Learner Characteristics and Feedback in Tutorial Dialogue

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Introduction

• Goal: Mixed-initiative NL tutorial interaction yielding both learning and self-efficacy gains
• Tutoring is complex:
  – Cognitive
  – Affective
  – Student-specific adaptations
• Focus: Cognitive vs. Motivational Tradeoff
Theoretical Foundations

• Motivation plays a key role in the learning process (Keller 1983)
• Components of motivation include (Lepper et al. 1993)
  – Challenge
  – Control
  – Curiosity
  – Confidence

Praise and reassurance are strategies for bolstering confidence (a.k.a. self-efficacy).
Exploratory Research Questions

Objective: Understand relation between...

- Tutorial dialogue structure
  - Cognitive corrective strategies
  - Motivational corrective strategies
- Learner characteristics
  - E.g., low vs. high incoming self-efficacy
- Outcomes
  - Learning gains
  - Self-efficacy gains

Related Work

- AutoTutor (Jackson & Graesser 2007)
- Betty’s Brain (Tan & Biswas, 2006)
- ITSpoke (Forbes-Riley et al. 2005)
- M-Ecolab (Rebolledo-Mendez et al. 2006)
- Mayer et. al. 2006
- Boyer et. al. 2007
Approach

Empirical analysis of human-human tutoring corpus
1. Corpus Acquisition
   Java Tutoring
2. Corpus Annotation
   Cognitive + Affective Channels
3. Predictive Modeling
   Tutorial Strategies → Outcomes

Data Collection

- Online Surveys
  (Demographics, Interpersonal Reactivity Index (IRI), Beliefs About Learning)
- Pre-Survey and Pre-Test
  (Self-efficacy, attitude, conceptual knowledge)
- 55-minute Tutoring Session
  (Working on an introductory Java programming exercise)
- Post-Survey and Post-Test
  (Self-efficacy, attitude, conceptual knowledge)
Experimental Setup

43 Students (Enrolled in a University Introductory Java Programming Class)

14 Tutors (2 Undergraduate + 12 Graduate Students in Computer Science)

Tutorial Dialogue Corpus

Tutor dialogue

Student dialogue

Student problem-solving
## Corpus Characteristics

- 1,528 student utterances
- 3,336 tutor utterances
- 29,996 student problem-solving keystrokes
- 1,277 periods of student scrolling

## Overall Effectiveness Measures

- **Cognitive: Learning outcomes**
  - Mean 5.9% gain from pretest to posttest
  - Instrument: 10-item pretest (isomorphic posttest), multiple choice and fill-in-the-blank items

- **Motivational: Self-efficacy outcomes**
  - Mean 12.1% gain from pre-survey to post-survey
  - Measure: Aggregate score on several survey items asking students to rate their confidence from 0-100
Corpus Annotation

- Automatic problem-solving action tagging
  - Applied rough heuristic measure for correctness
  - Questionable vs. Promising
- Dialogue act tagging
  - Cognitive channel
  - Motivation channel

Correctness

- Automatic problem-solving action tagging
  - Applied rough heuristic measure for correctness
  - Questionable vs. Promising
### Cognitive Dialog Acts

| Act                | Description                                                                 | Tutor and Student Example Utterances | Average Count Per Session (Standard Deviation) |
|--------------------|-----------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------|
| Question (Q)       | Questions that ask a student to pursue a knowledge state or a particular piece of knowledge. | “What should we do next?” 6.5 (4.2) 6.6 (4.3) |                                             |
| Evaluative Question (EQ) | Questions that explicitly request or require student evaluation of their work. | “Do you think you’ll complete this?” 9.7 (7.1) 7.0 (5.0) |                                             |
| Statement (S)      | Declarative assertion.                                                       | “Yes, I am on track.” 4.9 (4.1) 46.2 (31.0) |                                             |
| Acknowledgement (ACK) | Positive acknowledgement of a premise statement.                           | “Okay.” 3.8 (3.0) 2.5 (1.9) |                                             |
| Extraneous (EX)    | A statement not related to the computer science discussion.                 | “Hello” or “You’re Welcome.” 1.0 (2.1) 1.1 (2.4) |                                             |
| Positive Feedback (PF) | Unrelated positive feedback regarding student content.                      | “Yes,” I know how to declare an array.” 2.7 (2.5) 12.0 (7.6) |                                             |
| Negative Feedback (NF) | Negative feedback regarding student content.                              | “No.” 2.1 (1.8) 1.3 (0.9) |                                             |
| Late Warmth Feedback (LF) | Partially positive feedback regarding student content.                      | “Sort of,” “You’re close,” or “Well, almost.” 6.7 (1.2) 2.3 (2.4) |                                             |

