PAPER

Influence of Access to Reading Material during Concept Map Recomposition in Reading Comprehension and Retention

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SUMMARY This study investigated the influence of reading time while building a closed concept map on reading comprehension and retention. It also investigated the effect of having access to the text during closed concept map creation on reading comprehension and retention. Participants from Amazon Mechanical Turk (N = 101) read a text, took an after-text test, and took part in one of three conditions, "Map & Text", "Map only", and "Double Text", took an after-activity test, followed by a two-week retention period and then one final delayed test. Analysis revealed that higher reading times were associated with better reading comprehension and better retention. Furthermore, when comparing "Map & Text" to the "Map only" condition, short-term reading comprehension was improved, but long-term retention was not improved. This suggests that having access to the text while building closed concept maps can improve reading comprehension, but long term learning can only be improved if students invest time accessing both the map and the text.

key words: *concept map, Kit-Build, reading comprehension, recomposition*

1. Introduction

Reading comprehension is a process of connecting new information to prior knowledge [1]. When education shifts from early reading skills to understanding the content and attaining new information in texts, some students start falling behind [2]. This happens more often in students from low-income families [3]. Concept mapping is one technique that can support reading comprehension [4]–[8]. Concept maps are graphical tools that represent knowledge. Concept maps are composed of propositions, which are made up of two concepts and one link. The link represents the relationship between the two concepts. One explanation of how concept maps help comprehension is the idea that they provide a template, which helps organizing and structuring information [9]. Another explanation is that graphical structures, like a concept map, are closer to the macro structure of a text, which makes it easier to understand [10]. Furthermore, building the map allows students to continuously process the concepts [11]. Concept maps can also help with retention [9], [11]. This is important because learners benefit from remembering more information for later use.

When building concept maps, users usually start from a blank page and write all concepts and links. One alternative to this method are closed concept maps [12], [13]. In closed concept maps, the labels in the concepts and links are predefined. Not only is it predefined, but the learner often cannot change those labels. Not having the ability to freely change labels might seem like it limits the creativity of learners. However, it produces a different learning experience where users are tasked with trying to make sense of the thoughts of another person. One study has shown that closed concept map construction can have better retention for learners than traditional concept mapping [14].

Closed concept maps are often built while having access to a text [14]–[16]. However, one alternative is to not allow students to have access to the text while building the map. Instead, students would read the text before building the map and then lose access to it. Having no access to the text would make students have to rely on their memory and understanding of the content. By forcing students to have to remember, this could have an enhancing effect to the retention of the content. Building the map could be similar to a test in the testing effect [17]. On the other hand, by allowing users to have access to the text while building the map, they would be able to come revisit the text while building the map. By doing so, students might be able to cover up the parts they do not understand. Furthermore, handling two medias at the same time could increase access to memory, enhancing retention. At the same time, having two medias available could increase cognitive load, which can impair learning [18].

Given the above, verifying if having access to the text during closed concept map creation is beneficial or not to learning is necessary. As far as the authors know, this comparison has not been done before.

This work presents an activity of closed map construction integrated with text reading. It also investigates the learning properties of such an activity by verifying how reading time affects learning. It compares the group performing the activity with two control groups. The research questions of this study are whether reading time affects (1) reading comprehension and (2) reading comprehension retention. Whether students having access to text reading while building closed concept maps affects (3) immediate reading comprehension gains, and (4) retention of the reading comprehension gains are also research questions. The experiment group builds the closed concept map while having access to the text. One of the control groups builds the

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closed concept map without having access to the text. This group will be used to answer research questions (3) and (4), since the only difference between the two groups is the presence of the external resource. The other control group will read the text material one more time without building the map. This group mainly works as a baseline for both groups to give better context to the results.

2. Traditional Concept Mapping, Closed Concept Mapping, and Recomposition-Based Concept Mapping

This study uses recomposition-based concept mapping, which is a special type of closed concept map. The cognitive implications of traditional concept mapping, closed concept mapping, and recomposition-based concept mapping will be explored in this section. This study does not use traditional concept mapping, but the cognitive implications of the other approaches become more evident by comparing it to the traditional method.

