An Online Software to Support Lifelong Learning Strengthening Reading and Logical Mathematical Skills

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Abstract: The process of lifelong learning requires adults to have the basic skills for cognitive growth, including reading comprehension and mathematical/logical reasoning. Teaching tools for adult education will not be successful unless the learners have these skills, regardless of the tool design. This paper presents the results from the pilot implementation of the "Lectura Inteligente: Agilmente" software which was completed by 100 administrative workers from a Mexican government agency. The data shows statistical improvements between the pre-evaluation and the post-evaluation in four of the five variables measured: speed, comprehension, efficiency, logical and mathematical reasoning. The social validation surveys indicate that the learners had an overall positive review of the software, but did indicate it requires effort and dedication for success.

1 INTRODUCTION

Lifelong learning is the active participation by adults in learning experiences which maintain them current in their skills and knowledge required for their professional activities and daily life, being adults the central pillar in the learning process (Fisher, 2000; Coles & Werquin, 2007; Head, Van Hoeck & Garson, 2015). However, further research indicates that for lifelong learning to be successful, there is a need for adults to have better learning skills so they can regulate the process themselves.

A qualitative analysis of illiterate individuals in Turkey concluded that the fear of not being able to learn (as well as age, language/culture, and gender) kept the illiterate adults from enrolling in face-to-face programs (Yildiz, 2008). At two regional training centers in the Netherlands, participants in adult education programs reported that the improvement in their reading, writing, and Internet skills gave them a greater sense of satisfaction (Greef, Verté, & Segers, 2012). To help students acquire higher-order reading skills, a face to face course used a variety of approaches to address information processing, metacognition, and critical thinking. Students become stronger readers and learners through the direct application of learned skills into relevant courses (Shaffer, Eshbach, & Santiago-Blay, 2015).

Digital technologies create an alternative method of face to face courses. Online teaching tools not only can develop basic learning skills, they can also provide a better learning environment since they adapt to working hours and learning pace. Online teaching tools are improved by the availability of an online mentor who can supervise and provide individual feedback to the adult learners. Further, online tools can provide content to a large range of learners: from the fearful ones, who question their basic skills, to the (over) confident ones who challenge the need to further advance their skills (such as reading).

In order to accommodate the specific needs of adult learners with full-time jobs which expect constant advancement, the team created an educational online software system based on the "*Lectura Inteligente*" (LI) (Smart Reading) online system previously used only in formal educational environments (elementary through university). LI courses combined an online teaching system with in-class face-to-face teacher guidance and supervision The success of these courses was previously

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documented in (Flores-Macias, Otero, y Lavallee, 2010; Flores-Macías, Otero, 2013).

Educational software has several advantages, including (Warschauer & Healey, 1998; Kamil, Intrator, & Kim, 2000, in Flores-Macías et al.):

- Address the individual needs of each learner, allowing work at their own pace;
- Create a less hierarchical relationship with the teacher, who becomes an online mentor;
- Provide a creative, fun, motivating environment;
- Enabling individual support and feedback.

This paper describes the design and presents evaluation results for the new use of LI as "Lectura Inteligente: Agilmente" (LI:A) (*Smart Reading: Agility*). The system was adapted specifically to promote the reading and mathematical/logical reasoning of adults engaged in lifelong learning.

2 LI:A, SOFTWARE DESIGN

This section presents both the technical and pedagogic design of the LI:A software. The intention of the technical section is to describe how the software can reach a varied labor force; it does not delve deeply into the actual programming. The pedagogic design shows the reasoning behind the content of the courses.

2.1 Technical Description

LI has three modules: (1) Reader Module, in which the adult learner performs all their activities; (2) Mentor Module, used by on line mentors who monitor the progress and provide regular feedback and support to the learners; it includes the possibility to see individual and group progress; the mentors can see the content of the full course done by the students; and (3) Administrator Module, used by the core team to create and manage the content of the courses, allowing real-time adaptation of content and creation of new courses for new groups of learners. These three modules and their interaction are presented graphically in Figure 1.

