Reading Mirror: Social Navigation and Social Comparison for Electronic Textbooks

Jordan Barria-Pineda, Peter Brusilovsky, and Daqing He

School of Computing and Information, University of Pittsburgh, PA 15260, USA
jab464,peterb,dah44@pitt.edu

Abstract. Although many technological advances have been done in the last decades, textbooks in their traditional form are still the primary knowledge source for students' instruction around the world. With the aim of addressing this gap, we developed an online reading system that allows students to easily track their own progress on course mandatory readings and quizzes, as well as compare themselves with their peers through a mirrored *icicle plot* visualization. Preliminary results about the hypothesized effects of the social visualization in students behavior/performance in two classroom studies is presented, as well as their qualitative feedback about the system.

Keywords: electronic textbook · social visualization · social navigation

1 Introduction

Many innovations have been introduced to digital version of traditional textbooks throughout the last years. Among other novel additions to e-textbooks, we can list concept mapping activities [14], automatic recommendation of relevant external content (such videos [11], Wikipedia articles [1], etc.), social annotations [15], and embedded interactive learning activities [5]. All these efforts try to leverage the development of new technologies with the aim of modernizing the textbook as an educational resource.

In our own work, we explored an idea of extending electronic textbooks with *social navigation* [7], a technology that uses behavior of past users to guide future readers [3, 6]. Our results demonstrated that social navigation helps students to focus on most important pages and increases their reading engagement. In this paper we present some early results of our most recent work, which extends social navigation with a *social comparison* through an advanced reading support interface "Reading Mirror". This extension was motivated by our studies of social comparison interfaces in educational contexts [10, 4], which demonstrated that social comparison (SC) features could act as a motivator for students engagement and enable stronger students to act as guidance for weaker students. In the following sections, we introduce the Reading Mirror interface and report preliminary results of its classroom evaluation.

2   Reading Mirror

Reading Mirror is a textbook reading support interface with progress tracking and social comparison features. It attempts to integrate features of social navigation support, open social learner modeling, and social comparison [6, 3, 10, 9, 8] into a hierarchical structure of a typical textbook. Our main challenge was to design a visualization, which allows students to track their own reading performance and compare it with class performance while using space efficiently.

In our past attempt to implement social comparison in a textbook context [9] we used a sunburst visualization, which offered an expressive approach for tracking student progress, but consumed a considerable amount of space and provided poor support for social comparison. In the Reading Mirror project, we applied a colored *icicle plot* [2], which is able to efficiently visualize hierarchical data in a linear form. This approach provided space-saving support for both progress tracking and social comparison, i.e., comparing student own behavior with the progress of the whole class.

2.1   Self-Monitoring Visualization

Reading Mirror visualizes student own reading progress in the context of a hierarchical textbook visualization, which follow the following structure: *lecture* → *book_chapter* → *section* → *subsection* (see Fig. **??**). Each unit of reading is represented by a rectangle. The larger the height of a rectangle, the larger number of pages the chapter, section, or subsection has. This visual variable allows students to see at a glance which lectures are more heavy in terms of reading material. To display current reading progress, we colored rectangles representing readings units with different shades of blue. The color reflects the fraction of already read pages in a unit. If a rectangle is white it means that the student has not read any related page. Otherwise, the darker its blue shade, the more pages the student has visited in that specific unit.

The reading progress visualization is combined with visualization of student performance on quizzes. To show quiz performance, next to the progress *icicle plot* we added a small bar graph which reflects success rate on answering the quiz associated with each section (see Fig. 1). Here the red portion of the bar shows the proportion of incorrect answers while the green portion shows the fraction of correct answers on that quiz.

2.2   Social Comparison

The design of the social comparison part of the Reading Mirror was motivated by recent findings in information visualization research, which indicated that correlation tasks (i.e. detecting if two data distributions were similar or not) are better supported when presented with mirrored graphs [12]. This work confirmed earlier findings stating that capability of the human visual system for detecting visual differences between two regions is more efficient when they are laid out
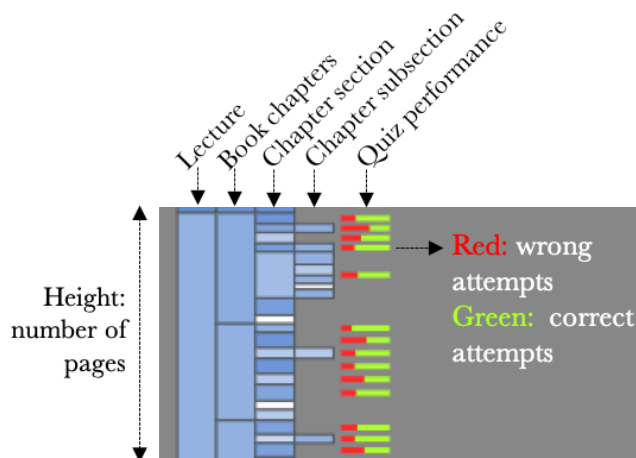
Fig. 1. Detail of the individual progress visualization and what visual variables convey

as mirror images of each other, compared to repeated translations of each other [13].

