Affect-aware support for exploratory learning environments

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Thanks to iTalk2learn colleagues

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iTalk2Learn

- European-funded (3 year) research project (FP7).
- 4 universities
  Artificial Intelligence, Computer Science,
  Technology-Enhanced Learning in Mathematics,
  Educational Psychology
- 3 commercial partners

iTalk2Learn Objectives

Aims:
- Adaptive support for learners
  - through machine learning from large-scale interaction data
  - switching between structured and exploratory tasks
  - taking cues from learners talking

Application domain:
- learning fractions for children aged 8-12
State-of-the-art: emphasis on procedural learning

Fractions Tutor

Exploratory Learning Environments: Emphasis on conceptual learning

Fractions Lab
iTalk2Learn

Fractions Lab – feedback
Affect and learning

• The learning process includes a range of positive and negative affective states:
  – While positive affective states contribute towards learning, negative affective states can inhibit it.

• Appropriate feedback might help students to overcome negative affective states.

iTalk2Learn

TDS (task dependent support)

<table>
<thead>
<tr>
<th>TASK LEVEL EXEMPLIFICATIONS FOR TASK 2.8 (Set 2): Make a fraction that equals 3/4 and has 12 as denominator.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF...</td>
</tr>
<tr>
<td>student makes a representation with the numerator 12 or 4</td>
</tr>
</tbody>
</table>

TIS (task independent support)

– Well done, you’ve have worked hard on this task. Why did you use this method?
– This is quite tricky. What is the task asking you to do?
– Please explain that again using the words denominator and numerator.
– Are you finding this too easy? Perhaps you should quickly finish this task, so you can tackle a more challenging task.
Feedback types

• Talk aloud
  • “Remember to talk aloud. What are you thinking?”
  • “What is the task asking you to do?”
  • “Please think aloud, what are your thoughts or feelings?”
• Talk mathematics
  • “Can you explain that again using the terms denominator, numerator?”
• Affect boosts
  • “It may be hard, but keep trying”
  • “If you find this easy, check your work and change the task”
• Problem solving
  • “You can’t add fractions with different denominators”
• Reflection
  • “What did you learn from this task?”
  • “What do you notice about the two fractions?”

Wizard-of-Oz study
Wizard-of-Oz study

WOZ Setup
Ecological validity

Wizard’s script for support
Feedback types

- Talk aloud
  - “Remember to talk aloud, and tell us what are you thinking”
  - “What is the task asking you to do?”
  - “Please think aloud, what are your thoughts or feelings?”
- Talk mathematics
  - “Can you explain that again using the terms denominator, numerator?”
- Affect boosts
  - “It may be hard, but keep trying”
  - “If you find this easy, check your work and change the task”
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- Reflection
  - “What did you learn from this task?”
  - “What do you notice about the two fractions?”

Annotation of affective states

- The student’s screen display and their voiced were recorded.

- 2 researchers annotated the affective states that occurred before and after a feedback was presented.

- We focus on a subset of affective states identified by Pekrun (2006):
  - enjoyment, surprise, frustration and boredom
  - we also add confusion (e.g. Porayska-Pomsta et al., 2008)
Annotation of affective states

Baker Rodrigo Ocumpaugh Monitoring Protocol (BROMP)

Wizard of Oz results

• 396 messages were sent to 26 students
From ‘confusion’ to...

From ‘frustration’ to...
Discussion

- By attending to student affect, students can be moved into an enhanced affective state (which is known to impact positively on learning).

- When students were confused, ‘instructive’ feedback was more effective than ‘other problem solving’ feedback.

- When students were frustrated, ‘affect boosts’ were effective in moving the student to ‘flow’ or ‘confusion’

- Low-interruptive feedback might be preferred by students when they are enjoying their activity as they can decide themselves when they want to receive the feedback.

Affective state reasoner

Dynamic Bayesian network to predict an enhanced affective state of the student:
Beyond wizardry - Two field trials

Experimental Design

<table>
<thead>
<tr>
<th></th>
<th>speech functionality</th>
<th>no speech functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELE</td>
<td><img src="image" alt="C1: Full Platform" /></td>
<td><img src="image" alt="C2: No Speech" /></td>
</tr>
<tr>
<td>no ELE</td>
<td><img src="image" alt="C3: No ELE" /></td>
<td></td>
</tr>
</tbody>
</table>
Participants

UK
- Y4 and Y5 primary school students
- 8-10 years old
- Three schools
- 184 students participated in stratified groups
- 177 students completed
  - \( N_{C1} = 61 \)
  - \( N_{C2} = 56 \)
  - \( N_{C3} = 50 \)

Germany
- 5th and 6th grade secondary school students
- 10-12 years old
- Five schools
- 243 students participated in classes
- 210 students completed
  - \( N_{C1} = 100 \)
  - \( N_{C2} = 59 \)
  - \( N_{C3} = 51 \)

Dependent Measures

- Pre- and post-test with fractions problems
  - Three procedural items
  - Three conceptual items
  - Offline (paper-based measures)
Example items

Dependent Measures

- Pre- and post-test with fractions problems
  - Three conceptual items
  - Three procedural items
  - Offline paper-based measures

- Attitudes to learning, mathematics and fractions
- User experience
- Affect observation
- Interaction with platform including speech
- Interviews
Procedure

10' Intro 15' Pre-Test 40' iTalk2Learn 25' Post-Test

Hypotheses

H1) Combining structured practice and exploratory tasks promotes robust learning

H2) An adaptive system that interacts with learners through speech enhances learning more than an adaptive system that does not
Combination effect: a teaser


Speech effect: results
Annotation of affective states - BROMP

![Image of a classroom setting with students using computers and a teacher standing at the front]

![Bar chart showing the distribution of affective states among C1 and C2 participants]
Conclusion

• The task independent support is able to:
  – Detect student’s affective state from speech and interaction.
  – Tailor feedback type and its presentation according to student’s affective state

• The evaluation in the UK has shown that students are less bored and significant less off-task when using TIS in comparison to students who used TDS.
Ongoing work

• Developing hypotheses from the data
  • e.g. ‘task 2.4’
    – adapted the representation to previous exercises and performance
    – students seem to have enjoyed more this task in C1 and demonstrated significantly less negative affective states than other tasks
• A case for ‘scaffolding difficult tasks’?

Questions - Discussion

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