The LI:A software, used the Administrator Module to create four new courses specifically for the lifelong learning adults, with four different levels (the design of these courses is detailed below). The Mentor Module was also enhanced to better address the need for mentors to *remotely* support the learners. Specifically, an integrated messaging

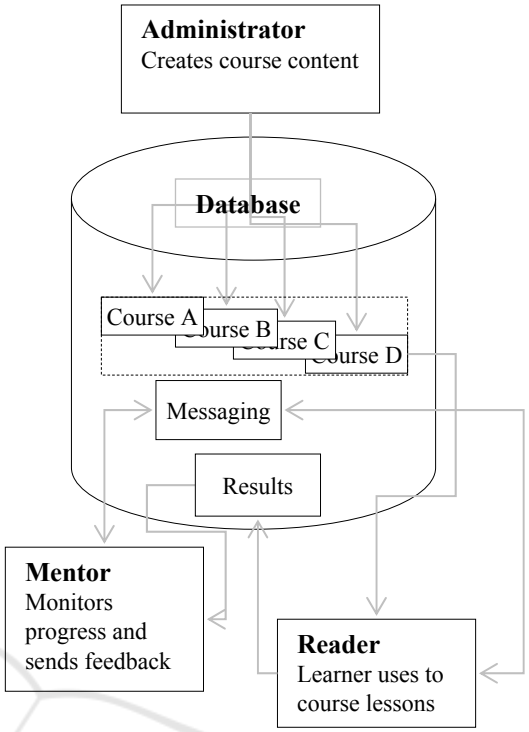

Figure 1: The modules of LI.

system was added and mentors were provided with better summary reports to help supervise a wide range of learners. Administrators of LI can use the Mentor Module to supervise the learners directly, and also the mentors themselves, ensuring there are multiple levels of supervision to ensure learners get constant feedback while working remotely at their own pace. The Reader Module was also enhanced to include the ability of learners to respond to the feedback from mentors, making the interaction two ways.

The process to start the course also required new improvements to LI. During normal LI courses, teachers directly told students what to do, and they were designed so all the students in a class took the course for their grade. LI:A required the learners to be automatically assigned to the right course level. To this end, the LI:A registration system used a-priori information on the educational level of the learners (elementary, preparatory/high school, undergraduate college, and advanced degrees). The program administered an initial speed and reading comprehension Diagnostic Assessment (DA) based on that a-priori educational level.

Based on the learner's performance on the DA, a course was assigned automatically: a very low diagnostic (< 30% comprehension) result meant a

learner would be assigned to a level below; a very high score (> 90% comprehension) assigned a higher level; other scores maintained the same level. After completing the diagnostic, the learner was automatically assigned to the corresponding "class" – but rather than a regular school class; it's a virtual group, all supported by the same mentor. The mentor sent an initial "welcome greeting" to the group, to all the learners. Figure 2 summarizes the LI:A process from registration through Final Assessment (FA).

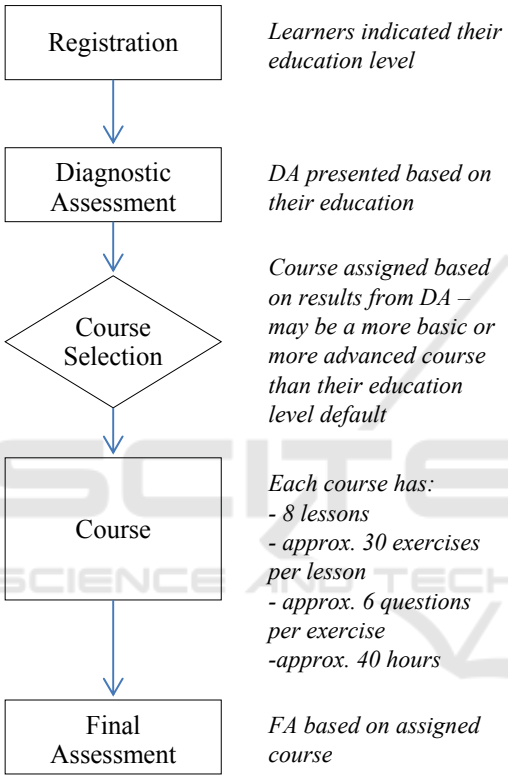

Figure 2: LI:A Course Process.