Considering this, the visualization component that allows learners to compare their own work with the rest of the class was designed as a mirrored version of the individual progress *icicle plot* (see 2 in Fig. 2). Here, the left side of the visualization shows the aggregation of the class behavior and the right side shows personal progress.

Students could interact with the visualization by either clicking a section, which takes them to the first page belonging to the corresponding lecture reading, or by *mouseovering* the rectangles which shows the values reflecting students/class reading progress and quiz answering performance (see 3 in Fig. 2).

3   Classroom Studies

To evaluate the Reading Mirror system, we performed a sequence of classroom studies in three different courses: graduate courses on Information Retrieval and Database Management and an undergraduate course Introduction to Object-Oriented Programming. We used open textbooks and licensed proprietary material as readings in the system and prepared a full set of quizzes for each book. Approximately 200 students have used the system over several semesters.

In this paper we review some data collected during our studies in a graduate-level Information Retrieval class over Spring and Fall 2018 terms. In this class, students had to use the platform weekly to review the readings related to the upcoming lecture. In addition, for each lecture they had to answer a series of short quizzes associated with the sections they had to read.

The course had 11 topics/lectures supported by the reading system. In the analysis below we do not consider the first lecture activity logs because learners
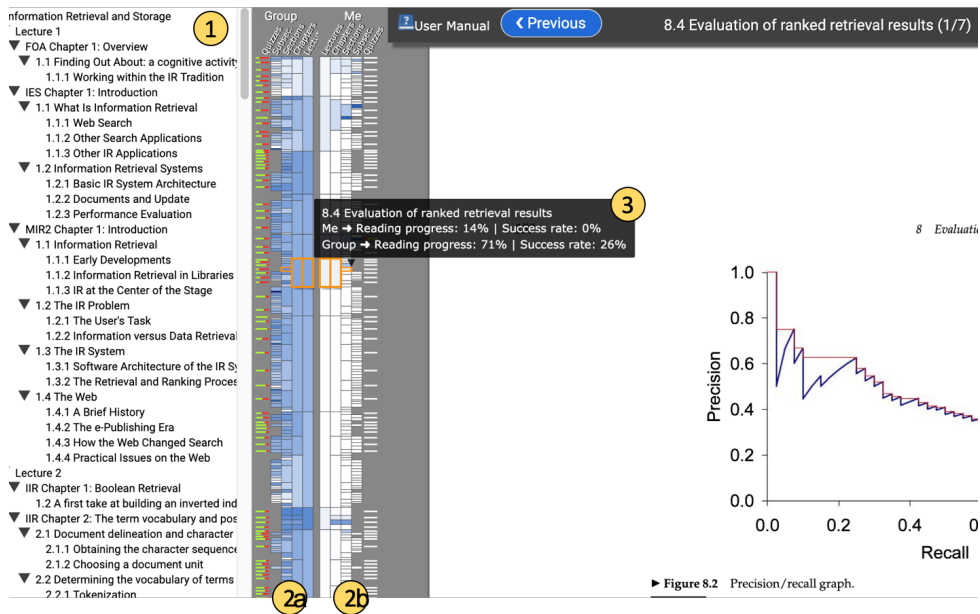
Fig. 2. Overview of Reading Mirror system. (1) Traditional table of content. (2) Mirrored progress visualization - (2a) average group progress at left, (2b) individual progress at right. (3) *Tooltip* that is showed when a user *mouseovers* on a lecture subsection with information about own student and average class progress/performance

during that time period could still add/drop the course so usage data is very sparse. A total of 80 students used the system actively every week in both terms (39 in Spring 2018 and 41 in Fall 2018). In order to measure the effect that the social comparison component of the progress visualization had on the students, we explored two different setups:

1. *Spring 2018*: In this semester, we turned on and introduced the social comparison features between Lectures 7 and 8. We expected that this design will help us to compare student behavior (reading progress/quizzes' performance) between the first seven and the last three lectures.
2. *Fall 2018*: Here, we incorporated the Social Comparison at the beginning of the course. In this case, we were interested to study the effect of Social Comparison in a long-term setup. It also allowed us to more reliably assess the effect of social comparison using the earlier semester as a baseline.

4   Preliminary Results

4.1   Performance Impact

With the aim of quantifying the influence of the social comparison component, we calculated the average success rate of students before and after it was enabled in the reading system in Spring 2018, and throughout the whole term in the case of Fall 2018 (see Fig. 2). We expected that the presence of social comparison will encourage students to work harder reaching higher success level in their quiz answers.

