiving a thorough introduction to digital skills? FC-Sprint² assumes that they can. Many skills can be learned just by doing, as evidenced by preschool children who start using computers, tablets, iPads, and so on, without any instruction or the help of older children or adults. If we only challenge them, then this is possible! The next phase of the project (September 2014 – February 2015) will reveal, in the four project countries, precisely how learners rise to this challenge.

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