Concept maps are graphic organizes, which help finding, organizing, and understanding information [19], [20]. As graphic organizers, concept maps have various advantages for finding and organizing information [20]. Graphic organizers can also help understand information from text. While there are many ways to use concept maps in education, one method is to give an empty canvas to the students and ask them to build a concept map based on a given subject. The students are then free to create any link or concept they want as in the Traditional concept Map Creation (TMC). In contrast, instead of giving an open canvas and full freedom in the composition activity, the students concept mapping options can be limited to only use predetermined terms for labelling the links and concepts. Concept map composition activity, which uses predetermined resources, is referred to a closed concept map assembling (CMA) in this study.

If users do not have access to the text, TMC involves free recall, where students think about nodes and links freely while trying to remember relevant information. There are no pre-defined terms and labels to guide them through the process. This is different from CMA. Also, deciding when the map is "done" becomes the job of the student. As such, the size of the map will depend on the judgement of the students. This contrasts with CMA, where students tend to use every term in the map. Using every possible piece available will inform the student that he is done with the map.

Still on the subject of users not having access to the reading material, one might think that CMA is easier than TMC, acting as a scaffolder for TMC. However, the activities are different in multiple ways. In TMC, to build a proposition, the user has to remember relevant information, translate a portion of it into a proposition and then translate that proposition into two concepts and a link. In CMA, to build a proposition, the user has to find two related nodes, access their memory to find a relationship between them and find, among the provided links, the one which best describes that relationship. TMC involves freely deciding the labels of links and nodes while doing free recalls of the information obtained before. CMA, however, involves cued recalls and constantly searching pieces while the students try to fit their knowledge into foreign pieces. Past studies indicate that cued recalls are more beneficial than free recalls [21], [22].

On the other hand, if users do have access to the reading material, then TMC users can rely on the text to build the map. One study has shown that, TMC, when compared to CMA, is more likely to have users build the maps by going sentence-by-sentence in the text [15]. Reading sentence-by-sentence has been associated with poor learning performance as a reading strategy [23]. One study that compared CMA with TMC, both having access to the reading material, indicated that students that used CMA have higher test scores after a two-week retention period [14]. The authors of that study argued that CMA outperformed TMC because students had to deeply process the text, while also looking at the entire text to build the map. This could be interpreted as CMA inducing a higher cognitive load on students. This way, if the CMA has a large number of pieces, it is hard to argue that CMA is easier than TMC.

To make this difference clearer for the reader, one good metaphor would be "writing a text" and "organizing the paragraphs of a text". It is hard to say that organizing the paragraphs that someone else wrote is an "easier version" of writing your own text, since they require different skills. Both activities have their own purpose in learning environments. Similar to how CMA and TMC each have their own purpose in learning. The benefits to reading comprehension and retention discussed in the introduction can be attributed to the cognitive differences between the two approaches discussed so far.

One concern on TMC and CMA is that CMA might limit creativity. However, past studies have shown that constraints can foster creativity [24], a bit of a paradox. Since CMA imposes more constraints than TMC, one could argue that it fosters creative thinking. Nevertheless, students may sometimes want to express an idea that is not possible with the pieces of the map. To reap the benefits of both TMC and CMA, a study has combined both into a single tool [25]. In this combined activity, users build a map using CMA and then extend it by freely deciding nodes and links, in a similar fashion to TMC. Students had access to the text in printed format while building the map. Results suggest better learning and better structure in the concept maps when compared to pure TMC. However, how that interacts with creative thinking was not discussed and it is still an open field for investigation.

TMC and CMA have been implemented in computer-based tools. These computer-based concept mapping tools have been used to improve reading comprehension [14], [26], [27] and learning in general [28]–[30]. Multiple advantages of computer-based tools have been pointed out in the past, such as ease of correction and construction [31], the capability to add behavior-guiding constraints [32], creation process personalization, and frustration reduction [33].

