

# Design of Agent Prompts as Scaffolding for Productive Reflection in an Intelligent Learning Environment

Longkai Wu and Chee-Kit Looi

National Institute of Education, 1 Nanyang Walk,  
Singapore 637616

longkai.wu@gmail.com, cheekit.looi@nie.edu.sg

## Abstract

This study tries to investigate whether agent prompts, acting as scaffolding, can promote students' reflection when they act as tutor through teaching the agent tutee in a learning-by-teaching environment. Two types of agent prompts are contrasted in this research, both from the perspective of a tutee, differing in their specificity. Generic prompts are content-independent tutee questions, aiming at fostering students' general reflection on metacognitive strategies and beliefs. Specific prompts, on the other hand, are content-dependent tutee questions that encourage students' specific reflection on domain-related and task-specific skills and articulation of their explanatory responses. The result indicates that designers on intelligent learning environment should concentrate on fostering students to reflect on their metacognitive strategies and beliefs, and allow students to take responsibility for directing their own learning autonomy.

**Keyword:** Reflection Prompts, Scaffolding, Learning-by-Teaching

## I. Introduction

The ability to carry out meaningful reflection is considered as indicative of the highest level of deep learning [1]. Question prompts, as the literature suggests, can be an effective way of fostering reflection [2], because they provide the cognitively complex ways learners think about, feel about,

and make connections in experience [3]. Specially, recent research shows the evidence of learning benefits to tutors from tutee's question prompts in the context of peer tutoring [4, 5]. Roscoe and Chi [6] note that tutee questions can motivate tutor explanations and metacognition, and thus have a significant and positive influence on the tutor's learning activities and opportunities.

Previous research in intelligent learning environments has demonstrated that question prompts can be positive in fulfill a number of cognitive and metacognitive functions (e.g., [7, 8]). Meanwhile, mechanisms of supporting self-explanation, tutorial dialog or reflective dialog have been prevalent in traditional intelligent tutoring systems (ITS), in which the computer plays the role of tutor (e.g. Cognitive Tutor [9], AutoTutor [10]). However, little research has addressed the different types of question prompts as scaffolding strategy to guide the learner's reflection with a computer simulated tutee when playing the role of tutor in learning-by-teaching context.

In this paper, we investigate the use of agent tutee as an active and inquisitive learning partner to scaffold student to elicit general or specific reflection when taking the role of a tutor in an adapted learning-by-teaching agent environment, Betty's Brain [11]. We compare two types of agent prompts to address the challenge to facilitate reflection of student tutor. Specific prompts (SP), as the specific tutee questions, are content-dependent and provide students a structure through the learning-by-teaching process. They lead the students to complete the specific cognitive task and articulate their explanatory responses. On the other hand, generic prompts (GP), as general tutee questions, are content-independent and stimulate students to monitor their learning-by-teaching processes and consider various perspectives and values regarding their learning-by-teaching activities.

The remainder of the paper is organized as follows. First, we present an overview of agent prompts generation in the adapted Betty's Brain. Second, the classroom study and the results of how these agent prompts deliver their proposed benefits to middle school students in learning-by-teaching environment are provided. Lastly, conclusions and future directions for this work are described.

## II. Agent Prompts Generation

### Overview

The design and implementation of agent prompts are within the Betty's Brain system (Figure 1) [11]. The purpose of generating agent prompts is to enhance the learning-by-teaching agent environment, reifying the epistemic, metacognitive, task-specific and domain-related reflection of students involved in such an environment, by forming a student-agent reflective dialogue.

