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

<table>
<thead>
<tr>
<th>Act</th>
<th>Description</th>
<th>Tutor and Student Example Utterances</th>
<th>Average Count Per Session (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question (Q)</td>
<td>Questions that explicitly require student knowledge state or correctness of problem-solving action.</td>
<td><em>Where should we start?</em></td>
<td>8.5 (4.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>How do I declare an array?</em></td>
<td>6.6 (1.6)</td>
</tr>
<tr>
<td>Evaluative Question (EQ)</td>
<td>Questions that explicitly require student knowledge state or correctness of problem-solving action.</td>
<td><em>Do you know how to declare an array?</em></td>
<td>9.7 (4.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Is that right?</em></td>
<td>7.0 (7.0)</td>
</tr>
<tr>
<td>Statement (S)</td>
<td>Declarative assertion.</td>
<td><em>You need a closing bracket there.</em></td>
<td>4.6 (6.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>I am looking for where this method is declared.</em></td>
<td>46.2 (31.9)</td>
</tr>
<tr>
<td>Acknowledgment (AC)</td>
<td>Positive acknowledgement of a premise statement.</td>
<td>*Okay, or <em>Yes.</em></td>
<td>3.8 (5.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Alright.</em></td>
<td>2.5 (1.9)</td>
</tr>
<tr>
<td>Extra Domain (EX)</td>
<td>A statement not related to the computer science discussion.</td>
<td><em>Hello!</em> or <em>You’re Welcome!</em></td>
<td>1.0 (2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Can I use my book.?</em></td>
<td>1.1 (2.4)</td>
</tr>
<tr>
<td>Positive Feedback (PF)</td>
<td>Utterances positive feedback regarding problem-solving assistance or student knowledge state.</td>
<td><em>You know how to declare an array.</em></td>
<td>2.7 (2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>That is right.</em></td>
<td>12.0 (7.9)</td>
</tr>
<tr>
<td>Lruwarm Feedback (LF)</td>
<td>Partly positive, partly negative feedback regarding student problem-solving efforts or student knowledge state.</td>
<td><em>Sort of.</em></td>
<td>0.7 (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>You’re close.</em> or <em>Well, almost.</em></td>
<td>3.3 (2.4)</td>
</tr>
<tr>
<td>Negative Feedback (NF)</td>
<td>Negative feedback regarding student problem-solving assistance or student knowledge state.</td>
<td><em>No.</em></td>
<td>2.1 (1.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Actually, that won’t work.</em></td>
<td>1.3 (3.1)</td>
</tr>
</tbody>
</table>

## Motivational/Affective Dialog Acts

<table>
<thead>
<tr>
<th>Act</th>
<th>Description</th>
<th>Tutor and Student Example Utterances</th>
<th>Average Count Per Session (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confusion (C)</td>
<td>Explicit expression of confusion. Indicates a situation that is beyond the student’s current level of understanding.</td>
<td><em>I have no idea what to do.</em> <em>I’m lost.</em></td>
<td>0.8 (1.2)</td>
</tr>
<tr>
<td>Frustration (F)</td>
<td>Explicit expression of frustration.</td>
<td><em>Grrrt.</em> <em>This is so frustrating.</em></td>
<td>0.1 (0.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>This is frustrating.</em></td>
<td>0.0 (0.3)</td>
</tr>
<tr>
<td>Excitement (E)</td>
<td>Explicit expression of excitement.</td>
<td><em>Sweet!</em> <em>Cool!</em></td>
<td>0.4 (0.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>That was cool.</em></td>
<td>0.3 (0.6)</td>
</tr>
<tr>
<td>Praise (P)</td>
<td>Statements intended to emphasize a student’s success. This goes beyond positive feedback, which serves as a factual confirmation of correctness.</td>
<td><em>Great job on that part!</em> <em>That’s perfect.</em></td>
<td>- (4.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>That part was great.</em></td>
<td>- (5.7)</td>
</tr>
<tr>
<td>Reinforcement (R)</td>
<td>Statement intended to reinforce a student’s success. Utterances that convey affective or motivational content, but for which there is no pre-defined tag.</td>
<td><em>Don’t worry about it.</em> <em>I’m sorry.</em></td>
<td>0.4 (0.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Don’t worry about it.</em></td>
<td>1.3 (1.9)</td>
</tr>
<tr>
<td>Other Emotion (O)</td>
<td>Utterances that convey affective or motivational content, but for which there is no pre-defined tag.</td>
<td><em>He he.</em> <em>I’m sorry.</em></td>
<td>9.7 (1.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>I’m sorry.</em></td>
<td>1.5 (2.1)</td>
</tr>
</tbody>
</table>
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 Response Analysis

Tutor:  Question
Student:  Answer
Tutor:  Positive cognitive feedback
Student:  Questionable problem-solving action
Tutor:  Negative cognitive feedback plus reassurance
Student:  Questionable problem-solving action
Tutor:  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

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.