In the Spring 2018 semester, we found no difference in success rate on answering quizzes with and without social comparison visualization. During the first weeks it was 0.63 (SD=0.08), while after its inclusion its value was 0.63 (SD=0.05). We hypothesize that it could happen because the change was introduced too late in the term, so the students did not have enough time to get a stronger influence from having access to others performance.

Indeed, in the following term (Fall 2018) where social comparison was offered from the beginning, we observed that students success rate was gradually increasing. While the overall profile of success was similar (likely reflecting varying difficulty of different chapters), starting from Lecture 3, student performance in the social comparison condition was always higher than the in the condition with individual progress tracking only (Fig. 3).

One of the reason that could explain this difference is that the students need time to get used to social comparison and . We can see in Fig. 3 that after the first three topics Fall 2018's students started to differentiate from Spring 2018's students. This coincides with the fact that in Spring 2018, with only three weeks of social comparison, we could not see any expected change in their behavior (i.e. increase in their previous average performance on quizzes). Notwithstanding the above, one could hypothesize that the noticeable average different in success rate between both terms could be explained by having better performer students in Fall 2018, but we found that there were no significant differences in average

grades' performance in both terms ($M\_Spring2018 = 88.0$, $SD\_Spring2018 = 4.6$ and $M\_Fall2018=88.8$, $SD\_Fall2018=7.3$).
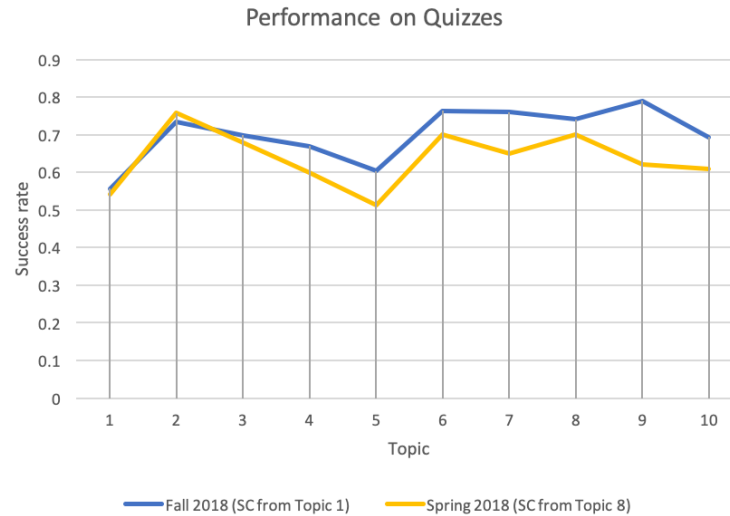

Fig. 3. Average students' performance on quizzes on each topic supported by Reading Mirror

4.2   Subjective Feedback

After using the system throughout the term, students were asked to fill out a survey in order to get their opinion about the main features of the online reading system (see Fig. 4). The survey included questions related to:

- How important was for them accessing to information about their own progress/performance.
- How important was for them to have access to the average progress/performance of the rest of the class.
- How well the visualization supported the goals of reflecting own and others performance.
- How the introduction of the Social Comparison influenced their behavior in the system (only Spring 2018 case).

As the Fig. 4) shows, student opinion about the key system features was highly positive. It was interesting to observe that the students were slightly more positive about the value of tracking own progress than the ability to see the class progress. They also considered the ability to compare quiz progress
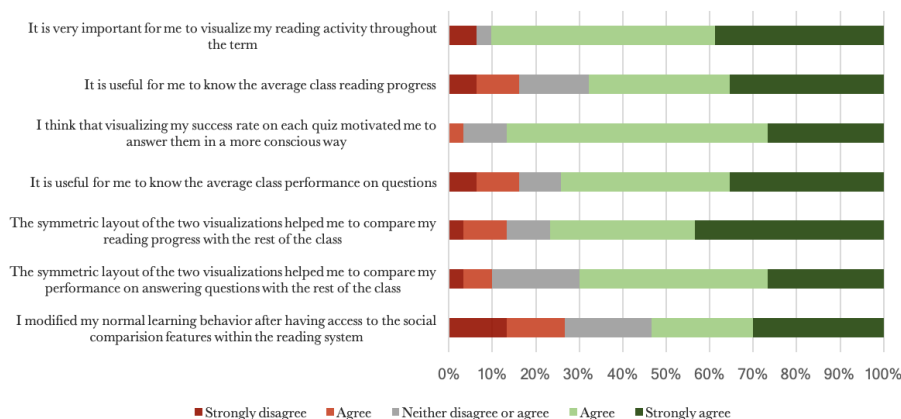
Fig. 4. Summary of students' qualitative feedback

slightly higher than reading progress. Also, more than a half of the students felt that they altered their behavior due to the social comparison features.