The automation of diagnosis is another strong advantage of computer-based tools. One study used semantic web technologies to automatize diagnosis [34]. Another study scored the maps using word proximity data [35].

Another option for automation of diagnosis is by comparing the student constructed map in a CMA context with an expert constructed map. Concept map tools that provide automatic diagnosis by expert map comparison are Cmap-analysis [36], Kit-Build [12], [37], CRESST [38], KAS [39], and ICMLS [13]. The expert map comparison is made trivial because the maps are closed concept maps. Since they are built from the same pieces, it is possible to display exactly in which ways the student map differs from the expert map. This type of automatic diagnosis was found to correlate with standard science tests [40] and was found to be reliable when compared to traditional map scoring approaches [41], [42]. Kit-Build, in particular, has been deemed accepted by students as a tool for concept map creation through the TAM questionnaire [43]. It has also been used to measure changes in interdisciplinary learning during high school [44]. With the diagnosis information, teachers can revise their lessons and give more precise feedback. This approach has shown good results in retention when compared to traditional teaching, especially when the teacher uses the map to give the feedback [45]. This type of automatic diagnosis also allows for automated feedback, which has been effective for improving reading comprehension [13].

While not offering as much freedom as traditional concept maps, users still have a variety of ways to express their own ideas by using closed concept maps. As such, the concept of a “correct map” or of a “goal map” is not obligatory in closed concept maps. However, there are two types of learning activities that involve recomposing a goal map using closed concept maps. Since the closed concept map construction used in this research is recomposition-based, it will be explored below.

2.1 Recomposition-Based Concept Maps

One situation where recomposition-based concept maps is used was described above with expert map recomposition. In that scenario, the pieces of the closed concept map are made up by decomposing the expert map. Students then attempt to recompose the expert map. However, sometimes the student can express valid ideas that are not present in the expert map. Some tools will go beyond simply scoring the map and will also show the teacher exactly how different the student map is from the expert map. With this information the teacher can decided whether or not to explore those matters further in class.

Another situation is the one found in reciprocal Kit-building [46]. In this study method, it is not an expert map that is being recomposed, but the map of a fellow student. In one reciprocal Kit-building study, the students designed their own map by freely designing links [47]. The students then attempt to build the map of each other as a closed concept map. In this case, the goal map is the map made by a fellow learner and the students are aware of this.

Both situations involve communication. Teachers are able to grasp the understanding of students by comparing the expert map to the map of the student. In reciprocal Kit-building, students actively build the map of their partner. When trying to build these maps, the students have no choice but to try to make sense of the pieces somebody else chose. We believe that empathetic understanding is a strong factor in this process. Empathetic understanding is the ability to understand things from the frame of reference of another person. It is less about finding the correct answer and more about understanding how another person thinks. The pieces of the closed concept map act like a scaffold to facilitate communication. Vygotsky framed learning as a social activity, where learning happens through communication with others [48]. When learning is seen as a social activity, this facilitation of communication becomes a facilitation of learning in itself.

3. Kit-Build

Kit-build is a learning framework that uses CMA with digital concept maps as one of its learning strategy. It provides a set of concept map components—the kit—for student to recompose into a complete concept map [37]. When students recompose the map, they reflected and structured their understanding and knowledge in the form of a concept map with only the provided kit. Even though there is yet a standard on how the kit should be designed, represented, or implemented; essentially, a Kit-build kit can be made from the decomposition of teacher concept map with concept and link nodes as its main components to recompose. In Kit-build concept map, one link node can only be connected to one source concept node and one target concept node to form a complete proposition; hence, the uniqueness of how a concept map be represented in Kit-build.

Several studies have used Kit-build in studying various learning subjects, including one that supported learning English as a Foreign Language (EFL) reading comprehension [49] and also several studies that supported online collaborative use [16], [50], [51]. The studies emphasized how reading becomes one determining factor in learning with Kit-build concept map.

