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Mindstar books – An imaginative new generation of intelligent tutoring systems in science and in reading

MindStar Books represents an imaginative new generation of intelligent tutoring systems in science and in reading. Great strides are seeking in the quest to immerse students more effectively in multimedia learning activities in which they are challenged, motivated and empowered to acquire the knowledge and skills to learn reading and science.

Key words: Tutoring system, Reading.

Introduction

MindStar Books (MSB) are designed to scaffold effective science learning with the following aims:

- They will enable students, especially including English, Italian, and Spanish language learners, to acquire the prerequisite vocabulary and concepts to listen to and understand science texts that are read aloud to them, eventually by a virtual tutor, while they view illustrations that help them visualize the science being explained.
- They will assess students' understanding of the science through spoken presentation of deep reasoning questions, challenging answer choices representing common misconceptions, and immediate formative feedback on their answer choices.
- They will engage students in activities that lead to accurate, fluent and expressive reading of grade-level texts; skills that correlate highly with reading comprehension and future reading success (Baker, Smolkowski, Katz, Fien, Seeley, Kame'enui & Beck, 2008; Fuchs, Fuchs, Hosp & Jenkins, 2001; LaBerge, Samuels, 1974; Perfetti, 1985; Reynolds, 2000; Samuels, 1997; Stanovich, 2000).

These are important and exciting aims based on prior research and development, and they are within grasp. As for "Scientific Foundations", MindStars Books are based on theory and evidence indicating that a student's ability to read and understand a text – their reading comprehension ability – consists of two component skills: listening comprehension and word reading automaticity. Listening comprehension is an individual's ability to listen to a text and answer spoken questions about it. Reading fluency is the ability to recognize words accurately and effortlessly. Research shows that students' reading comprehension abilities can be accurate-

ly predicted by independent measures of their listening comprehension skills and their ability to recognize words accurately and rapidly (Gough, Hoover & Peterson, 1996; Gough, Tunmer, 1986; Hoover, Gough, 1990).

We should however underlined that the knowledge that the skill of reading comprehension is based on only these two components in the reading model called "Simple View Reading" (SVR) (Hoover, Gough, 1990), that is the listening comprehension and the ability to recognize the words has been frequently criticized in the literature. As an example, Harrison (Hall, Goswami, Harrison, Ellis & Soler, 2010) criticizes this model as a too simplistic view that ignores some important aspects such as fluency, vocabulary, cognitive flexibility, and morphology. For example, it argues that the recognition of the written word and its sound are two related but different processes (225) and that being able of decoding is not the same as being able to read (226). Even Pressley (Pressley, 2000) says that this model is not sufficiently explanatory: "Although skilled and eventually fluent word recognition certainly facilitates comprehension, it is not enough."

- SVR has often been erroneously associated to the definition of reading (Uppstad, Solheim, 2011); "the SVR was as a model to predict reading comprehension by means of two factors: decoding and linguistic comprehension. Over time, the SVR has acquired the status of a definition of reading, and it counts as a starting point for both research and teaching programs for reading."
- Even the authors of the SVR model underlined that the two cited components are necessary but not sufficient.
- Hoover and Gough (Hoover, Gough, 1990) showed that the children's needs on the two dimensions of SVR are subject to change as the children become more fluent in the reading of the words and the reading process becomes automatic.
- In a study of Wolf and Bowers (Wolf, Bowers, 1999), it was shown that also the speed with which we process linguistic elements has its own importance.
- Joshi and Aaron (Joshi, Aaron, 2000) have confirmed that this is a component that allows you to make predictions on students of elementary school level.

In other words, SVR is not the only model and it is surely lacking of completeness, however, its finding that students' reading comprehension abilities can be predicted by independent measures of their listening comprehension skills and their ability to recognize words accurately and rapidly is still a valid conclusion and MSBs will exploit this finding.

1. *Design and Organization of MindStars Books*

The MindStars Books Toolkit was developed to provide an easy to use authoring environment for developing the listening comprehension activities in MS Books, and publishing the book in a library.