The software was designed with deadlines, but not a set pace. Specifical registration took place on Sep 2015, and the courses ran from Oct 2015 to Dec 2015. Each learner could work as fast or as slow as they needed, while being required to complete the course by the deadline.

The LI:A system is programmed using a standard LAMP (Linux/Apache/MySQL/PHP) setup. This allows the online courses to dynamically be presented, including real-time data collection and availability between learners and mentors. There was no need for the learners to install any special software, and the students were able to conduct the course on multiple devices and platforms. Learners successfully used PC's and tablets – the program is not geared towards phone use (although it can work), since it requires text (sometimes multiple paragraphs) input during some exercises, which is complex to do in the small screen/keyboard space of small devices.

2.2 Pedagogic Design

Experts in educational psychology have collaborated in the development of the educational content, it is also the result of several investigations related to fluency and reading comprehension and the development of logical / mathematical thinking that began in 2006 (Flores, Otero, Lavallée & Otero, 2101; Flores & Otero, 2014).

For its instructional design, desirable features are considered in this learning tool such as: the adaptation to the characteristics of learning (cognitive and affective) of users with different levels of education (from elementary school to college); the curricular requirements; to maintain appropriate challenges to create interest or avoid frustration.

The activities in LI are designed thinking of the user to become autonomous and learning engaged, besides of the reading comprehension or strategic thinking in solving problems; the goal is to promote self regulated learning, critical thinking and communication skills. But the reading fluidity exercises require drill and practice. In general, LI does not encourage learning by trial and error method

LI:A was designed specifically for adults whose work environment requires them to be efficient and effective readers of all kinds of texts, as well as to demonstrate mathematical and logical thinking which enables them to find solutions to problems which may arise in real-time.

The pedagogic contents (readings, activities, and types of exercises) for the LI:A software were chosen in consultation with the Mexican government agency, which provided the courses for a select group of their administrative staff. In this way the staff was able to both, enhance their reading and mathematical/logic skills, while also reading material relevant to their work at the agency. In summary, the contents of the online courses pursued the following learning objectives:

1) For reading abilities: improvements on both the speed and comprehension while maintaining reading self-regulation. This includes the use of different readings (narratives, expository texts); additional vocabulary; training on different reading strategies for before, during, and after

reading a text; learning strategies; argumentative abilities; and critical thinking.
2) For mathematical reasoning: real world problem solving strategies (budgeting, interest rates, percentage calculation, fraudulent sales, etc.); interpretations of tables and charts; and extraction of information from maps.
3) For logical reasoning: creative and flexible thinking strategies in daily life situations; recognition of similes and opposites; finding differences; create analogies; classify events; and establish causality between different events.

Each lesson has different content based on a strategy to learn at that point. All lessons address reading, mathematics, and logic abilities. By emphasizing a strategy in each lesson the students are able to develop multiple techniques to help their learning skills. These include study habits, ability to self-regulate learning, skills to develop an argument, and even finding answers online. In all exercises LI:A offer immediate feedback.

3 PILOT PROGRAM RESULTS

LI:A was implemented by the Universidad Nacional Autónoma de México (UNAM) upon request by the government agency. The agency leaders provided an initial description of the administrative workers as: age; between 40 to 60 years old; any gender; had concluded their formal education over 20 years ago; and had regular full-time jobs with the agency; during different training courses the performance was sub-standard, mostly due to limited self-learning skills.