Since the initial development of its authoring tool, Kit-build has several concept map authoring features on its composition tool, including supports to generate concept maps from text [52], [53] and support to automate the layout composition of concept map [54]. One of the important features the tool provides is the ability to show the learning content while recomposing the kit into a complete concept map. Students could have access the reading while they recomposed the kit. Said feature can be optionally disabled or enabled by the system as necessary; hence, the research questions of this study. This study does not employ automated layout or authoring tools because the goal is learning, not allowing for ease of use. Automated layout has been

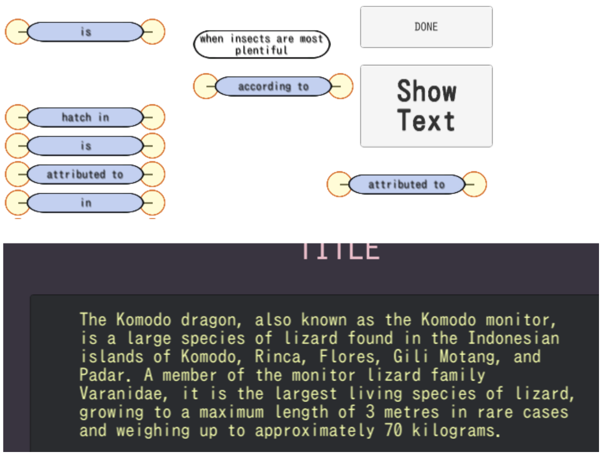

Fig. 1 The Kit-Build interface with the show button text and the interface for seeing the text. The text interface cannot be visualized at the same time as the map

shown to allow for maps to be built faster but it diminishes learning gains in Kit-build [54].

A screenshot of Kit-Build used in this study can be seen in Fig. 1. The Kit-Build interface is featured in the upper side of the screenshot. Blue gizmos are links. White gizmos are nodes. When the activity begins, all links and nodes are listed in columns. To create propositions, users have to drag gizmos in the links to the nodes. Users can drag-and-drop the various elements in the map. Users cannot change the labels in the link and the nodes. Furthermore, for this study, Kit-Build has been customized to include a button that allows students to visualize the text related to the map. The text visualizing interface can be seen on the lower side of Fig. 1.

4. Method

This study used a between-subjects design with three conditions: "Map & Text", "Map only", and "Double Text". There was no overlap between the groups. The experiment had a main phase and an optional delayed phase. Analyses are done using quantitative methods from test results. In the main phase, participants were required to:

- Read tool instructions ("Double Text" does not do this);
- Build the training map using Kit-build ("Double Text" does not do this);
- Read a narrative;
- Take the comprehension after text test;
- Perform their main activity depending on the condition ("Map & Text" build the map while being able to access the text, "Map only" builds the map with no access to the text, "Double Text" re-reads the text);
- Take the comprehension after activity test.

Participants who completed the main phase were invited to participate in the delayed phase. The delayed phase consisted of the same comprehension post-test used in the main phase, but with a delay of two weeks. A timeline for this experiment can be seen in Fig. 2.

4.1 Participants

Participants were recruited through Amazon Mechanical Turk (AMT). AMT is an amazon-run crowdsourcing system where requesters can hire remotely located crowdworkers to perform tasks. AMT has been used in past research in various fields and past research has attested for the quality of the data collected using the platform [55]. Participants were recruited in two different periods, between January and February of 2019 ("Map only" users) and between December of 2020 and January of 2021 ("Map & Text" and "Double Text"). There was no overlap between conditions and none of the users had experience with Kit-build before. Participants were required to be residents of the U.S. and were also required to have completed more than 5000 tasks on AMT with an approval rate above 97%. This was done to ensure quality and avoid automated programs from participating in the experiment. Participants were also required to use a computer while participating since the experiment was not optimized for mobile devices. Participants who had to build the map were paid \$2.50 upon completion of the activities. Participants who did not build the map were paid \$1.85 upon completion. This difference in payment is due to the fact that the people who did not build the map were expected to expend less time during the main phase since reading the text one more time is faster than building the map. Participants who agreed to take the delayed post-test received an additional \$0.80.