Each MSB consisted of three independent activities:

- Narrated multimedia science explanations,

- Multiple choice questions for assessing students' knowledge and providing them with immediate feedback on their answer choices, and
- Reading practice, which used automatic recognition of children's speech while reading aloud to provide them with feedback on their reading.

Narrated multimedia presentations of science produce optimal learning, as measured by both short-term retention of information and by transfer of learning to new tasks. During narrated science explanations, each "page" of a book is presented to a student as a sequence of pictures. The student looks at each picture (or a collage of pictures) while the voice of the intelligent agent presents information related to the picture.

Multiple Choice Questions (MCQs) were presented at logical stopping points within the book to assess students' understand of science presented in the preceding several pages, and to provide students feedback on their answer choices. Each multiple-choice question concluded with an expansion of the correct answer choice, with the goal of helping students master concepts and build on them during the remainder of the book.

The goal of reading practice in MSBs was to improve students' confidence in their ability to read text passages about science, by enabling them to practice reading them fluently, with both support and feedback on their oral reading fluency. Creating a reading passage in the MSB Editor consists of the author a) typing the text passage into the Editor, b) recorded each sentence in the text, c) recording each word in the sentence individually, and d) optionally importing a picture associated with each sentence. When the author "builds" or publishes the book, the typed and recorded text is automatically transformed into the complete set of oral reading fluency activities students can do within the MindStars Book.The MSB Editor was used to create each of these activities.

The MSB Editor is an authoring tool that was used to create, test and refine the books developed over the course of the project by various teachers. The Editor is an intuitive, flexible and powerful tool that could be used by individuals with no programming experience for creating, testing and publishing MSBs. Creation of a book within the MSB Editor produces a published book with all of the interactive science learning and reading activities, which included automatic feedback to students on their oral reading fluency. Working from a completed script, a complete MSB can be developed and published in a single day.

In particular, the MSB Editor is a tool that enables an author to:

a. type in each sentence MSB will say, eventually by a virtual tutor;
b. record the sentences in English and record the Italian and Spanish translation of each sentence;
c. select a picture that will be presented with each narrated sentence (portions of pictures are highlighted using Photoshop);
d. include optional sound files into the narration;

e. design one or more multiple choice questions, with optional illustrations, that are presented after the page has been narrated;
f. record the questions and answer choices in English and both Italian and Spanish. Once the listening comprehension activities have been developed, the oral reading fluency training activities, which follow listening comprehension, are generated automatically, using the text that is narrated, eventually by a virtual tutor, during listening comprehension training.

2. *Listening Comprehension*

In MSBs, each page of a science text is narrated, eventually by a virtual tutor, while the student views illustrations that help them visualize the science. The narration is self-paced in alignment with research that indicates that self-paced presentations improve learning (Baker, 2003; Cole, Van Vuuren, Pellom, Hacioglu, Ma, Movellan, Schwartz, Wade-Stein, Ward & Yan, 2003; Cole, Halpern, Ramig, Van Vuuren, Ngampatipatpong & Yan, 2007). Students can stop and resume the narration after each sentence is spoken, and have the sentence repeated in English or say an Italian or Spanish translation of the sentence.

Figure 1a - *Screen shot in MSB Editor of the first page of a book called "The Bird, The Brain and The Train." The Picture at the top of the page is associated with the first sentence. The pictures associated with the second and third sentence are shown before these sentences*