Participation in the LI:A program was voluntary. 279 learners began the course. 100 learners completed the final evaluation. Most workers completed the first lesson, but many did not finish the second one. The full courses were estimated to require 40 hours for completion; as mentioned, the students had 12 weeks (Oct to Dec) to complete the course.

LI:A collected data on five quantifiable variables: reading speed (average words per minute); comprehension (percentage of correct answers to questions regarding the readings presented to the learners; the questions increased in complexity as the lessons progressed); efficient reading (a measure that combines speed and comprehension, to provide the efficiency of reading; it ranges from 1[lowest] to 5 [highest]); mathematical reasoning (percentage of correct answers in: word problem solving, exercises with table and charts interpretations and extraction of information from maps); and logical reasoning (percentage of correct answers in exercises).

Table 1 presents the improvements measured between the Diagnostic Assessment (DA) and Final Assessment (FA). The data is statistically significant and shows a positive trend in all the skills required for improved self-learning as related to reading. The improvements were: Speed (words per minute) [*DA: M=220.2, ED= 69.1* and *FA: M= 323.4, ED=8.8; t(99) = −12.4, p =.00*]; Comprehension [*DA: M=71.8, ED= 16.2* and *FA: M= 82.8, ED=2.3; t(99) = −6.2, p=.00*]; Efficient Reading [*DA: M=2.30, DE= .95* and *FA: M= 3.6, ED=1.0; t(99) = −10.1, p=.00*]; and Logical Reasoning [*DA: M=66.6, DE= 32.2* and *FA: M= 83.1, DE=15.4; t(99) = −5.0, p=.00*]. The data for mathematical reasoning was not statistically significant, but it did show a positive trend in general and an improvement between DA and FA [*DA: M=45.6, ED= 30.4 and FA: M= 51.6 ED=25.4; t(99) = -1.7, p >.00*].

Table 1: Comparison between the results obtained in Diagnostic Assessment (DA) and Final Assessment (FA).

Variables assessed in LI:A	DA	FA
Reading speed (words per minute)	220	323
Reading comprehension (percentage of correct answers)	72	83
Efficient reading (ratio between speed and comprehension; out of 5)	2.3	3.6
Math reasoning (percentage of correct answers)	46	52
Logical reasoning (percentage of correct answers)	67	83

Figure 3 shows the progress of the learners in LI:A. In addition to the diagnostic assessment and final assessment, the figure shows the results during lessons L3 and L6. The most significant improvements are in reading speed, comprehension, and efficient reading (which are the main goals of the original LI software). A substantial improvement is also present in the logical reasoning (a new pedagogic element to LI:A). The improvements in mathematical reasoning (also new to LI:A) were moderate and varied much to be statistically significant.

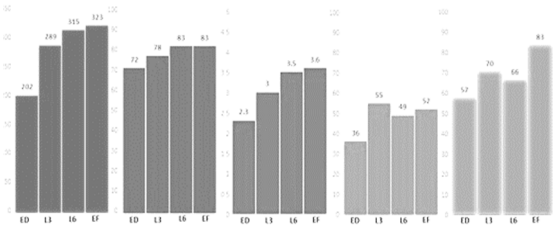

Figure 3: Diagnostic, formative, and final assessment in LI:A. From left to right: speed (green), comprehension (blue), efficient reading (purple), mathematical reasoning (orange), logical reasoning (yellow).

The additional presentation of data from lessons L3 and L6 demonstrates a constant improvement as the course continued. For example, in L3 comprehension rose to 78%; by L6 it rose more, to 83% (the final average at the time of the FA). It is important to notice that, since the difficulty of the readings increases with each lesson, the percentages obtained in the later lessons and the final assessment not only show an improvement in comprehension, but an acquisition of new strategies to approach more complex texts.

The mathematical reasoning data had fluctuations. Still, the results of all the lessons and FA show an improvement over the DA. As with other types of exercises, the complexity of the problems increased as the course progressed. Therefore it is safe to imply that while the trend is not as clear, the students acquired new mathematical reasoning skills as the course progressed.