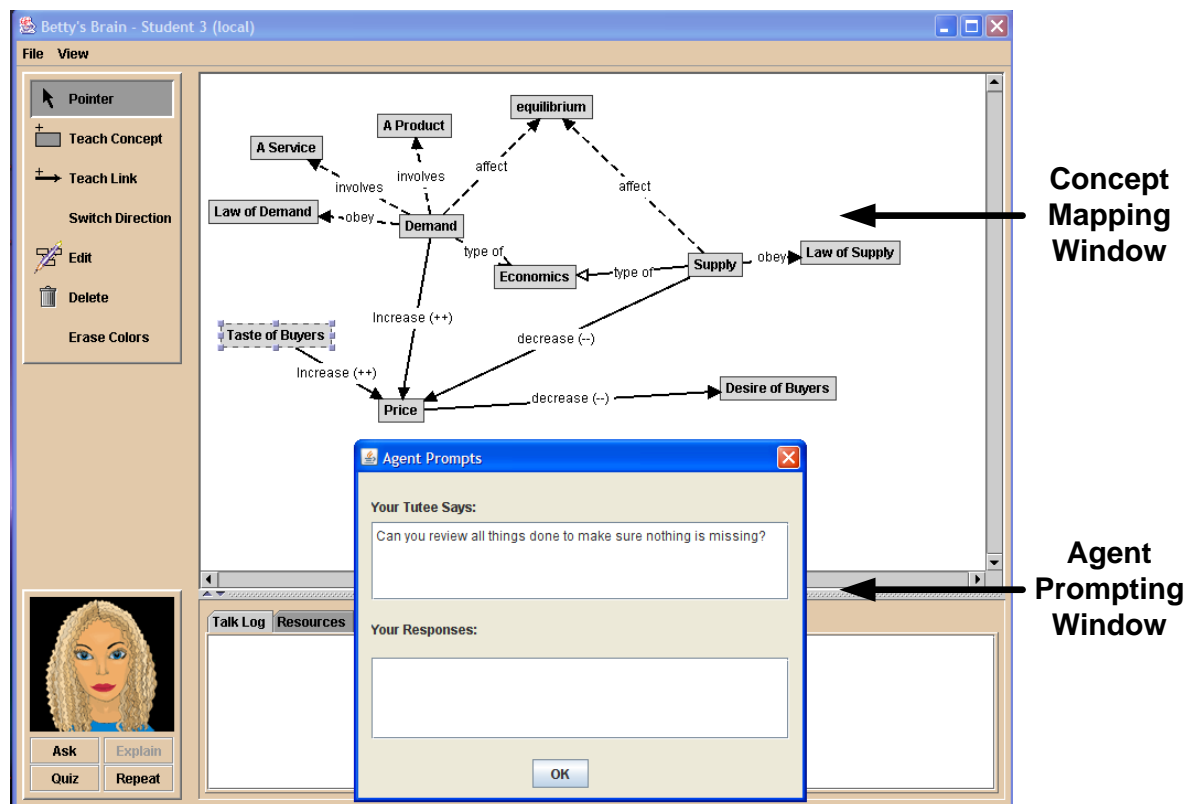


Figure 1. Adapted Betty's Brain with Agent Prompts

### Reflection Types

We design agent prompts to foster two major types of reflection for students in the learning-by-teaching environment based on the three levels of instruction [12] for designing metacognitive components. (i) General level (ii) Domain-related level (iii) Task-specific level

- General Reflection is content-independent, stimulates students to monitor their learning-by-teaching processes and consider various perspectives and values regarding their learning-by-teaching activities.
- Specific Reflection is content-dependent, provides students a structure through the learning-by-teaching process and leads them to complete the specific cognitive task and articulate their explanatory responses

***Patterns and Agent Prompts***

Table 1 shows the samples of patterns found in student maps and appearing corresponding agent prompts stored in the repository.

*Table 1. Patterns in Student Map*

<b>Pattern</b>	<b>Description</b>
<b>Missing Expert Concepts</b> (e.g. Missing “Income” concept)	Generic Prompts: “Can you review all things to check for missing important parts to teach me and give me an explanation?” Specific Prompts: “Do you consider that you could teach me the concept of ‘Income’ and give me an explanation?”
<b>Incorrect Expert Concepts</b> (e.g. Incorrect “Electricity” concept)	Generic Prompts: “Can you stop and review each part in the map to see if you have made a mistake and give me an explanation?” Specific Prompts: “Do you want to reconsider the concept of ‘Electricity’ you teach me and give me an explanation?”
<b>Incorrect Expert Links</b> (e.g. Incorrect Link between “Opportunity Cost” and “Demand”)	Generic Prompts: “Can you stop and review each part in the map to see if a mistake has been made and give me an explanation?” Specific Prompts “Do you want to reconsider the link of ‘Determine’ between ‘Opportunity Cost’ and ‘Demand’ you teach me and give me an explanation?”
<b>Missing Expert Links</b> (e.g. Missing Link between “Income” and “Demand”)	Generic Prompts: “Can you review all things done to make sure nothing is missing and give me an explanation?” Specific Prompts: “Do you consider teach the link between ‘Income’ and ‘Demand’ and give me an explanation?”