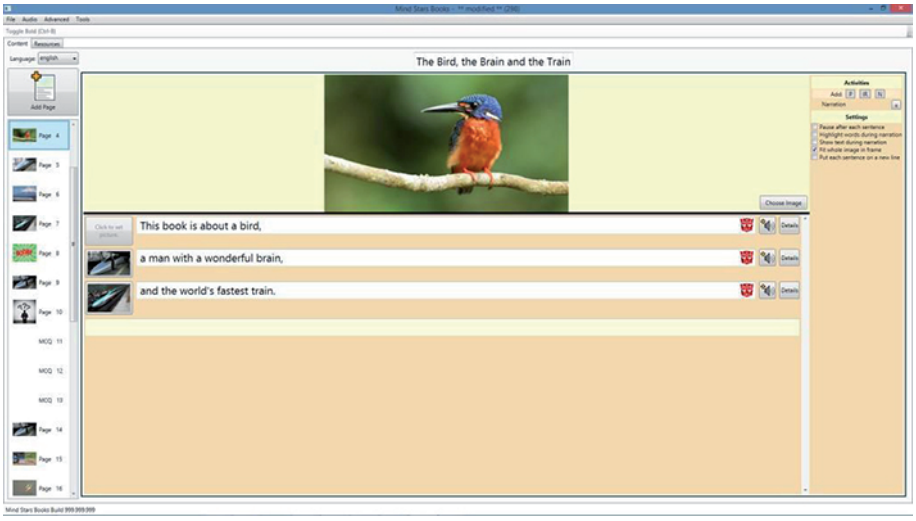


Figure 1a shows a single page of an MSB called "The Bird, The Brain and The Train." in the Editor. Figure 1b shows the first two screens presented to the student, corresponding to the first two lines of the page in the Editor.

Figure 1b - *Screen shots of first two pages for students. Students see pictures only while the agent narrates the sentences shown in the MSB Editor*

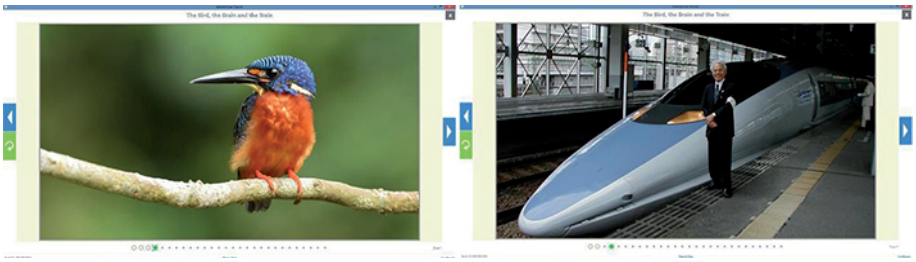
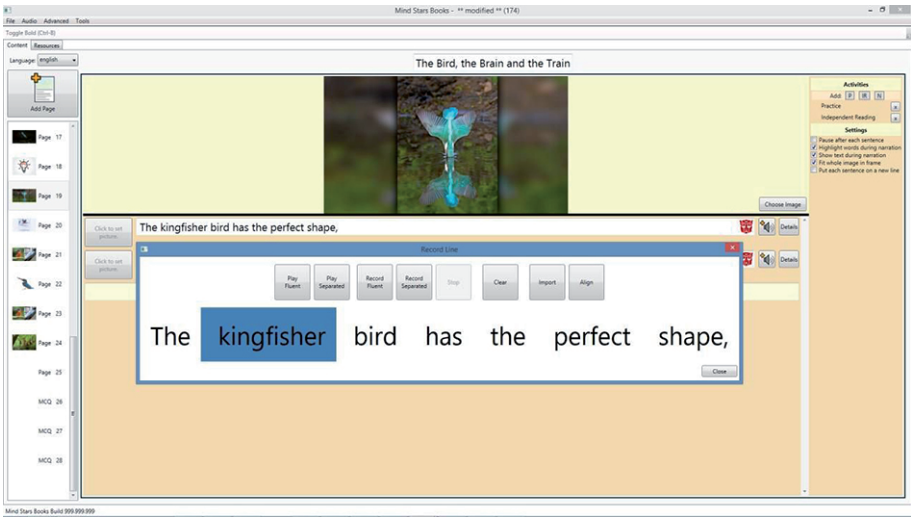


Figure 2 - *Recording function within MSB editor. The author has recorded the sentence that will be spoken to the student while looking at a picture on a page, and is watching the words highlight during playback of the recording to assure accurate synchronization of her speech to each highlighted word*



Differently from the Editor (Figure 2), we emphasize that words are not displayed on screen during narrated multimedia presentations, as the goal is to have students listen to the agent's voice while looking at the pictures, enabling them to construct rich multimodal mental representations of the science. Research has shown that putting words on the screen during a narrated multimedia presentation impedes learning (relative to not having words on the screen), as students will switch attention between the printed words and the pictures, resulting in poorer recall of the presented information.