The learners that completed the course filled out a social validation survey to provide subjective feedback on LI:A. With regards to the question, W*ill the skills help you in other professional settings*?" the results were 61.4% said LI:A is very useful and 31.6% said LI:A is useful. The question, "*Is LI:A a user friendly course?*" was answered 86% positive. Regarding, W*ere the mentors helpful during the course?*" 68.4% replied they were very helpful and 21.1% that they were somewhat helpful. The question, "*How much time and effort is needed for positive results?*" received 59.6% of answers that indicated it did require substantial time and effort, but good results were obtained; 21.1% responded that it requires substantial time and effort, and the results are moderate. 70.2% of the pilot study participants completed the course from home, even though they were given one hour during work time to complete the LI:A course.

The participants who did not continue the program were asked why they had stopped. 80.6% of them indicated that their workload did not allow them to continue with LI:A.

4 CONCLUSIONS

The results obtained indicate that, as expected, one of the main obstacles for adults to benefit from lifelong learning is the limited skill to comprehend the content of courses and self-regulate their learning programs (de Greef, Verté, & Segers, 2012; Shaffer, Eshbach, & Santiago-Blay, 2015). The data shows that the use of an online system designed to directly improve these skills, such as LI:A, contribute positively to overcome this obstacle.

The learners that completed LI:A developed important reading skills, and improved their mathematical and logical reasoning (although LI:A can contribute more to mathematical reasoning in future versions).

Mathematical reasoning presented the largest challenge, as the data showed large differences between learners. Some learners did not have issues with mathematical reasoning. But for the users who had many difficulties with mathematical reasoning, it will be necessary to create a more gradual lesson plan and add more skills exercises, so that these learners can experience a constant improvement. The team will further analyze the results and update the LI:A courses.

The effectiveness of an online system can be influenced by the background of the users. While LI:A provided important reading and reasoning skills, it was also noticed that some participants required more support than others. While the average results are mostly statistically significant, some data clearly shows that there were participants that required substantially more support. The mentor program is essential to provide the help needed by these students, and will be further improved, based on the lessons from the pilot program. The results of the Diagnostic Assessment will be used to identify the learners at greater risk, and mentors will work more closely with these users – while maintaining regular contact with the others.

To address the issue of participants who dropped out of the program between lessons L1 and L2, the team learned that it will be necessary to decrease the difficulty of these two initial lessons, providing a more gradual start to the course. The difficulty may then increase a little more steeply in future lessons, once the learners have acquired the initial basic skills presented in the first two lessons.

It is important to be aware that the Mexican government agency provided an economic incentive to those participants who *finished* the LI:A course and provided both facilities (computers / internet access) and work time for their staff to participate in the program. These incentives will continue in future implementation of LI:A.

Last, but not least, the results obtained by the users as well as their opinions on LI:A indicate that it is an educational tool that prepares adults for other lifelong learning experiences. However, it is necessary that experts in the teaching of adults in work environments assess LI:A in a comprehensive manner. For these purposes the rubrics have been shown to be useful and raised relevant characteristics that should be considered when evaluating an educational app (Lee & Cherner, 2015;) Papadakis, Kalogiannakis & Nicholas Zaranis, 2017). In particular for LI:A it is important to recognize: the relationship between the skills that teach LI:A and the preparation for lifelong learning; the relationship between the content and learning objectives proposed for LI:A (knowledge and skills); the adaptation of the instructional design to the learners' characteristics and If LI:A is friendly and easy to interact and navigate.

Collaboration between different professionals (psychologists, engineers, mathematicians) and complying with the requirements of the government agency, are inescapable and complex task;. however, have been very enriching to LI:A.

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Note: If you are interested in knowing LI:A software, please write to cat@lecturainteligente.com.mx to ask for a free demo.