Student models to generate automated feedback on intermediate steps in solving mathematical problems

Marieke Bor-de Vries Paul Drijvers Peter Boon Sietske Tacoma
Bastiaan Heeren Johan Jeuring Niels Steenbergen Sergey Sosnovsky
Wink van Zon Jesse Koops Armin Weinberger Allison Kolling
Brigitte Grugeon-Allys Françoise Chenevotot-Quentin Ben-Manson Toussaint

Poster presented at International Conference on Technology in Mathematics Teaching ICTMT 14, 22 July 2019, Essen

Motivation

Using ICT for assessing mathematics achievement:

- Targeted at 12-15 years old students.
- Setting up algebraic expressions and equations, and simplifying and solving them.

Detailed assessment of free-form answers to mathematical problems:

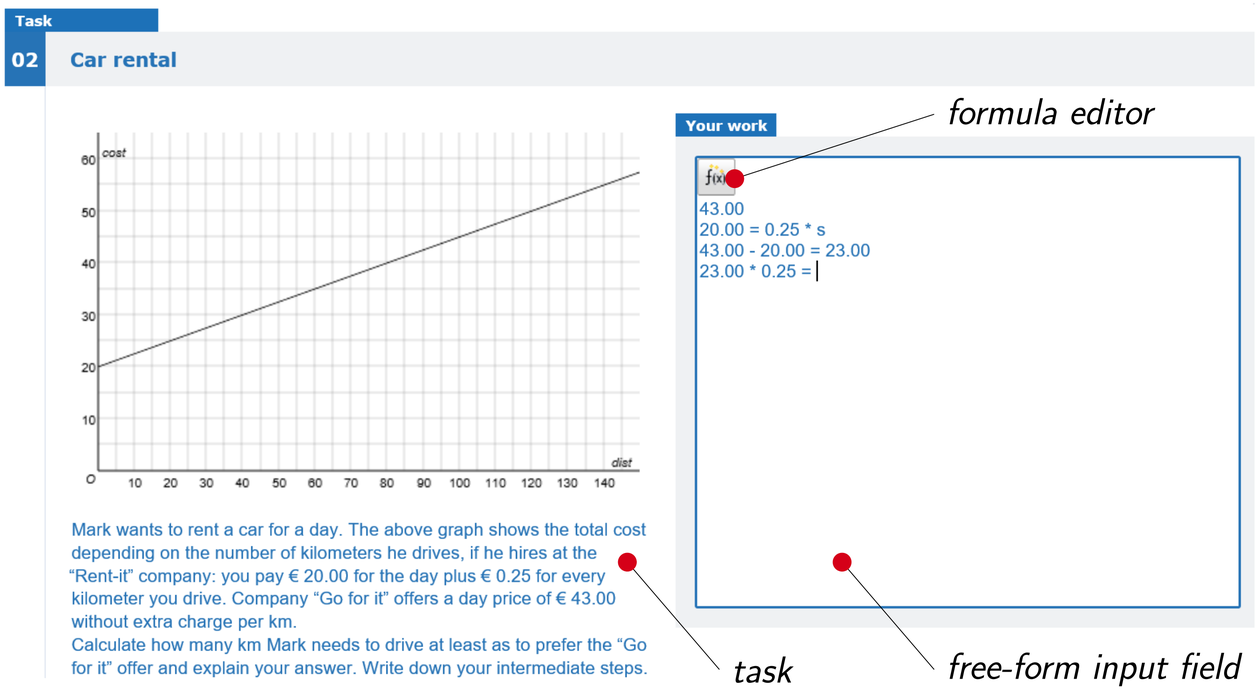
- Analysis of intermediate steps.
- Determining the solution approach.

Research approach

- Focus on obtaining a detailed picture with strengths and weaknesses of the student.
- No restrictions in complexity of the task. Going beyond easily verifiable questions such as multiple-choice or closed items.
- Complex tasks with multiple solution strategies.

Our research goal: analysing free-form input to mathematical problems in a formative assessment setting

Task



Strategies

```
Choose variables
cost = 20.00 + 0.25*dist
20.00 + 0.25*dist = 43.00
0.25*dist = 43.00 - 20.00 = 23.00
dist = 23.00 / 0.25 = 92.00
Answer: 92 km or more
```