4.1.1 Materials

The text used described various characteristics of the Komodo dragon. It is a modified, shorter version of a text found in Wikipedia[†]. The text has 2701 words and has an academic tone. The comprehension after-text and after-activity tests contained the same questions. The questions consisted of ten multiple choice questions created to test the content of the text. An English native speaker who is a University teacher of English as a second language verified the test and found no problems with it. The map participants were requested to build was based on the text and on the reading comprehension exercises. The expert map used in this experiment had seventeen concepts and seventeen links. Since each link corresponds to a proposition, it contained seventeen propositions. The expert map was built based on the text.

Those materials have been used in other studies by 49 people. Those people were divided into two groups randomly. There are no differences between the groups at the moment they first performed the test. On Table 1, test scores for the first time they performed the test can be observed for

[†]https://www.researchgate.net/publication/329555664_Dataset_Experimental_use_of_Airmap_and_Kitbuild_by_using_a_concept_map_about_Komodo_Dragons

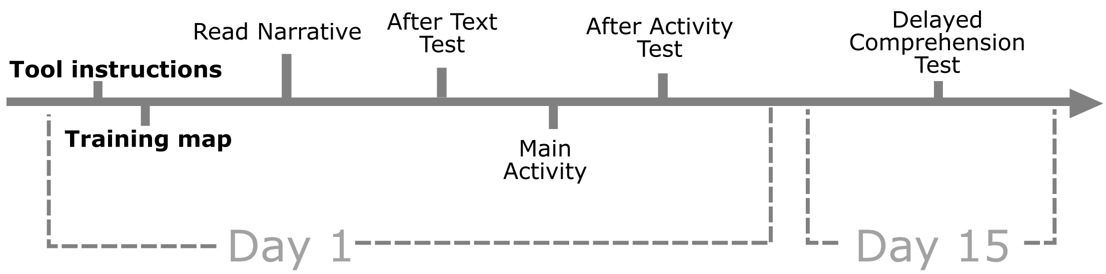

Fig. 2 Timeline for the Experiment. The steps in bold are only performed by the two conditions that build the concept map. The "main activity" is different for each condition. "Double Text" re-reads the text, "Map & Text" builds the map while having access to the text, and "Map only" only builds the map for the main activity.

Table 1 Mean and Standard Deviation of Test scores for all learners who answered the test answers after reading the text

Group	N	Test Scores
Session 1	24	0.58 (0.22)
Session 2	25	0.65 (0.22)

all groups.

Since all groups were drawn from the same population (Amazon Mechanical Turk users), we expect those scores to be similar if the test is reliable. This is confirmed by looking at the standard deviations and differences in average. Since the standard deviation is quite larger than the difference in means for this number of samples, it is assumed that there are no significant differences between the groups without the need of performing statistical tests.

To help testify further for the validity of the material, the correlation between the time the student took to read the text and the test scores was calculated for the participants of this study. The motivation for this is because it is assumed that if the test and the text are closely related, students who spend more time reading should have an advantage when doing the test. A statistically significant positive correlation between reading time and test scores was found, $r = 0.35$, $p < 0.001$. These results suggest that the there is a relationship between the questions in the test and the content of the text.

4.2 Procedure

The experiment was delivered through a website. Participants belonged to three conditions. The conditions are "Map & Text", "Map only", and "Double Text". Two of these conditions built the concept map as part of the experiment.

First the procedure for users who built the map will be introduced. From this point it is already clear the participant is aware that there will be an optional delayed phase. Those participants are informed about how their data will be used, the purpose of the experiment, the fact that they can stop the experiment at any time, and other information. Participant then proceeded to read instructions on how to use Kit-build. Afterward, they would build the training map to get used to Kit-build. The training map consisted of three concepts and three links. The content of this training map had no relation to the rest of the experiment. After building the training map, participants from both groups read the narrative and answered the after text test. Following the 'after text test', participants had to build the map related to the text using Kit-build. "Map & Text" participants had access to the text while building the map. "Map only" participants had no access to the text. Participants then answered the after-activity test, ending the main phase of the experiment. All activities in the main phase had a 5-minute limit, except for building the map, which had a 20-minute limit. The reason behind the limit is because if the activities do not have a time limit, Amazon Mechanical Users might take a long time to complete the experiment by taking long pauses. This could affect the results so the time has been limited and, from the experience of the authors in past experiments, the time allotted is enough to complete the task. Participants who did not build the map did the above procedure without reading instructions on how to use Kit-Build. Additionally, they did not build any concept maps. Their main activity was re-reading the text.

