Interventions to Regulate Confusion during Learning

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Abstract. Experiences of confusion have been found to correlate with learning, particularly for learning at deeper levels of comprehension. Previously, we have induced confusion within learning environments that teach critical scientific reasoning. Confusion was successfully induced with the presentation of contradictory information and false feedback. Next, we would like to regulate experiences of confusion to increase learning. In the current paper, we propose a series of experiments that investigate potential interventions to help regulate confusion during learning. Specifically, these experiments will address the impact of feedback specificity and emotional support.

Keywords: confusion, contradiction, false feedback, affect, tutoring, intelligent tutoring systems, scaffolding, learning

1 Introduction

Learning is an emotional experience and confusion is one emotion that plays a particularly important role in learning [1]. Learners experience confusion when they are confronted with an anomaly, contradiction, or system breakdown; and are uncertain about how to proceed. Although confusion has been correlationally linked to learning, it is unlikely that the mere experience of confusion promotes deep learning. Instead, confusion creates opportunities for learning because it causes students to stop, reflect, and begin active problem solving to resolve their confusion. These cognitive activities enable learners to work through confusion and acquire a deeper understanding of complex topics [2]. Hence, our working hypothesis is that learning can be increased if intelligent tutoring systems (ITSs) can capitalize on the benefits of confusion.

To take advantage of the benefits of confusion, an ITS must include events that *trigger* confusion in learners, *track* and monitor learner experiences of confusion, and provide support so that learners can *regulate* confusion. Previously we have conducted experiments to address the induction and tracking of confusion [3]. However, we have not yet addressed the third task: regulating confusion. We propose a series of three experiments that will test the effectiveness of interventions to regulate learner experiences of confusion in order to increase positive learning outcomes.

2 Previous Research

We have experimented with confusion induction techniques within learning environments that promoted the learning of scientific reasoning concepts (e.g., experimenter bias, replication). In these experiments, learners engaged in either a trialogue with two pedagogical agents (tutor and student) (Experiments 1, 2, 3, and 5) or a dialogue with one agent (tutor) to diagnose flaws in hypothetical research studies (Experiment 4). Confusion was induced through the presentation of contradictory information by two agents in Experiment 1, 2, 3, and 5 [3]. Confusion was successfully induced when the two agents presented opposing opinions and asked the learner to pick one side. In Experiment 4, we induced confusion using false system feedback. After learners attempted to diagnose the flaw in a study, the tutor agent delivered either accurate or inaccurate feedback. We found that learners who responded correctly but received negative feedback (e.g., "That's wrong.") were more confused than learners that received accurate feedback.

In addition to confusion induction, we also investigated methods to track learner confusion. The accuracy of learner responses immediately following the manipulations was used to track confusion in the contradictory information experiments, such that incorrect responses were indicative of being in a state of confusion. In the false feedback experiment, learners were asked to self-report experiences of confusion after receiving feedback. Through response quality and strategically placed self-report probes, we have been able to track learner confusion with minimal interruption to the learning process.

There is evidence that partial or complete resolution of confusion can increase learning, particularly at deeper levels of understanding [4]. The two systems discussed above do not currently provide any support for the regulation or resolution of learner confusion. However, increased learning was still found in both experiments. We expect that interventions that help learners regulate and potentially resolve confusion will further increase learning.

3 Future Research Plans

Confusion regulation interventions will be investigated within an ITS that discusses scientific reasoning topics. Learners will engage in trialogues with two agents (tutor and student) while diagnosing the flaws in research studies. Confusion will be induced through the presentation of contradictory information by the two agents and tracked through a combination of response accuracy and strategically placed self-report probes. We will compare interventions based on *feedback specificity* and *emotional support* to help learners regulate their confusion.

In previous experiments learners have provided self-explanations (SEs) after they diagnosed the flaw in a research study, but were not given feedback about SE quality. We hypothesize that elaborated feedback on SE quality will facilitate confusion regulation. To test this hypothesis we will test the impact of feedback specificity on confusion regulation (Proposed Experiment 1). Learner-generated SEs will first be classified as correct or incorrect and then incorrect SEs will be further classified based

on the type of error present. We have already developed mechanisms to facilitate the classification of learner SEs [5]. The tutor agent will either provide *no feedback*, *non-elaborated feedback only* (e.g., "That's correct"), or elaborated feedback. For elaborated feedback the tutor agent will first deliver feedback and then either provide the correct answer (*feedback + correct answer*) or correct the specific error that was present in the SE (*feedback + error correction*). Feedback that is tailored to specific errors is expected to facilitate confusion regulation and ultimately improve learning [6].

Proposed Experiment 2 will investigate emotionally supportive interventions in response to induced confusion. It is hypothesized that learners view confusion as indicative of failure and is a threat to their self-concept of intelligence [7]. We will test two types of emotional support to help learners change these negative attributions of confusion. In one condition the tutor agent will serve as an "encouraging and supportive mentor" for the learner by providing *general encouragement* (e.g., "I know you can figure this out!"). To specifically address learner misgivings about confusion, the tutor agent will explain the benefits of confusion (*confusion reappraisal*). We expect that directly targeting learner beliefs about confusion will be more effective for confusion resolution than general encouragement. Finally, Proposed Experiment 3 will compare the most effective interventions from Experiments 1 and 2.

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