# Cohesion/Knowledge Interactions in Post-tutoring Reflective Text

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**Abstract.** In a previous paper we showed that providing a reflective/abstractive text can significantly improve how much middle motivation students learn from qualitative physics tutoring. In this paper we further find that the effect can be substantially improved by adjusting the cohesiveness of that text according to these students' level of prior knowledge. However, in contrast to previous work in the field, we find that our high knowledge students learned significantly more from *high* rather than low, cohesion text.

**Keywords.** Tutoring, reflection, textual cohesion.

## Introduction

In previous work [5], we described a method of improving learning from the Itspoke qualitative physics tutor by giving students a reflective/abstractive text to read after tutoring. This text compared how certain physics concepts (e.g. Newton's Laws) had been applied in different problem situations, which we expected would encourage students to generate better and more abstract representations of those concepts. Our results showed that learning by middle motivation students was substantially improved.

In this paper we further ask if the *cohesiveness* of that text makes it more or less effective. We define cohesion as the extent to which logical, causal or temporal relationships in the text are explicitly stated. In the absence of cohesion, these relationships within a text have to be inferred by the reader. McNamara and her colleagues (e.g. [4]) have shown an interaction between textual cohesion and student knowledge. Students with low domain knowledge sometimes learn better from texts with *high* cohesion. Students with higher domain knowledge can learn better from texts with *low* cohesion.

In this paper we will investigate whether cohesion has similar effects in our reflective/abstractive text. Following McNamara, we hypothesize that our high pre-testers will learn more from a low cohesion text because its cohesive gaps will trigger inference and learning. We expect this inference will improve the students' situation model, and so improve retention for these readers as measured by a delayed post-test. We will also use the

same division of students into "high" "middle" and "low" motivation groups as reported previously [5], and investigate interactions between motivation and cohesion.

## 1. Study Design, Results and Discussion

In this experiment we use Itspoke, a qualitative physics spoken dialog tutor which is described more completely in [5]. Before tutoring, subjects read background material about physics principles, then took a multiple-choice pre-test to measure their physics knowledge. After this, they engaged the Itspoke tutor in dialogs about five qualitative physics problems. Then they read a post-tutoring reading, then took a post-test which was isomorphic to the pre-test. One week later they returned to take a delayed post-test.

The Itspoke tutor was identical for all subjects, and the only difference between conditions was the content of the post-tutoring reading. In this paper we compare the effects of a high cohesion version of the post-tutoring reflective text (the "hiCoh" condition) to a low cohesion version of the reflective text (the "loCoh" condition).

| | **loCoh** | **hiCoh** |
|---|---|---|
| loPre | 17 | 13 |
| hiPre | 17 | 19 |

Table 1.Subject Dist.

As described more completely in [5], subjects were recruited using an extreme groups design [2]. Subjects in the middle third of the pre-test score distribution were dismissed after the pre-test. Subjects with higher scores were retained as high pre-testers ("hiPre"), and subjects with lower scores were retained as low pre-testers ("loPre"). 27 of the remaining students were removed because of incomplete data, and 66 of those remaining were randomized into one of the two cohesion conditions. Their distribution between knowledge category (hiPre, loPre) and cohesion condition (hiCoh, loCoh) is shown in Table 1. As described in [5], we further subdivide these subjects by motivation level. For middle motivation subjects average N per cell was about six.

Both "high" and "low" cohesion versions of our reflective text had similar structure and semantic content. However, the high cohesion version was written to remove places in which inference would be required to understand the low cohesion text. For example, referring expressions were made more consistent, and causal and logical relations that were only implied in the low cohesion version were spelled out.

These differences made the low cohesion text, at 1,541 words, shorter than the high cohesion text, which had 2,161 words. Relevant CohMetrix [3] measures of cohesion were consistently higher for our high cohesion text, supporting the conclusion that cohesive gaps were more prevalent in the low-cohesion text, as we intended.

**RESULTS:** An anova explaining Normalized Learning Gain (NLG: [post-pre]/[1-pre]) by motivation category (high, mid or low), pre-test category (hiPre or lowPre), cohesion category (hiCoh or loCoh), and their interactions showed a significant three way interaction between motivation category, knowledge level and cohesion type, on the delayed measure of NLG. This suggests that the hypothesized interaction between knowledge level and cohesion type is different at different levels of student motivation.

Next, following the analysis reported in [5], we separately examine the two way interaction between knowledge and cohesion at each of the three levels of motivation. As shown in Table 2, we found that this interaction was significant on the delayed measure of NLG, for students with middle motivation. Middle motivation students also showed a trend toward an interaction on the immediate measure of learning. Highly and poorly motivated students had very non-significant interactions.

| | pValues | | | Mean Norm. Learning Gain | | | |
|---|---|---|---|---|---|---|---|
| NLG | | | preTest | hiPre | | loPre | |
| Measure | preTest | Cond | : Cond | hiCoh | loCoh | hiCoh | loCoh |
| Immediate | 0.535 | 0.284 | **0.071** | 0.479 | 0.306 | 0.364 | 0.476 |
| Delayed | 0.638 | **0.006** | **0.003** | 0.506 | 0.102 | 0.180 | 0.312 |

**Table 2.** Knowledge/cohesion interactions for middle motivation students.

As can be read from the right four columns of Table 2, our low pre-testers learned more from the low cohesion reflective text than from the high cohesion text. In contrast, the high pre-testers learned more from the high cohesion reflective text.

Post-hoc Tukey-HSD tests indicated that the difference in NLG between cohesion conditions was not significant for the high pre-testers on the immediate post-test ($p = 0.22$), and also not significant for the low pre-testers on either the immediate ($p = 0.79$) or delayed ($p = 0.73$) post-tests. However, the high pre-testers did learn significantly more from high than from low cohesion text, as measured by the delayed post-test ($p = 0.001$).

**DISCUSSION:** This work shows for the first time that the *cohesiveness* of a reflective text significantly affects learning, and suggests that manipulating cohesion could be helpful for certain students. However the direction of the effect was opposite to what we expected. Other work has shown that high knowledge readers tend to engage and learn more from text (e.g. [1]). We suspect that this effect swamped the effect of low cohesion in triggering inference. Our high knowledge students engaged both texts, and learned more from the text with more explicitly stated content. Our low knowledge readers knew enough physics to make inferences but, having "middle" rather than "high" motivation only did so when triggered by cohesive gaps. This caused them to learn more (although not significantly more) from low cohesion text.

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## References

[1] Boscolo, P., Mason, L.: Topic knowledge, text coherence, and interest: How they interact in learning from instructional texts. The Journal of Exp. Education 71(2), 126–148 (2003)

[2] Feldt, L.: The use of extreme groups to test for the presence of a relationship. Psychometrika 26(3), 307–316 (1961)

[3] Graesser, A., McNamara, D., Louwerse, M., Cai, Z.: Coh-metrix: Analysis of text on cohesion and language. Behavior Research Methods, Instruments, and Computers 36, 193–202 (2004)

[4] McNamara, D.: Reading both high-coherence and low-coherence texts: Effects of text sequence and prior knowledge. Canadian Journal of Exp. Psychology 55, 51–62 (2001)

[5] Ward, A., Litman, D.: Adding abstractive reflection to a tutorial dialog system. Proc. 24th Intl. FLAIRS (Florida Artificial Intelligence Research Society) Conference (2011)