Furthermore, we allowed students to give their opinion about how the system could be improved. Some of the comments they gave were the following: *"The hierarchy bar may not be a good way to visualize the reading sections especially when the sections have too many pages that can't be properly visualize"*. Indeed, while the Reading Mirror visualization shows the "big picture" of comparative behavior, the ability to zoom on a specific chapter or section might be important for better comparison. We plan to add this ability in future versions.

5 Conclusion and Future Work

In this paper, we introduced the Reading Mirror interface, which enhances student textbook reading with progress tracking, social navigation, and social comparison features. Early results of two classroom studies demonstrated that the students' perception of the system is very positive. However, by comparing students performance on answering quizzes in both studies we can hypothesize that social comparison might take some weeks to have an influence in students.

In our future work, we plan extending the social visualization to include estimations of students knowledge inferred from their reading behavior and performance on quizzes. On the other hand, we are working on using the knowledge modeling to recommend most relevant external learning resources. Ultimately, we would like to combine both visualization and recommendation approaches in order to explain why an specific external learning content was suggested given their current level of knowledge.

References

1. Agrawal, R., Gollapudi, S., Kenthapadi, K., Srivastava, N., Velu, R.: In: Proceedings of the First ACM Symposium on Computing for Development, ACM DEV'10. https://doi.org/10.1145/1926180.1926204
2. Barlow, T., Neville, P.: A comparison of 2-d visualizations of hierarchies. In: IEEE Symposium on Information Visualization, InfoVis 2001. pp. 131–138 (2001)
3. Brusilovsky, P., Chavan, G., Farzan, R.: Social adaptive navigation support for open corpus electronic textbooks. In: De Bra, P., Nejdl, W. (eds.) Third International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (AH'2004). Lecture Notes in Computer Science, vol. 3137, pp. 24–33. Springer-Verlag (2004)
4. Brusilovsky, P., Somyürek, S., Guerra, J., Hosseini, R., Zadorozhny, V., Durlach, P.: Open social student modeling for personalized learning. IEEE Transactions on Emerging Topics in Computing **4**(3), 450–461 (2016)
5. Ericson, B.J., Guzdial, M.J., Morrison, B.B.: Analysis of interactive features designed to enhance learning in an ebook. In: Proceedings of the Eleventh Annual International Conference on International Computing Education Research,ICER '15. pp. 169–178. ACM (2015)
6. Farzan, R., Brusilovsky, P.: Social navigation support through annotation-based group modeling. In: Ardissono, L., Brna, P., Mitrovic, A. (eds.) 10th International User Modeling Conference. Lecture Notes in Artificial Intelligence, vol. 3538, pp. 463–472. Springer Verlag (2005)
7. Farzan, R., Brusilovsky, P.: Social navigation. In: Brusilovsky, P., He, D. (eds.) Social Information Access: Systems and Technologies, pp. 142–180. Lecture Notes in Computer Science, Springer, Cham (2018)
8. Guerra, J., Hosseini, R., Somyürek, S., Brusilovsky, P.: An intelligent interface for learning content: Combining an open learner model and social comparison to support self-regulated learning and engagement. In: Proceedings of the 21st International Conference on Intelligent User Interfaces (IUI '16). pp. 152–163. ACM (2016)
9. Guerra, J., Parra, D., Brusilovsky, P.: Encouraging online student reading with social visualization. In: AIED Workshops (2013)
10. Hsiao, I.H., Bakalov, F., Brusilovsky, P., König-Ries, B.: Progressor: social navigation support through open social student modeling. New Review of Hypermedia and Multimedia **19**(2), 112–131 (2013)
11. Kokkodis, M., Kannan, A., Kenthapadi, K.: Assigning educational videos at appropriate locations in textbooks. In: Proceedings of the 7th International Conference on Educational Data Mining (EDM). pp. 201–204 (2014)
12. Ondov, B.D., Jardine, N., Elmqvist, N., Franconeri, S.L.: Face to face: Evaluating visual comparison. IEEE Transactions on Visualization and Computer Graphics **25**, 861–871 (2018)
13. Treder, M.S.: Behind the looking-glass: A review on human symmetry perception. Symmetry **2**(3), 1510–1543 (2010)
14. Wang, S., Walker, E., Wylie, R.: What matters in concept mapping? maps learners create or how they create them. In: André, E., Baker, R., Hu, X., Rodrigo, M.M.T., du Boulay, B. (eds.) Artificial Intelligence in Education. pp. 406–417. Springer International Publishing, Cham (2017)
15. Zyto, S., Karger, D., Ackerman, M., Mahajan, S.: Successful classroom deployment of a social document annotation system. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 1883–1892. CHI '12, ACM (2012)