After listening to one or more pages of text, students are presented with multiple choice questions (MCQs) to assess their understanding of the vocabulary and concepts. These are deep reasoning questions with challenging answer choices that represent common misconceptions. Students can listen to

the question and answer choices either in English or in Italian or Spanish as often as they like.

After selecting an answer, the student receives immediate feedback about the answer they selected. A positive feedback is obviously provided to a correct answer. If the student selects an incorrect answer choice, learning is supported by providing a hint; e.g., that spider has 8 legs, so it can't be an insect. After two tries, the correct answer is presented to the student, along with an explanation as to why the answer is correct. During listening comprehension activities, words are not presented on the page, as the goal is to have students listen carefully while viewing illustrations; research indicates that printed words can distract the student's attention from the illustrations and reduce learning (Cole, Wise & Van Vuuren, 2007).

Figure 3 displays the Editor interface (Figure 3a) for developing multiple-choice questions (Figure 3b). It shows slots for typing or importing questions, pictures, answer choices, and feedback on answer choices. The Editor uses the same recording tool for recording each question and spoken answer choices.

Figure 3a - *Editor for Multiple Choice Questions in the MSB Editor. The top of the page shows the question; the first line is the answer choice and feedback. The pairs of sentences, more broadly, show answer choices to the MCQ's followed by feedback after selection of the answer*

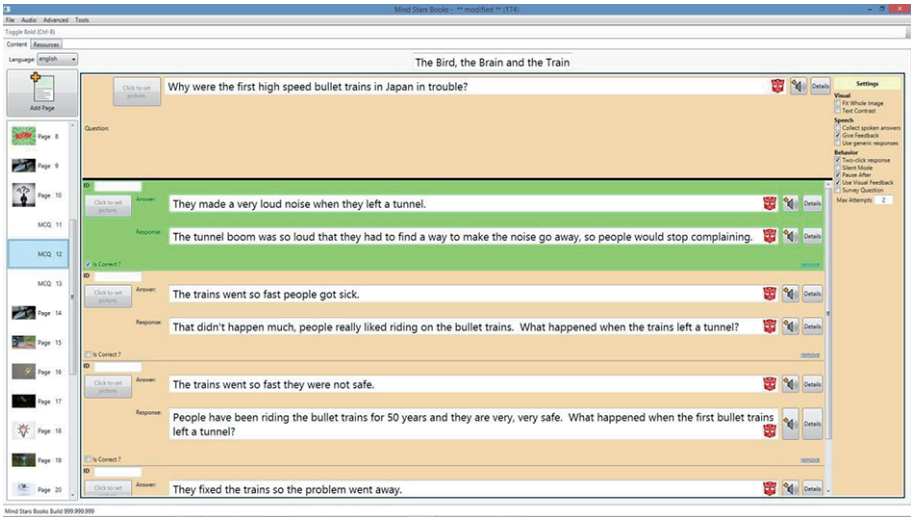
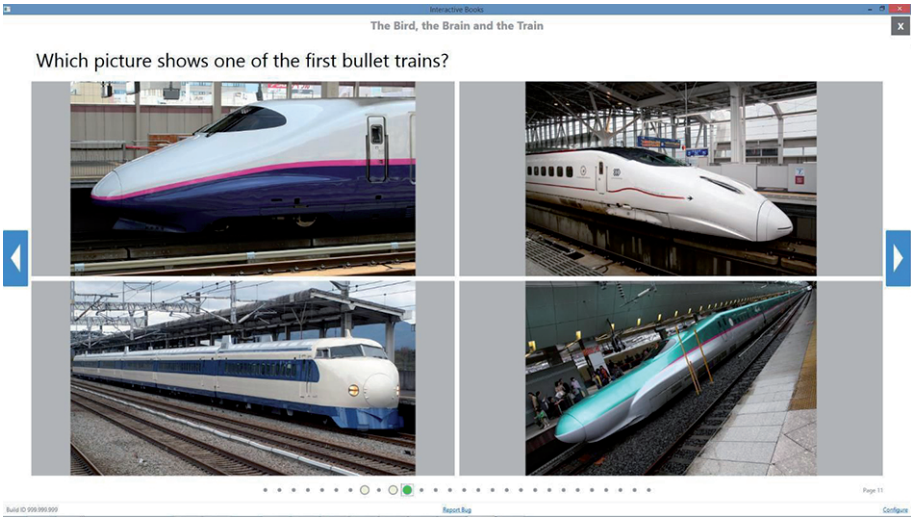


