The Effect of Text in Understanding Photosynthesis Among University Students With Different Learning Strategies

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Abstract. The purpose of this study was to investigate how a refutational text supports university students with different regulation and processing strategies in understanding photosynthesis. Pre- and posttest design was used. Participants were 91 student teachers who were randomly assigned to refutational and non-refutational text groups. Our study indicated that a refutational science text supports university students' learning more effectively than a traditional, non-refutational text. In addition, those students who process the learning materials deeply and self-regulate their learning achieved more sophisticated understanding than those who reported lack of regulation and stepwise processing. Our study may have implications for development of science text books in university level, where independent studying across different domains is required.

Keywords: Refutational text, science learning, conceptual change, self-regulation, processing strategies

Introduction

The understanding of science phenomena, such as photosynthesis, often suggests conceptual change, which can be defined as a revision of prior representations (e.g. Duit 1999). According to previous research, fact-centered science texts seem not to support conceptual change effectively enough. Refutational texts have been shown to be more effective than traditional texts in facilitating conceptual change with a variety of science topics (see e.g. Alvermann & Hynd 2001; Mikkilä-Erdmann 2001). A refutational text is a particular kind of text design which systematically tries to point out the differences between students' thinking and scientific notions and assist the learner in revising his/her mental model (Hynd 2001). Individual characteristics of learners, such as the regulation and processing strategies (see Vermunt 1998), may also play a role in revising mental models supported by text (see Sinatra & Mason 2008).

As there are very few refutational text studies targeted at adult students, the purpose of this study is to investigate 1. How does a refutational versus a non-refutational text affect conceptual understanding concerning photosynthesis among university students? 2. How are students' regulation and processing strategies related to conceptual understanding?

Method

Participants were 91 Finnish second year student teachers who were between 19 and 48 of age (M = 24, SD = 6). Twenty (22 %) of the participants were male. The study was based on a pre- and posttest design, where the participants were randomly assigned to refutational and non-refutational text groups. In the pretest ($N = 91$) students answered eight open-ended questions about photosynthesis. After that, they read either a refutational ($n = 45$) or a non-refutational ($n = 46$) text concerning photosynthesis. The factual contents of the texts were the same and their lengths were nearly equal. In the refutational text there were two extra paragraphs concerning the previously diagnosed misconceptions (see e.g.

Chi 2008; Roth 1990). After reading, participants answered the same eight open-ended questions again. After two weeks, a delayed posttest was conducted, which was a replication of the eight pre- and posttest questions. The participants also answered 42 items from the adapted version of an Inventory of Learning Styles (ILS) (Vermunt 1998) on a five-point Likert scale (1 = I totally disagree, …, 5 = I totally agree).

Data analysis

Based on the text and questions, an analysis tool, where a total of 12 links connected central concepts of photosynthesis according to scientific model, was constructed. Participants' representations in all three tests were analysed and scored with the tool (scientific links +2 p, simplified links +1p, false links -2p). The reliability of the analysis was 81%. The level of previous knowledge between students who read a refutational or a non-refutational text was compared using a t-test for independent samples and examined further by using previous knowledge as a covariate in repeated measures ANOVA. Participants' performance between the tests was compared using paired samples t-tests. Repeated measures ANOVA were administrated in order to compare participants' performance between the text type groups as well as between the groups of students with different learning strategies.

Principal component analyses with Varimax rotation were administered first to the 20 items concerning processing strategies (KMO .75, Bartlett $\chi^2(153) = 549.87$, $p < .001$), and secondly the 22 items about regulation strategies (KMO .675, Bartlett $\chi^2(105) = 470.11$, $p < .001$). Based on these analyses, five sum variables with satisfactory Cronbach alpha values were formed: stepwise prosessing ($\alpha = .83$), deep processing ($\alpha = .82$), self-regulation of the learning content ($\alpha = .82$), self-regulation of learning processes and results ($\alpha = .74$) and lack of regulation ($\alpha = .69$). Further, a cluster analysis with all the sum variables was performed. Based on theoretical expectations, a two cluster model was applied. The groups were named according to their typical characteristics. Repetitive and support-dependent learners (n = 35, 82.4% female, 17.6% male) process the study materials in a stepwise fashion, do not self-regulate their learning and experience lack of regulation. Deep and independent learners (n = 48, 76.6% female, 23.4% male) process the study materials deeply, self-regulate their learning and do not experience lack of regulation.

Results

There was no statistically significant difference between the experimental and control groups before text reading, which indicates that the groups were comparable ($t\ (89) = .71$, $p > .05$). When we used the pretest scores as a covariate in repeated measures ANOVA, it was noticed that previous knowledge was related to learning outcomes similarly in both text type groups ($F\ (1, 83) = .51$, $p > .05$).

In the pretest participants achieved score on average 10 of 24 (M = 9.84, SD = 7.05). In the posttest, students' average score was 16 of 24 (M = 16.20, SD = 5.26) and it increased highly significantly when compared to the pretest ($t\ (90) = -10.60$, $p < .00$). Participants' average score decreased slightly in the delayed posttest being 16 of 24 (M = 15.54, SD = 5.17). However, the difference between the pretest and the delayed posttest remained highly significant, which indicates that the scores of the participants remained relatively high ($t\ (86) = -8.71$, $p < .00$).

A repeated measures ANOVA with text as between subjects factor was administered. Our results indicate that students who read a refutational text improved their scores significantly more between the pre- and posttest than students who read a non-refutational text ($F\ (1, 89) = 4.89$, $p = .03$). However, when we compared the text type between the pre-, post- and delayed posttest, there was not a

significant interaction effect with different text type and measurement time ($F\ (2, 12) = 2.80, p = .08$). Nevertheless, a significant difference in quadratic correlations of different text types was discovered ($F\ (1, 85) = 5.00, p < .03$).

Next, we analysed how regulation and processing strategies are related to conceptual understanding with repeated measures ANOVA. Our results show that deep and independent learners performed significantly better from pre- to posttest compared to repetitive and support-dependent learners ($F\ (1, 79) = 5.51, p < .03$). The success of students with different learning strategies was also examined between the pre-, post- and delayed posttest and it became apparent that there was only an indicative interaction effect with different text type and measurement time ($F\ (2, 14) = 3.14, p = .06$). However, a significant difference in quadratic correlations between students with different learning strategies was discovered ($F\ (1, 77) = 5.37, p = .02$). Thus, deep and independent learners outperformed the repetitive and support-dependent learners even from pretest to delayed posttest. Finally, the effects of different texts on performance of different learners were compared. We investigated with repeated measures ANOVA, how students with different regulation and processing strategies benefit from different texts. No statistical interaction effect was detected ($F\ (1, 77) = .002, p > .05$), but there seemed to be a weak trend that repetitive and support dependent learners benefit more from a refutational text whereas deep and independent learners' success does not seem to be related to text type.

Discussion

To conclude, a refutational science text supported university students' learning more than a traditional, non-refutational text. In addition, those students who process the learning material deeply and self-regulate their learning achieved more sophisticated understanding than those who reported lack of regulation and stepwise processing. Furthermore, our study may have implications for development of science text books in university level, where independent studying across different domains is required.

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