Attitudinal Gains from Engagement with Metacognitive Tutors in an Exploratory Learning Environment

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Abstract. MILA–T (MILA–Tutoring) is constructed to give students explicit instruction on scientific modeling and inquiry, intending in part to help cultivate positive attitudes toward science. The results of a two-week controlled experiment using MILA–T in middle school classroom show a significant effect of MILA–T on students' attitudes towards science.

Keywords: Attitudes toward science; metacognitive tutoring; middle school education; scientific inquiry; scientific modeling.

1 Introduction

Middle school science education carries metacognitive learning goals: students learn about scientific inquiry and modeling to reflect on and regulate their knowledge of science [6]. Attitudinal learning goals on curiosity, skepticism, and positive argumentation are addressed [2]. Here, we examine whether metacognitive tutoring helps improve middle school students' attitudes toward science, scientific inquiry, and careers in science. Our hypothesis is that metacognitive tutors improve students' attitudes towards these topics. We present a controlled experiment with an exploratory learning environment called MILA (**M**odeling & **I**nquiry **L**earning **A**pplication, [3]) that evolves from the ACT system [4], and a metacognitive tutoring extension called MILA–T (MILA-**T**utoring), in which access to MILA–T was varied. Attitudinal surveys were given before and after engagement, and we report changes to these scores.

2 Experimental Design & Results

Students participated in the intervention for approximately 50 minutes per day for nine days. Students completed attitudinal surveys on the first and last days and participated in a seven-day curriculum in between. The survey measured five constructs: Attitude Toward Scientific Inquiry [1], Career Interest in Science [1], Anxiety toward Science [5], Perception of the Science Teacher [5], and Desire to Do Science [5]. This study is a controlled experiment. In the control condition, students received MILA without MILA–T enabled during the seven-day curriculum. In the experimental con-

adfa, p. 1, 2011.

dition, MILA–T is available to the students, providing individualized, situated feedback on the model construction process. 237 students participated in the intervention, with 99 in the control condition and 138 in the experimental.

The primary question of this research is whether changes in students' scores on these metrics changed over the course of the intervention based on exposure to MILA–T. To answer this question, we conducted a multivariate analysis of variance. First, we examined whether students were roughly equivalent on the given metric prior to the intervention. Then, we examined whether students' scores on that metric changed, and whether those changes were connected to the experimental condition.

Prior to the intervention, no significant relationship between attitude toward scientific inquiry and condition existed. Analysis of the overall change to attitude toward science inquiry revealed no significant change overall. However, breaking the groups down by condition revealed a statistically significant ($p < .05$) difference between the two groups. Students in the experimental group experienced an average increase of 1.46 points on their attitude toward scientific inquiry score ($\sigma = 7.16$). Students in the control group, on the other hand, experienced an average *decrease* of 1.16 points on their attitude toward scientific inquiry score ($\sigma = 6.33$). Thus, students interacting with MILA–T experienced a statistically significant increase in their attitudes toward scientific inquiry compared to students without MILA–T. Students in the experimental condition concluded the study with a higher ($p < .05$) attitude toward scientific inquiry ($\mu = 22.14$, $\sigma = 7.73$) than those in the control condition ($\mu = 20.02$, $\sigma = 7.44$).

Prior to the intervention, no statistically significant relationship existed between career interest in science and condition. Analysis of changes within groups revealed that students in the experimental group experienced a statistically significant increase in their career interest in science ($p < .05$) of 2.03 points ($\sigma = 6.01$). Students in the control group, on the other hand, no significant increase. These results indicate that participation with MILA–T led to an increase in career interest in science, while participation without MILA–T did not.

3 References

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