Two weeks later, participants were contacted by email to take part in the optional delayed phase. A shorter wait period (a week or two days) would possibly lead to more users coming back for the delayed phase but it would also be less interesting for measuring retention of information. The delayed phase consisted of the same comprehension test taken in the after text and after activity tests. Participants did nothing else other than answer the comprehension test. For the analysis of the data, scoring the test is straightforward since it contains multiple answer questions with only one correct answer.

The maximum retention period for a particular user is 16 days and the minimum retention period is 12 days. This is because of how Amazon Mechanical Turk Works. This also means that participants could have done the delayed phase in a different time of the day from the regular phase. The influence of this difference in retention time is not part of the scope of this paper.

5. Results

101 people completed the experiment successfully. Of these users, only 63 completed the delayed test. The distribution

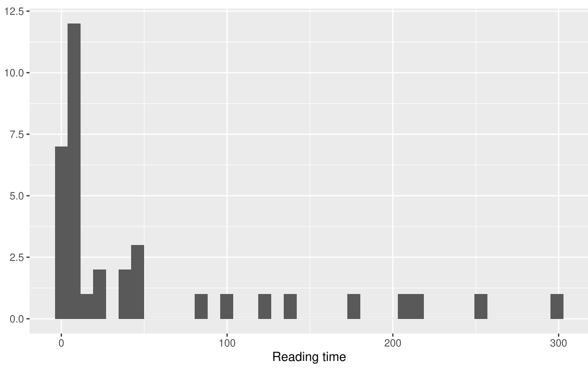

Fig. 3 Histogram of reading time while building the map for the Map&Text condition

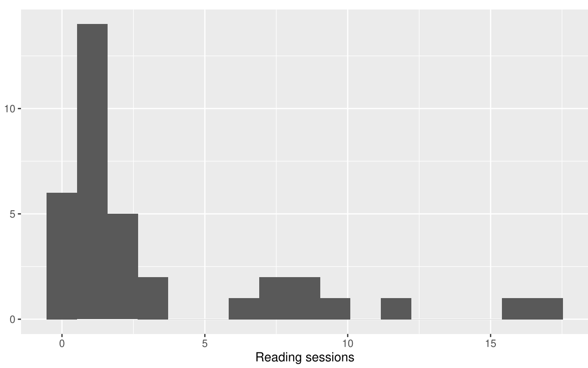

Fig. 4 Histogram of the number of reading sessions while building the map for the Map&Text condition

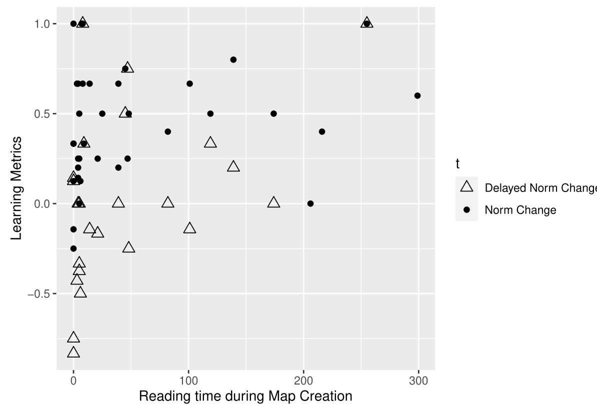

Fig. 5 Normalized Change and Delayed Normalized change against Reading Time while building the map for the Map&Text condition