Figure 3b - *Screenshot of multiple-choice question followed by four pictures. The train with the flat nose cone is the correct answer. Answer choices are randomly placed on the screen each time a question is presented*



3. *Oral Reading Fluency (ORF)*

ORF practice and training occurs immediately after the listening comprehension activities are completed; that is, after all pages of the science text have been narrated to the student and MC questions have completed.

The goal of the ORF training is to help students learn to read grade level science texts accurately and fluently; oral reading fluency has been demonstrated to be a strong predictor of reading comprehension and later reading proficiency (LaBerge, Samuels, 1974; Perfetti, 1985; Ward, Cole, Bolaños, Buchenroth-Martin, Svirsky, Van Vuuren, Weston, Zheng & Becker, 2011).

Fluency training occurs through repeated reading of each page of the science text. The student is presented with the first page of the text, with each sentence displayed on the page. The student can choose to practice reading the text, with eventually support from a virtual tutor, before reading it independently. During practice, the student can listen an entire sentence to be read, or individual words in a sentence to be pronounced. The students can record themselves reading these sentences or words and play back their recordings to compare their reading with the correct one, eventually spoken by a virtual tutor. During playback of their recordings, each word is highlighted on the page as it spoken by the student. English learners can listen to MSB read a translation of the sentence in Italian or Spanish. When the student has finished practicing, they click an icon to read the page independently. Immediately after reading the page, the student receives feedback on the number of words they read correctly (out of the total number of words on the page), and their reading rate (relative to MSB's natural reading rate). The MSBs highlight words

that the speech recognizer scored as misread or skipped, so the student can practice reading these words and sentences. Repeating readings of the page, with practice before each reading and feedback on the student's reading performance immediately after independent reading, continues until the student achieves a criterion level of oral reading performance (90% word reading accuracy, reading speed within 10% of MSB's) or after three independent readings. Repeated reading of texts with feedback and practice following each reading has been shown to be a powerful tool to improve reading fluency, which correlates highly with reading comprehension (Baker et al., 2008; Fuchs, 2001; LaBerge, Samuels, 1974; Perfetti, 1985; Reynolds, 2000; Samuels, 1997; Stanovich, 2000).

4. *Final Considerations*

English, Italian and Spanish speech recognizers needed for ORF practice are already well developed and at an advanced level. Development and evaluation of MindStars Books is already on a good stage for English and Spanish and will be hopefully extended to Italian in the next year, depending on the effective funding of various submitted research projects and grants.

Bibliography

Baker, L. (2003). Computer-assisted vocabulary acquisition: The cslu vocabulary tutor in oral-deaf education. In *Journal of Deaf Studies and Deaf Education*, 8(2), 187-198.