### III. Pilot Study

To investigate the impact of agent prompts to student's reflection and learning, we took a pilot study on 33 students from two local secondary schools (ages ranged from 13 to 15) on a voluntary basis. They were randomly assigned to one of three conditions. Eventually, 29 students (76%), 20 female (69%) and 9 male (31%) completed all activities of the experiment, resulting in the following division over the three conditions: no prompts (NP) condition as control group:  $n = 10$ , specific prompts (SP) condition:  $n = 10$  and generic prompts (GP) condition:  $n = 9$ ,

Figure 2 indicates that the three conditions were in the approximately same level in pretest while both the two prompted conditions (GP and SP) outperformed the non-prompted condition in the posttest.

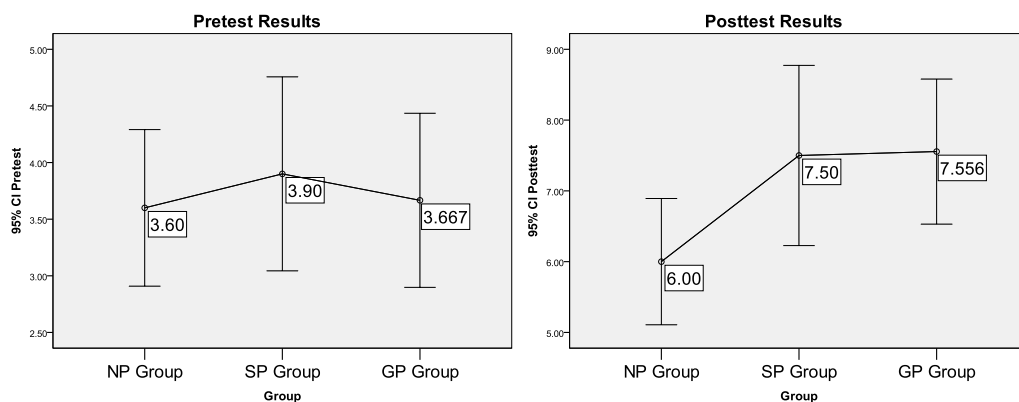


Figure 2. Domain Knowledge Pre- and Post-Test Results

The ANOVA test of domain knowledge pretest-to-posttest gains indicated a significant effect of the two prompted conditions compared to the non-prompted condition ( $F(2, 25) = 20.145$ ). The calculation of pre test-to-posttest effect sizes (Cohen's  $d$ ) showed a prominent difference between the SP group ( $d = 2.37$ ) and the GP group ( $d = 3.30$ ). However, the pair-wise comparison showed

that there was no significant difference (Sig. = .154) between the SP and GP groups as to the learning gains from pretest to posttest.

### III. Conclusion and Future Work

In this study, we explored the inquisitive agent tutee as a learning partner in learning-by-teaching activities. Overall results in learning outcomes showed that the agent prompts did add value and encouraged student in reflection and achieving better learning outcomes because the prompted students performed better, on pretest-to-posttest gains than non-prompted students. Students generated better response statements more frequently when they received generic prompts than specific prompts. Based on the analysis of response statements, it was concluded that the generic prompts did promote deeper contemplative reflection and specific prompts elicited more reactive reflection.

Future work of this study should be on exploring the relationship between agent prompts and intellectual flow. The answers will provide an in-depth understanding of intellectual enjoyment that students encounter when using agent tutee systems as learning partners.

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**Longkai Wu** is currently a Research Associate in Learning Sciences Lab, National Institute of Education, Singapore. His current research interests include intelligent tutoring system, agent technology and computer supported collaborative learning.



**Chee-Kit Looi** is Professor in the National Institute of Education, Nanyang Technological University. His recent research related to technology-enabled learning involves design and development of digital manipulatives to bridge model methods to algebraic methods; implementing innovations like SimCalc, Group Scribbles and mobile technologies in Singapore classrooms.