▶ algebraic strategy, equation

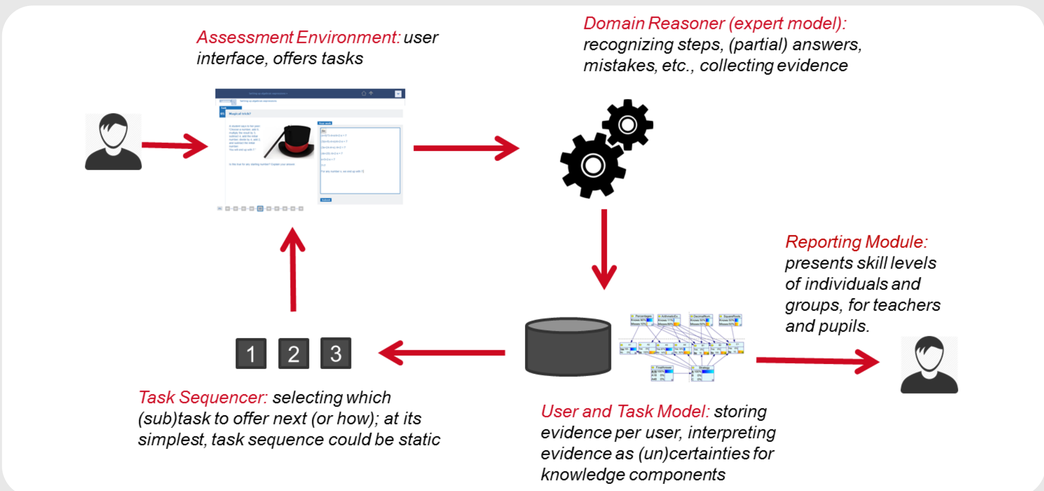
```
Choose variables
cost = 20.00 + 0.25*dist
20.00 + 0.25*dist > 43.00
0.25*dist > 23.00
dist > 92.00
Answer: 92 km or more
```

▶ algebraic strategy, inequality

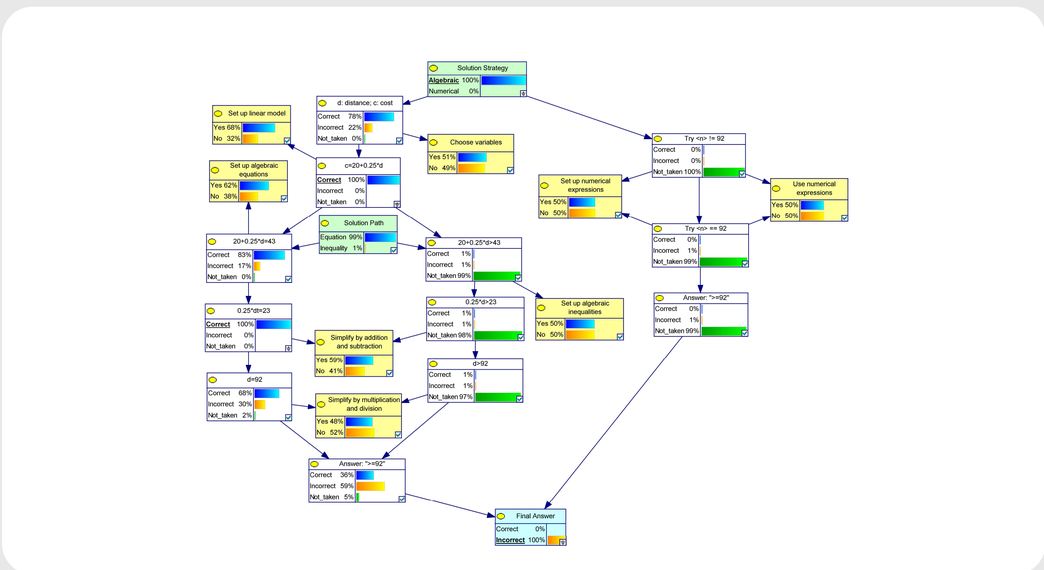
```
20.00 + 0.25 * <number >
= <other number>
20.00 + 0.25 * 92 = 43.00
Answer: 92 km or more
```

▶ numerical strategy

High-level architecture



Example of a task model:



Pilot and evaluation studies

Students worked on 10 tasks and answered a short questionnaire.

Small-scale pilot:

- Germany (N=19), France (N=6) and the Netherlands (N=37).
- We used the data to improve the tasks, the domain reasoner, and the task and student models.

Evaluation studies:

- Germany (N=114), France (N=96) and the Netherlands (N=130).
- We made a comparison between the automated feedback given by the domain reasoner and human assessment.

Conclusion

- We have developed a framework for formative assessment of free-form solutions to complex mathematical problems.
- The domain reasoner finds evidence for intermediate steps and solution approaches.
- The data from the evaluation studies still needs further processing.

The Advise-Me project (Automatic Diagnostics with Intermediate Steps in Mathematics Education) has received funding from the European Union's Erasmus+ Programme, Strategic Partnerships for school education for the development of innovation.

http://advise-me.ou.nl bastiaan.heeren@ou.nl