The Adaptive Features of an Intelligent Tutoring System for Adult Literacy

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Introduction

Adult learners with low literacy skills compose a highly heterogeneous population in terms of demographic variables, educational backgrounds, knowledge and skills in reading, self-efficacy, motivation etc. They also face various difficulties in consistently attending offline literacy programs, such as unstable worktime, transportation difficulties, and childcare issues. AutoTutor for Adult Reading Comprehension (AT-ARC), as an online conversation-based intelligent tutoring system that incorporated a theoretical model of reading comprehension, was developed with great efforts to meet adult learners' needs and be adaptive to their knowledge, skills, self-efficacy, and motivation. In this paper, we introduced the adaptive features of AT-ARC from four aspects: learning material selection, adaptive branching, trialogues, and interface, as well as the rationale behind these designs. In the end, we suggested further research on improving the adaptivity of AT-ARC.

Background

Research shows that literacy proficiency and the ability to use computers are positively related to one's success in finding jobs with relatively higher salary (Carnevale & Smith, 2013). It also has been documented that literacy proficiency is one of the strongest factors that influence the problem-solving in computer-based environments (OECD, 2015). Following this logic, literacy should be one's basic skills in modern life. However, one in six adults in the United States have low levels of literacy skills (OECD, 2013). It has a negative impact on the social health and economic stability of entire countries as well as the personal well-beings (OECD, 2013; Rasu et al., 2015). Most literacy programs are not designed to be adaptive to the needs and characteristics of adult learners with low literacy proficiency but for K12 students because they have higher priority. And, the existing adult literacy programs, which are often funded by government or non-profit organizations, generally do not reach the level that can accommodate all adults in need. Moreover, it is difficult to teach comprehension strategies at deeper levels because few teachers and tutors in literacy centers are trained to cover these levels of reading difficulty.

Relevant Theories

AutoTutor for Adult Reading Comprehension (hereafter, AT-ARC) is an online intelligent tutoring system that help adult learners improve their reading comprehension skills. The system was deployed in a learning management system, Moodle (https://adulted.autotutor.org), as well as a self-made website (https://read.autotutor.org) for public access. The data of AT-ARC is stored in a learning record store (Veracity Learning) which uses a standard (xAPI) to format the data. AT-ARC uses a tutor agent (Cristina) and a peer agent (Jordan) to deliver the 30 lessons. The two computer agents hold conversations with the human learner and with each other, which is called trialogue (Graesser et al., 2017). Each lesson focus on one or more reading skills in a theoretical model of comprehension (Graesser & McNamara, 2011).

Theoretical Framework of Reading Comprehension

The design of the AT-ARC curriculum also incorporated a theoretical model of reading comprehension which is proposed by Graesser and McNamara (Graesser & McNamara, 2011). The theoretical model adopts a multicomponent, multilevel framework. Graesser and McNamara (2011) framework identifies six levels of reading comprehension components: words (W), syntax (S), the explicit textbase (TB), the referential situation model (SM), the discourse genre and rhetorical structure (RS), and the pragmatic communication level (between speaker and listener, or writer and reader). We will specify the meanings and its components of each level. The pragmatic communication level is not tapped in the AT-ARC curriculum. Therefore, it will not be introduced.

Words and Syntax. Words and syntax are lower levels basic reading comprehension skills. They consist of the reading components of morphology, word decoding and identification, word order, and vocabulary (Perfetti, 2007).

Textbase. The textbase level consists of the basic idea units or explicit meaning of the text but not necessarily the exact wording and syntax. These basic idea units include statements, clauses, or propositions.

Situation Model. The Situation Model (sometimes called the mental model) is the readers' mental representation of the subject matter of the source text. It requires readers to make inferences relying on world knowledge (Zwaan, & Radvansky, 1998). This situation model varies with the genres of texts. In narrative texts, situation model includes information about characters, settings, actions, and emotions. In informational text, it would contain more technical content (e.g., knowledge and inferences about automobiles when reading a maintenance document on a truck). AT-ARC lessons target on the strategies of using connectives (e.g., because, so that, however), adverbs (finally, previously), transitional phrases (in the next section, later on that evening), or other signaling devices (such as section headers) to build situation models.

Genre and Rhetorical Structure. Genre and Rhetorical Structure refers to the type of discourse and its composition. Genre refers to the type of discourse, such as narration, persuasion, exposition, and information, as well as their subcategories. For example, narrative encompasses folk tales and novels, whereas persuasive texts include newspaper editorials and religious sermons. The Rhetorical Structure of a text provides the differentiated functional organization of paragraphs. There are different rhetorical frames, such as compare–contrast, cause–effect, claim–evidence, and problem–solution (Meyer et al., 2010).

AT-ARC LESSONS

Each of the 30 lessons of AT-ARC consists of instruction and practice sections. Within each lesson, the adult learners first receive a mini lecture about a reading skill that the lesson tapped, then practice the skill by answering multiple choice questions related to words, sentences, texts, or visual information (such as text style and picture images). The number of questions in the AT-ARC lessons ranges from 6 to 30. In most lessons, when an adult learner answers a question incorrectly or does not provide a complete answer, they will receive hints from one of the two computer agents, providing a second chance with somewhat more guidance. It usually takes 20-50 minutes for an adult

learner to complete a lesson.

The 30 curriculum lessons are categorized into 3 groups based on their modalities, that is, the forms of the learning materials. The three groups are words and sentences, stories and texts, and computer and internet. The les-sons falling in the words and sentences category teach knowledge about words (word decoding and identification) and sentences (syntax). The Computer and Internet lessons teach knowledge about using computer and internet to file job applications, send emails, search information, and interact with people on social media sites. The stories and texts teach deep reading comprehension strategies related to lengthy entertaining, informative, or persuasive texts.

ADAPTIVE FEATURES OF AT-ARC

Massive work has been done by the AT-ARC research group to tailor the instruction and learning materials to meet the various needs of the adult learners and adapt the interface and interaction features to their characteristics. The adaptive features of AT-ARC were introduced from the following four aspects: learning material selection, adaptive branching, trialogues, and interface. The 30 lessons were carefully scripted to contain learning materials (words, sentences, and texts) that have practical values that are adaptive to the adult learners' needs in their daily life and to their zone of proximal development (Wass, & Golding, 2014). Most of the 30 lessons have easy, medium, versus difficult learning materials (words, sentences, and texts) measured by Coh-Metrix (Graesser et al., 2014). Within the practice section of a lesson, the adult learners start with practice questions pertaining to words, sentences, or a text at the medium level of difficulty. Depending on their accuracy on these questions, the adult learners receive questions pertaining to either easier or harder learning materials. The AT-ARC uses two computer agents to deliver the EMT trialogue. The tutor agent is named *Cristina* and the peer agent's name is *Jordan*. Trialogues can be designed in different ways. At last, the interface was also designed to be adaptive to adult learners' limited skills of using computers. AT-ARC tends to rely on point & click interactions, drag & drop functions, multiple choice questions, and limited typing.

FUTURE

Although much work has been done to improve the adaptivity of AT-ARC, it is far from perfect. Future research can explore the deeper levels of human-computer interaction. For example, AT-ARC incorporates all types of trialogues in each lesson. The computer agents choose the type of trialogues adaptive on adult learners' characteristics, such as their knowledge and skills in reading, motivation, self-efficacy, or even personality. Currently, AT-ARC lessons are organized in a linear form. That is to say, the adult learner cannot jump to an activity (e.g., answering a question, reading a text) by skipping over the previous activities. Another strand of research can focus on breaking a lesson into smaller chunks and making each chunk accessible independently when the adult learner would like to review a specific activity.

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