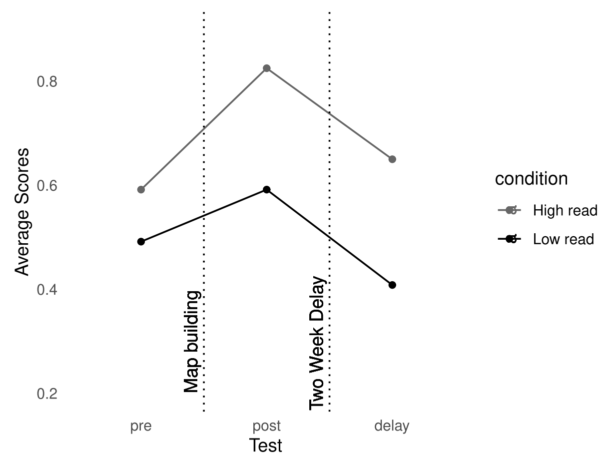

Fig. 6 After text, after activity and delay score averages for participants who built the map with access to the text, divided between users with high text reading time and low reading time

of reading time for the Map&Text condition can be seen in Fig. 3. There are two peaks for the lowest values of reading time, suggesting that a large portion of users spent little time reading the text while building the map. Figure 4 shows the distribution of the number of reading sessions. There are peaks similar to Fig. 3, suggesting similar distributions for read times and for the number of reading sessions. This means that users with a higher value of reading sessions spend more time reading, which is expected. Most users only read the text for one session and did it for a short amount of time. Figure 5 shows the relationship between learning gains and reading time during map creation. While users who have low reading times have widely varying performance, increases in reading time seem correlated with better performance in learning, but it is hard to understand the whole picture with just that graph. Figure 6 can better illustrate the differences in learning caused by differences in reading time. In that figure, users from the Map&Text condition are divided in half. One half has the users with high read times (N=12). The other half has the users with low reading time (N=12). From looking at the graph, users who read more have better improvements both in short-term gains and after two weeks.

To address the first research question, whether reading times while building a closed concept map affect immediate reading comprehension, we performed a linear regression model with after-map scores as the dependant variable, reading time as the predictor, and after-text scores as a control variable. The model was fitted with a multiple R-squared value of 0.83. Reading time was identified as a significant predictor ($p < 0.001$) of immediate reading comprehension when controlling for after-text scores.

To address the second research question, whether reading times while building a closed concept map affects reading comprehension retention, we performed a linear regression model with delay test as the dependant variable, reading time as the predictor, and after-text test scores as a control variable. The model was fitted with a multiple R-squared value of 0.44. Reading time was identified as a significant predictor ($p < 0.01$) of reading comprehension retention when controlling for after-text scores.

Mean and standard deviation for relevant metrics can be seen in Table 2, while similar metrics for people who completed the delayed post-test can be seen in Table 3. On Fig. 7, how test scores varies through time can be visualized.

To address the third research question, whether students having access to text reading while building a closed

Table 2 Mean and standard deviation of measured statistics for all groups

Group	N	After-text Test	After-map test	Norm. change
Double Text	35	0.61 (0.19)	0.73 (0.20)	0.35 (0.39)
Map Only	30	0.64 (0.24)	0.67 (0.24)	0.04 (0.43)
Map & Text	36	0.55 (0.21)	0.71 (0.22)	0.44 (0.32)

Table 3 Mean and standard deviation of measured statistics for all groups, only for the participants who completed the delayed test

Group	N	After-text Test	After-map test	Delay Test	Norm. change	Delayed Norm. Change
Double Text	19	0.63 (0.16)	0.74 (0.18)	0.51 (0.19)	0.29 (0.38)	−0.18 (0.33)
Map & Text	24	0.54 (0.20)	0.71 (0.23)	0.53 (0.25)	0.42 (0.34)	0.02 (0.47)
Map Only	20	0.64 (0.19)	0.66 (0.18)	0.56 (0.20)	0.08 (0.29)	−0.11 (0.30)

