BEEweb: A Multi-Domain Platform for Reciprocal Peer-Driven Tutoring Systems

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Abstract. Tutoring systems that engage each student as both a tutee and a tutor can be powerfully enhanced by motivating each tutor to try to appropriately challenge their tutee. The BEEweb platform is presented as a foundation upon which to build such systems, based upon the Reciprocal Tutoring protocol and the Teachers Dilemma. Three systems that have recently been built on the BEEweb platform are introduced.

1 Introduction

Educational research on peer tutoring has shown beneficial effects on the achievement and attitude of the tutors and tutees [1]. These peer-driven methodologies have more recently been introduced into the arena of Intelligent Tutoring Systems [2]. Our SpellBEE system incorporated a reciprocal tutoring approach, in which each participating student is engaged both as tutor and tutee [3]. Over 12,000 people have used SpellBEE during its first two years online at `http://SpellBEE.org`. This work has informed the development of a platform upon which tutoring systems could be built to leverage the Reciprocal Tutoring protocol and the Teachers Dilemma. This platform, called BEEweb, was designed to enable the rapid development of highly-scalable new tutoring systems that require minimal domain expertise to prepare. Here, we describe the core protocols of the BEEweb platform and three recently-released tutoring systems in different task domains built on this platform.

2 Reciprocal Tutoring and the Teachers Dilemma

All web-based tutoring sessions using BEEweb systems have a common structure: Initially, each student is presented a list of pseudonyms of other currently-available students and must indicate whom they are willing to be matched with. Mutual interest between two students initiates a match between them consisting of a fixed number of rounds of interaction. The structure of these rounds defines the Reciprocal Tutoring (RT) protocol. Each round is a four-step process that the pair of students synchronously progress through. From the student's perspective, one round consists of the following steps:

1. Student assumes the **Tutor** role by preparing a challenge for their Tutee.
2. Student assumes the **Tutee** role by preparing a response to their Tutor.
3. Student is given feedback about the response that they prepared in Step 2.
4. Student is given feedback about how their Tutee responded to the challenge that they prepared in Step 1.

While the RT protocol[1] specifies the structure and progression of the interactions among a pair of students, it makes no attempt to motivate or influence the student's actions when preparing challenges and responses. The Teachers Dilemma refines this RT protocol (TD-RT) with an extrinsic motivational mechanism biasing the tutor towards selecting *appropriate challenges* [3]. This is accomplished by adding the following constraints:

a The difficulty of any challenge in the task domain can be estimated.
b The accuracy of a response to a challenge in the domain can be assessed.
c The feedback provided in Step 3 and Step 4 is supplemented with a role-specific reward. Acting as Tutee, the student is rewarded for response accuracy; acting as Tutor, the student is rewarded for selecting challenges that reveal the tutee's strengths and weaknesses (see [3] for more details.)

3 BEEweb Tutoring Systems

Each BEEweb tutoring system applies the TD-RT protocol to a different task domain by uniquely specifying the domain's *challenge* and *response* structures, the user interface *toolkits* for interacting with these structures, and the challenge *difficulty estimators*.[2] Each new BEEweb system is introduced accordingly.

PatternBEE (`http://PatternBEE.org`) focuses on a spatial-reasoning task, loosely based on Tangram puzzles, in which a challenge is an outline of a geometric shape, and a response is an arrangement of available pieces attempting to fill one such outline. The challenge toolkit consists of a space into which the tutor drags, rotates, flips the pieces. The response toolkit is similar, but also presents an outline of the target goal shape. PatternBEE estimates the difficulty of a challenge based on the number of pieces required and perimeter of the outline.

MoneyBEE (`http://MoneyBEE.org`) focuses on a coin-based elementary algebra task, in which a challenge characterizes a set of coins by its combined value and number of coins, and a response is a guess at how many of each type of coin was being described. The challenge toolkit consists of stacks of coins, from which the tutor selects some number of quarters, dimes, nickels, and pennies. The response toolkit is similar, but also states the challenge (in terms of number of coins and combined value.) Challenge difficulty estimates are based on the number of steps required for a heuristic search algorithm to reach a solution.

[1] The protocol can be further elaborated as follows: In Steps 1 and 2, the challenge and the response are each either selected from a list of options or constructed from a suitable toolkit. In Steps 3 and 4, the feedback generally includes the challenge posed, the response submitted, and the correct response to the challenge.

[2] Our own student programmers do this now, and we expect to release a public API.

GeograBEE (`http://GeograBEE.org`) focuses on a geographical knowledge domain, in which a challenge contains a question about one of the states in the U.S. Three categories of questions are currently deployed: (a) identify the capital city in the specified state, (b) locate the specified state on a map of the U.S., or (c) identify a state by an illustration of its boundaries. The challenge toolkit is divided into two steps: first choosing a state on the map about which to pose a question, and then selecting one of the three types of questions to ask about that state. The response toolkit for the identification-based questions (categories a and c) states the question in multiple-choice form, from which the tutee must make a selection. The response toolkit for the location-based questions (category b) state the question and display a map, upon which the tutee clicks to respond. Challenge difficulty estimation in GeograBEE currently takes into account the specific state and question category selected.

All of these BEEweb systems have been deployed to publicly-accessible websites, each of which has been instrumented to collect action and interaction data. Now that these websites are being used by students, both in and out of the classroom, we are beginning to accumulate this data for analysis.

4 Challenges and Future Work

The initial research aim of the BEEweb was to convincingly determine whether the TD-RT protocol can serve as a principled basis for peer learning while requiring minimal curriculum domain expertise and content costs. Many new research challenges and opportunities presented themselves once the platform was built. For example, we are working on replacing the hand-built difficulty estimators with adaptive ones based on statistical analysis of student match data, using techniques similar to Conejo et al. [4]. We are also experimenting with ways of using collected data to further enhance the tutoring experience (by making portions accessible to the student and their parents, teachers, and peers.) Finally, we are developing programming tools for others to develop and contribute their own reciprocal tutoring systems to the BEEweb.

References

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