A Framework to Understand the Nature of Co-Regulated Learning in Human-Pedagogical Agent Interactions

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Abstract. Contemporary research has examined the learning process through the lens of self-regulated learning (SRL) while relatively little effort has been given to examining human tutors' (HTs) or pedagogical agents' (PAs) role in supporting learners' development of SRL strategies. This paper addresses this shortcoming by outlining the design of an emerging coding scheme that facilitates the examination of co-regulated learning (CoRL) between a human learner and artificial PAs within the context of learning with MetaTutor, an intelligent tutoring system (ITS).

Keywords: Co-regulated learning, self-regulated learning, externally-regulated learning, intelligent tutoring systems, pedagogical agents

1 Co-Regulated Learning: the Missing Puzzle Piece

Contemporary research has examined the learning process through the lens of self-regulated learning (SRL) while relatively little effort has been given to examining human tutors' (HT) or pedagogical agents' (PAs) role in supporting learners' development of SRL. Failing to take into account the potential role of co-regulated learning (CoRL; i.e., interplay between learners and agents) leaves us with a gap in our understanding between how learners engage in and improve their SRL during learning and the role that HT and/or PAs play in this process. This shortcoming must be addressed in order to provide researchers with a lens through which to examine the effectiveness of human tutors and PAs prompts and feedback, and in doing so, provide theoretical and methodological tools to better gauge the degree of scaffolding learners require to internalize SRL processes while interacting with human tutors and PAs.

There are a variety of terms available to describe regulated learning including SRL, externally regulated learning (ERL), co-regulated learning (CoRL), and socially-regulated learning (SRL). We hold that CoRL is the most appropriate process to describe the interaction between learners and regulating agents (i.e., PAs and/or HTs) because of the emphasis placed upon examining the interactive role that each agent plays in supporting and developing SRL with the outcome goal being for the learner to be able to regulate learning independently both alone and within a group setting [1].

Hadwin [2] described three types of research recently conducted in the area of co-regulation in different educational contexts. First, researchers have assessed how learners interact with and speak with others so they can work independently and self-regulate their own learning. A second area of research has focused on how each member of a group has a role in regulating all members' learning in a collaborative work space. The third focus of research analyzes the processes which are influenced by social settings that enable co-regulation to occur.

A few researchers [3–5] have assessed CoRL in computer-based learning environments. All three studies used a coding scheme to assess the dialogues that stemmed from the interactions between the students. These studies support the importance of examining interactions between all members involved in learning because of the crucial role of communication in facilitating effective collaboration and successful learning.

2 Proposal: A Framework for Understanding Human –PA Interactions with ITSs

2.1 Purpose

This proposal outlines a coding scheme that can examine CoRL between a learner and PAs in a multi-agent ITS, MetaTutor. Our coding scheme and subsequent findings will help us address the following research questions for which there is little empirical research: (1) are there identifiable patterns in human-PA dialogue turns in which both human learners and PAs contribute toward regulated learning? (2) What do these patterns look like (e.g., instructional and learning strategies)? (3) How do these patterns relate to learners' prior knowledge, achievement (e.g., learning gains) and embodiment of different emotional states? And (4) are there differences between various co-regulated learning dialogue patterns in terms of increases in self-initiated (internalized) SRL behaviors over the course of a learning session?

2.2 MetaTutor

We are currently addressing these research questions in MetaTutor, a multi-agent ITS designed to train, model, and foster students' SRL while learning about the human circulatory system. The primary goal underlying the design of MetaTutor is to investigate how advanced learning technologies can adaptively scaffold SRL within the context of learning about complex biological topics [6]. As a learning tool, MetaTutor has a host of features that foster self-regulated learning embodied by four PAs who: (1) guide students through the two-hour learning session; (2) prompt them to engage in planning, monitoring, and strategic learning behaviors; and (3) provide feedback and engage in a tutorial dialogue in order to scaffold students' selection of appropriate sub goals, accurate metacognitive judgments, and use of particular learning strategies. Currently, our development of the CoRL-HPA (co-regulated learning – human peda-

gogical agent) framework is informed by the sub goal setting task that learners engage in with the assistance of one of the MetaTutor PAs to set three appropriate sub goals.

2.3 Development of the CoRL-HPA Framework

In our review of the literature regarding dialogue patterns, co-regulated learning, and intelligent tutoring systems, we identified Graesser and colleagues' [7] five-step dialogue frame as a good starting point to code and situate human and PA dialogue. The five-step dialogue framework was originally developed in the context of tutoring with a HT, though it was later imported into AutoTutor's (an ITS) dialogue management facilities [8] and additional dialogue patterns have since been coded and used in research with AutoTutor [9]. We found that applying the five-step dialogue framework to the sub goal setting task allowed us to code many of the PA-learner dialogue interactions, including several (e.g., tutor splices in a complete or partial answer, tutor gives hint), but not all instances of tutorial feedback. Furthermore, we found that given the difference in contexts between (1) a HT vs. a PA providing feedback to a learner and (2) the specific context of the sub goal setting task in MetaTutor, that some of the steps and contents of the steps of Graeser et al.'s [7] framework were not relevant (e.g., *step 5:* "tutor assesses student's understanding of the answer" (p. 505)). As a result of these differences, our coding framework consists of four steps, which we were able to use to code a sample of 20 participants' sub goal setting task episodes (see Table 1). Codes are a combination of those from the five-step framework and others which emerged inductively from the content of the sub goal setting task log files. Coding was done at the dialogue-turn level. While the CoRL-HPA framework is still under development, it is a promising tool for analyzing learner-PA interactions and co-regulated learning in particular, and will help us address numerous gaps in our understanding of regulated learning.

Table 1. Coded Human-PA Dialogue Example Using the CoRL – HPA Framework

1 - PA Makes Request	
"OK, let's set up some sub goals then."	No coding
2 - Student Responds (proposes a sub goal)	
"I would like to learn about the different parts of the circulatory system"	Competency Code: 1.1. Related to the Human Circulatory System
3 - PA Gives Short Feedback (tries to improve quality of sub goal or summarizes its understanding of sub goal)	
"That's good, but I think it might not be specific enough to focus on an achievable sub-goal. I think 'Blood vessels' or 'Blood components' relate to what you stated. Which one would you like to learn about?"	Tutorial Strategy Code: 1.2. PA splices in the correct answer with feedback to student.
4 - Student Responds (either accepts or rejects one of the PA's suggestions, or confirms PA's understanding)	
"Blood vessels"	No coding

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