Mining information from tutor data to improve pedagogical content knowledge

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School-based intelligent tutoring systems present a unique, largely untapped, teacher-development opportunity. Research on teacher content knowledge has shown that effective teachers develop a specialised 'pedagogical content knowledge' for teaching mathematics. School-based tutors provide a rich record of the student learning process. This record can be mined for insights that contribute to teacher's 'pedagogical content knowledge'. By situating this knowledge in the context of an active teaching-learning process occurring in the school, these insights contribute to a continuous data-driven teacher development exercise.

1. Introduction

School-based intelligent tutoring systems are designed to assist teachers in meeting learning objectives by providing personalised learning opportunities to students. Such systems embody expert pedagogical knowledge as well as student models which are used to guide students through content so as to maximise learning. Mindspark®, developed by Educational Initiatives, is a mathematics tutoring system being used as a part of the school curriculum by nearly 7000 students in more than 13 schools across India.

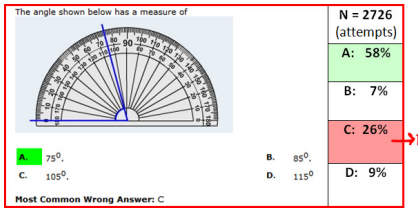
While most tutoring systems aim to provide comprehensive learning opportunities within the tutoring environment, a school-based tutoring system presents a unique, largely untapped teacher-development opportunity. Research on teacher content knowledge in the past 3 decades has brought to the table and refined the notion of 'pedagogical content knowledge' [1] and provided empirical measures of the subject knowledge that is required for teaching[2]. Insights mined from tutoring systems can be used to inform teachers about the nature of the learning process students go through in specific content domains and thus provide a source of continuous teacher development.

2. Data

The Mindspark® system consists of a sequence of specially designed learning units (clusters), which contain finely graded questions on concepts that make up the topic. Students learn through feedback and by going through specific remedial clusters, which help address specific problems. The questions are MCQs, 'fill-in-the-blank' type, multiple-select or interactive. Student response, the time taken in making the response, the time spent reading the feedback, the no. of repetitions of each learning unit and other data is recorded in a database.

3.1 Detecting misconceptions and common errors

The Mindspark system helps teachers identify specific misconceptions or learning gaps prevailing at the grade or school level. Mindspark consists of distractor-driven MCQs that are capable of trapping common errors.



Question. Code	Question No.	Option A (%)	Option B (%)	Option C (%)	Option D (%)	Std. Dev. Of Wrong Answer %
27E09	9	4.56	27.94	6.64	59.45	31.10
27E13	13	27.42	7.11	14.86	49.09	22.33
27E31	31	3.37	48.11	41.95	5.72	21.62
27E34	34	24.78	8.073	18.62	46.68	19.95
27E20	20	5.29	42.01	40.53	10.93	19.77

Figure 1 – Example of a common error/misconception highlighted and a table showing the use of standard deviation of wrong answer % as a sorting criterion. The correct answer is marked in green, common wrong answers in red/pink.

A measure that directly picks up questions where a large proportion of students have been drawn to a particular wrong answer (thus indicating a common error pattern) is the standard deviation of the % of students choosing the various wrong answers. A higher SD identifies clustering of response in particular options. Tutor data from across grades can then be used to inform teachers about how misconceptions evolve with age and ability.

3.2 Identifying 'speed-breakers' in learning

The Mindspark learning units contain very finely graded learning units based on conceptual progression as determined by curriculum and content experts.. However, students sometimes treat closely related question-types very differently and such a situation often represents a 'kink' in the curriculum and a mismatch between student understanding and teacher's perception of how difficult different related tasks are. Such potential kinks in the curriculum represent specific points where student learning may be derailed, both in the tutor environment as well as in the classroom.

3.3 Identifying and gaining from difficult learning situations

Students using the Mindspark system occasionally get trapped in difficult learning situations. They make no progress and repeatedly fail to clear particular learning units despite feedback. By using correlation-based measures to classify student trajectories, we provide useful information to teachers on the student's experience and make it possible for these situations to be fruitfully utilized to systematically improve teacher's pedagogical content knowledge.

4. Conclusion

School-based intelligent tutoring systems provide a rich record of the student learning process. This record can be mined for insights that contribute to teacher's 'pedagogical content knowledge'. By situating this knowledge in the context of an active teaching-learning process occurring in the school, these insights contribute to a continuous data-driven teacher development exercise.

4. References

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