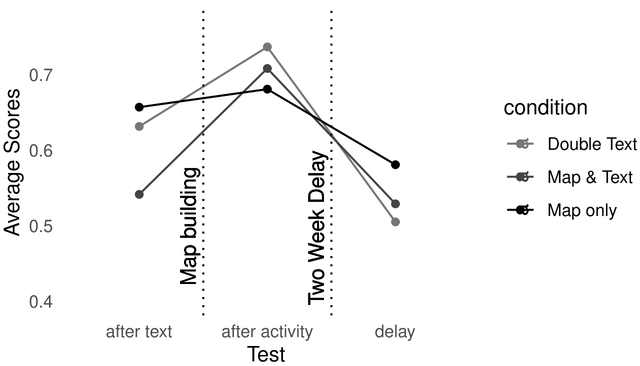

Fig. 7 After text, after activity and normalized change scores for all participants

concept map affects immediate reading comprehension gains, we performed a Kruskal-Wallis test with normalized change as the dependent variable and condition as the predictor. The Kruskal-Wallis revealed a main effect of condition on normalized change (chi squared = 9.95, $p < 0.01$). Post-hoc comparisons using Dunn's test revealed that normalized change for the "Map & Text" (Med = 0.45) was significantly higher than normalized change for the "Map only" (Med = 0), $p < 0.001$. No other pairwise comparisons were significant.

To address the fourth research question, whether students having access to text reading while building a closed concept map affects the retention of reading comprehension gains, we performed a Kruskal-Wallis test with delayed normalized change as the dependent variable and condition as the predictor. Condition did not have a significant effect on delayed normalized change.

5.1 Exploratory Analysis on the High Read Group

The research questions of this study have already been answered. However, results so far show that many users of the Map&Text group have low reading times. Results also have shown that higher reading times have been associated with better learning results. As such, the following two exploratory research question comes to mind: do students with high reading times while building the map outperform the two control groups in (1) reading comprehension gains and the (2) retention of reading comprehension gains?

To address the first exploratory research question, whether high reading time students have better reading comprehension gains than the two control groups, we performed a Kruskal-Wallis test with normalized change as the dependant variable and condition as the predictor. The Kruskal-Wallis revealed a main effect of condition on normalized change, chi squared = 14.30, $p < 0.001$. Post-hoc comparisons using Dunn's test revealed that normalized change for the high read users (Med = 0.58) was significantly higher than normalized change for the MapOnly users (Med = 0), $p < 0.001$ and significantly higher than normalized change for the "Double Text" users (Med = 0.33), $p = 0.01$.

To address the second exploratory research question, whether high reading time students have better retention of reading comprehension gains than the two control groups, we performed a Kruskal-Wallis test with delayed normalized change as the dependant variable and condition as the predictor. The Kruskal-Wallis revealed a main effect of condition on normalized change, chi squared = 7.33, $p = 0.03$. Post-hoc comparisons using Dunn's test revealed that normalized change for the high read users (Med = 0) was significantly higher than normalized change for the MapOnly users (Med = −0.18), $p = 0.02$ and significantly higher than normalized change for the "Double Text" users (Med = −0.25), $p = 0.01$.

5.2 Discussion

The main finding of this study is that higher reading times while building the map are associated with better reading comprehension both in the short and long term. However, a large portion of users have low reading times, suggesting that making the text available while building the maps is not enough to improve long term learning for the group as a whole. Short term reading comprehension, however, is improved significantly just by having access to the text. This suggests that learning gains obtained by users who quickly read are not committed deeply into memory and might give a false idea of learning achievements by the students. It is believed that the improvement on long term learning are caused by having to translate between two different media (the text and the map). Searching for information in the text and organizing it in the map results in a high number of access to the working memory of the student. This is believed to result in higher retention of that information.

6. Conclusion

Results suggest that having high reading times in parallel with building closed concept maps enhances reading comprehension and retention. Furthermore, many users have low reading times during closed concept map creation. These findings potentially have broad applications for improving reading comprehension, since finding a way to improve reading times during closed map construction enhances both immediate comprehension and retention. One important limitation of these results is that only one material was used to obtain these results. The properties found on this experiment could be limited to this material. For future works, measuring whether or not these results are applicable to more materials is one important task. Also, whether or not incentivizing reading will result in better comprehension and retention is also necessary.

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