### Motivational/Affective Dialog Acts

| Act                 | Description                                                                 | Tutor and Student Example Utterances | Average Count Per Session (Standard Deviation) |
|---------------------|-----------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------|
| Confusion (C)       | Explicit expression of confusion.                                          | “I have no idea what to do.” 0.8 (1.2) |                                             |
| Frustration (F)     | Explicit expression of frustration.                                        | “Sorry.” 0.1 (0.4) 0.0 (0.3) |                                             |
| Excitement (E)      | Explicit expression of excitement.                                         | “Sweet!” 0.4 (0.7) 0.3 (0.6) |                                             |
| Surprise (P)        | Statement intended to emphasize a student’s success.                       | “Great job on that part!” 0.8 (1.3) 4.2 (5.7) |                                             |
| Restorance (R)      | Statement intended to restore a student’s confidence.                      | “That part was hard.” 0.4 (0.9) 1.3 (1.6) |                                             |
| Other Emotion (O)   | Utterance that conveys affective or motivational emotion, but for which there is no pre-defined tag. | “No he.” 9.7 (1.5) 1.5 (0.9) |                                             |
Kappa Statistics

- Cognitive channel: 0.76
- Motivational channel: 0.64

Tutor Response Analysis

| Tutor:       | Question |
|--------------|----------|
| Student:     | Answer   |
| Tutor:       | Positive cognitive feedback |
| Student:     | Questionable problem-solving action |
| Tutor:       | Negative cognitive feedback plus reassurance |
| Student:     | Promising problem-solving action |
| Tutor:       | Neutral cognitive feedback |
| Student:     | Questionable problem-solving action |
| Student:     | Questionable problem-solving action |
| Student:     | Questionable problem-solving action |
| Tutor:       | Positive cognitive feedback |
| Tutor:       | Question |
| Tutor:       | Question |
Tutor Response Analysis

Tutor: Question
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Student: Questionable problem-solving action
Tutor: Promising problem-solving action
Tutor: Neutral cognitive feedback
Student: Questionable problem-solving action
Student: Questionable problem-solving action
Tutor: Positive cognitive feedback
Tutor: Question.

Analysis Goal

Want to Predict:
- Learning gain group (high vs. low)
- Self-efficacy gain group (high vs. low)

Using as Predictors:
- Pretest score
- Incoming self-efficacy rating
- Tutorial strategy (dialogue act tag) immediately following questionable student problem-solving action
Result 1: Presence of Encouragement

*Explicit tutorial encouragement following questionable student problem-solving action*

- 56% less likely to result in high learning gain ($p = 0.001$)
- 57%* more likely to result in high self-efficacy gain ($p=0.054$)

*Compared with no explicit tutorial encouragement*

* Weak statistical relationship

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Result 2: Cognitive Feedback “Plus”

*Purely cognitive feedback*

- 40% less likely to result in high learning gain
- No statistically significant difference in self-efficacy gain

*Compared with cognitive feedback plus praise*
Result 3: Standalone Encouragement

**Tutorial standalone motivational act (i.e., no cognitive feedback component)**

- No statistically significant impact on learning gain
- Initial low self-efficacy, 300% as likely to have high self-efficacy gain
- Initial high self-efficacy, 90% lower odds of having high self-efficacy gain

*Compared with all other tutorial acts*

Result 4: Positive Cognitive Feedback

**Positive cognitive feedback (no explicit motivational component)**

- No statistically significant difference in learning gain
- 190% increased odds of high self-efficacy gain

*Compared with lukewarm, negative, and neutral cognitive feedback as well as tutorial questions*
Future Work

• Expand affective/motivational dialogue acts under consideration
• Broaden window from pairs to triples and beyond, to investigate higher-level tutorial strategies
• Refine automatic tagging for correctness of student problem-solving actions
• Examine impact of other student characteristics

Conclusions

• Tutorial strategies can be chosen to focus on specific cognitive or motivational outcomes during tutoring
• Results reinforce findings that there are tradeoffs between cognitive and motivational outcomes in tutoring.

(Jackson & Graesser 2007, Tan & Biswas 2006, Kelly and Weibelzahl 2006, Wang et al. 2005, Rebollendo-Mendez et al. 2006, Mayer et al. 2006)
