A Case Study in Progress: Using Multiple Data Sources to Study Collaborative Learning With an Intelligent Tutoring System

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Main Question

• Data of small-group (dyads) collaborative learning activities with an intelligent tutoring system
  • Pre/post test (domain learning)
  • Dialogue data (audio and transcripts)
  • Tutor logs
  • Eye-tracking data
  • Screen captures

• How can we take advantage of these multiple data sources to understand
  • Whether collaboration is fruitful
  • What domain-level learning might result
  • And inter-relations
Our Project in a Nut Shell: How the Data Set was Collected

- Conducted pull-out study in two elementary school
- 26 dyads, students in grades 4 and 5
- Key activities
  - Online pre-test of fractions knowledge (25 mins)
  - Learning collaboratively with intelligent tutoring system (45 mins)
  - Online post-test (next day, 25 mins)
Intelligent Tutor for Fractions

• Adaptive support for problem solving
  • Prompts for steps, provides step-by-step guidance (feedback and hints)

• Non-adaptive support for collaboration
  • Embedded collaboration script, tied to specific phases of problem solving
Analyses

- Pre/post test
- Dialogue data
- Tutor logs
- Eye-tracking data
- Screen captures

Learning curves

- Evidence of learning of domain knowledge during tutor use?
- Typical type of analysis for ITS research, not as common in CSCL
DataShop

Online data repository and suite of analysis tools

Learning Curves

• Does students’ performance improve on successive steps in tutor problems that involve the same knowledge component (KC)?

Identify knowledge components (KCs), maps steps in tutor problems to KCs

For any given KC, plot error rate across successive opportunities, averaged across students

What is the highest number in the common factors list?

This is the greatest common factor.
Results - Student Learning Averaged Across All KCs

All Selected Knowledge Components

Error Rate

opportunity

All Data  All Data - Default (Predicted)
Conclusion – Tutor Log Data Analysis

• Learning curves help us analyze students’ domain learning within the given learning environment

• Possible additional analyses
  • Analyze which KCs are most difficult for students
  • Analyze for which KCs the tutor is/is not effective
  • Help interpret pre/post data – expect to see consistency (cross-validation)

• Also useful in combination with other data sources
Analyses

- Pre/post test
- Dialogue data
- Tutor logs
- Eye-tracking data
- Screen captures

Coded according to ICAP framework (Chi, 2009)
ICAP Categories of Learning Activities

- Interactive
- Constructive
- Active
- Passive

Assumption: categories are ordered in terms of how effectively they support learning

- Not always confirmed in data
Analyses

- Pre/post test
- Dialogue data
- Tutor logs
- Eye-tracking data
- Screen captures

Coded according to ICAP framework (Chi, 2009)

- How frequent is each category of collaborative talk?
- Is fruitful collaborative talk correlated with higher learning gains?
- Does fruitful talk co-occur with successful problem solving?
Does Fruitful Talk Co-occur with Successful Problem Solving?

![Graph showing mean errors for different types of talk.]

- Interactive
- Constructive
- Monologue
- Other
Conclusion Dialogue Analysis

• Dialogue analysis tells us whether fruitful collaboration is occurring

• In combination with other data sources (log data, pre/post test data) dialogue analysis sheds light on
  • which dialogue types relate to learning
  • and how (e.g. what happens during pauses in the interaction stream after errors)
Analyses

• Pre/post test
• Dialogue data
• Tutor logs
• Eye-tracking data
• Screen captures
Intuition: Effective collaborators often look simultaneously at the same element on the tutor screen.
(Dale & Richardson, Nüssli & Jermann)
Gaze Recurrence

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How Do Joint Attention Graphs of High- and Low-Performing Dyads Compare?
Let's reduce 9/12 to its simplest form to find equivalence.

1. What are the factors of 9 starting with the smallest?
   - 1 \times 9 = 9
   - 3 \times 3 = 9
   - 2 \times 6 = 12
   - 3 \times 4 = 12

2. What factors are in both lists (list smallest to largest)?
   - 1, 3

These are the common factors.
Let's reduce $9/12$ to its simplest form to find equivalence.

1. What are the factors of 9 starting with the smallest? 
   - [ ] $1 \times 9 = 9$
   - [ ] $3 \times 3 = 9$
   - $2 \times 6 = 12$
   - $3 \times 4 = 12$

2. What factors are in both lists (list smallest to largest)?
   - [ ] $1$
   - [ ] $3$
   - These are the common factors.

3. What is the highest number in the common factors list?
   - [ ] $3$
   - This is the greatest common factor.

4. By reducing the fraction, you are making an equivalent fraction with a smaller numerator and denominator that is easier to compare with other fractions.

5. To reduce the fraction to its simplest form, divide the numerator and denominator by the greatest common factor.

6. Is the purple fraction equivalent to the blue fraction?
   - [ ] Yes
   - [ ] No
Conclusion – Eye Tracking Data

• Gaze convergence help us find time intervals with high or low joint visual attention
• Interesting to study these separately
• Interesting to relate to dialogue data – E.g., is interactive talk related with greater gaze convergence?
Conclusion

• ITS technology can be a useful platform for CSCL research

• Use of multiple data sources helps in analyzing collaborative learning processes and outcomes
  • Pre/post test data and dialogue data remain useful
  • Tutor log data useful by itself and in combination with other data sources – dialogue analysis and log data analysis can mutually support each other
  • Gaze convergence as an indicator of fruitful collaboration?
  • Eye tracking data may be useful in conjunction with other sources

• Sometimes, more is more!
Thank you

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