Baker, S.K., Smolkowski, K., Katz, R., Fien, H., Seeley, J.R., Kame'enui, E.J. & Beck, C.T. (2008). Reading fluency as a predictor of reading proficiency in low-performing high poverty schools. In *School Psychology Review*, 37, 18-37.

Cole, R., Van Vuuren, S., Pellom, B., Hacioglu, K., Ma, J., Movellan, J., Schwartz, S., Wade-Stein, D., Ward, W. & Yan, J. (2003). Perceptive animated inter-faces: First steps toward a new paradigm for human-computer interaction. In *Proceedings of the IEEE*, 91(9), 1391-1405.

Cole, R., Halpern, A., Ramig, L., Van Vuuren, S., Ngampatipatpong, N. & Yan, J. (2007). A virtual speech therapist for individuals with parkinson disease. In *Educational Technology*, 47(1), 51-55.

Cole, R., Wise, B. & Van Vuuren, S. (2007). How Marni teachers children to read. In *Educational Technology*, 24(1), 14-18.

Fuchs, L.S., Fuchs, D., Hosp, M.K. & Jenkins, J.R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. In *Scientific Studies of Reading*, 5, 239-256.

Gough, P.B., Hoover, W.A. & Peterson, C.L. (1996). Some Observations on a Simple View of Reading. In Cornoldi, C., Oakhill, J.V. (Eds.), *Reading comprehension difficulties: Processes and intervention*. Mahway, New Jersey: Lawrence Erlbaum Associates, 1-13.

Gough, P.B., Tunmer, W.E. (1986). Decoding, reading, and reading disability. In *Remedial and Special Education*, 7, 6-10.

Hall, K., Goswami, U., Harrison, C., Ellis, S. & Soler, J. (Eds.) (2010). *Interdisciplinary Per-spectives on Learning to Read. Culture, cognition and pedagogy*. Routledge: London.

Hoover, W.A., Gough, P.B. (1990). The Simple View of Reading. In *Reading and Writing: An Interdisciplinary Journal*, 2, 127-160.

Joshi, R.M., Aaron, P.G. (2000). The component model of reading: Simple view of reading made a little more complex. In *Reading Psychology*, 21(2), 85-97.

Laberge, D., Samuels, S. (1974). Toward a theory of automatic information processing in reading. In *Cognitive Psychology*, 6, 293-323.

Perfetti, C. (1985). *Reading ability*. Oxford, England: Oxford University Press.

Pressley, M. (2000). What should comprehension instruction be the instruction of?. In Kamil, M.L., Mosenthal, P.B., Pearson, P.D. & Barr, R. (Eds.), *Handbook of Reading Research: Volume III.* Mahwah, NJ: Erlbaum, 545-561.

Reynolds, R.E. (2000). Attentional resource emancipation: Toward understanding the interaction of word identification and comprehension processes in reading. In *Scientific Studies of Reading*, 4, 169-195.

Samuels, S. (1997). The importance of automaticity for developing expertise in reading. In *Reading and Writing Quarterly*, 13, 107-122.

Stanovich, K.E. (2000). The interactive-compensatory model of reading: A confluence of developmental, experimental, and educational psychology. In Stanovich, K.E. (Ed.), *Progress in understanding reading: Scientific foundations and new frontiers*. New York, NY: Guilford Press, 44-54.

Uppstad, P.H., Solheim, O.J. (2011). Code and Comprehension in Written Language – Considering Limitations to the Simple View of Reading. In *L1-Educational Studies in Language and Literature*, 11, 159-174.

Ward, W., Cole, R., Bolaños, D., Buchenroth-Martin, C., Svirsky, E., Van Vuuren, S., Weston, T., Zheng, J. & Becker, L. (2011). My science tutor: A conversational multimedia virtual tutor for elementary school science. In *ACM Transaction on Speech and Language Processing*, 7(4), 18.

Wolf, M., Bowers, P. (1999). The "double-deficit hypothesis" for the developmental dyslexias. In *Journal of Educational Psychology*, 91(3), 415-438.