STUDENT MODELS TO GENERATE AUTOMATED FEEDBACK ON INTERMEDIATE STEPS IN SOLVING MATHEMATICAL PROBLEMS

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Digital technology can help with providing detailed assessment of mathematical competences. We present the Advise-Me project, in which evidence of the level of mastery is collected from free-form input, without restricting user interaction. We discuss the novel components of our approach, such as the use of a domain reasoner and Bayesian networks for open algebra problems, and an upcoming evaluation study in three countries.

Keywords: Step-based assessment · Free-form input · Solution strategies · User modelling

ADVISE-ME RESEARCH SUMMARY

Low achievement in mathematics is a common concern for all European countries. An extensive review of research evidence on what works for children with mathematical difficulties has concluded that interventions should ideally be targeted towards an individual child's particular difficulties (Dowker, 2004). General research on feedback (Hattie, 2009; Kluger & DeNisi, 1996) states that feedback is most effective if it is about the task, reports about correctness, and builds on changes from previous trials. Learning environments used for stepwise solving homework are just as effective as individual tutors (VanLehn, 2011), and have the added advantage of giving teachers information about progress of individual students.

In this poster, we present the Advise-Me project. The objective of this project is to develop flexible support for detailed diagnostics of mathematical competences of students, and to use this in existing testing and practicing environments in mathematics education. The actions of a student when working in a digital environment can be collected in, and interpreted by, a so-called student model. It is essential that this model not only analyses final answers, but also intermediate steps (VanLehn, 2011). We thus want to analyse intermediate steps to get precise diagnostic information. The interface should not restrict students; we therefore allow free-form input.

For the Advise-Me project ten open tasks on setting up and solving algebraic equations are developed, in which students can choose their own solution strategy. Figure 1 (left) shows one such task. Different solution strategies are specified in a domain reasoner that is based on the Ideas framework. The domain reasoner recognizes the solution approach, but also (intermediate) steps and mistakes. This information is interpreted by task and student models, which estimate the competences of the student based on Bayesian inference. The inference results can be reported to students and teachers, and used by a task sequencer to select a new task. Figure 1 (right) shows the information flow (Heeren et al., 2018).

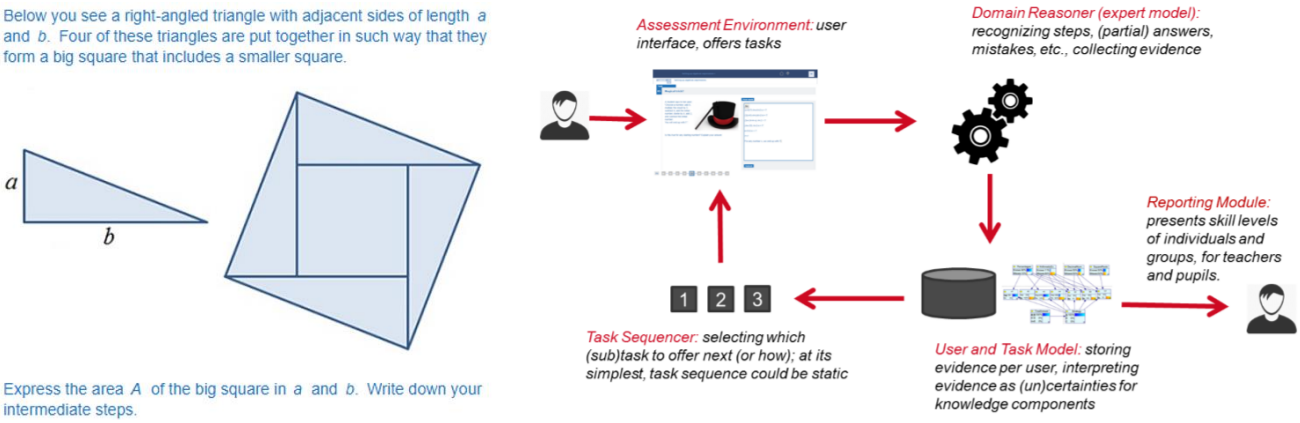

Figure 1. Task used in pilots (left) and information flow (right)

To test the feasibility of our approach, we organized pilots in which 62 students from France, Germany and the Netherlands participated. The collected data helped us to improve the tasks, the domain reasoner and the task and student models. In spring 2019 we ran more extensive evaluation studies with 358 14-15-year old students. They worked on the tasks within the Dutch Digital Mathematics Environment or the French Pépite software. The analysis of the collected data will include a comparison of machine and human scoring, leading to an improved student model.

CONCLUSION

We have developed a novel approach to the assessment of mathematical competences in a digital environment, with free-form student input. Key components in this approach are the domain reasoner for recognizing solution strategies and information about steps, and student and task models for interpreting this information. Upcoming studies will evaluate our approach.

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