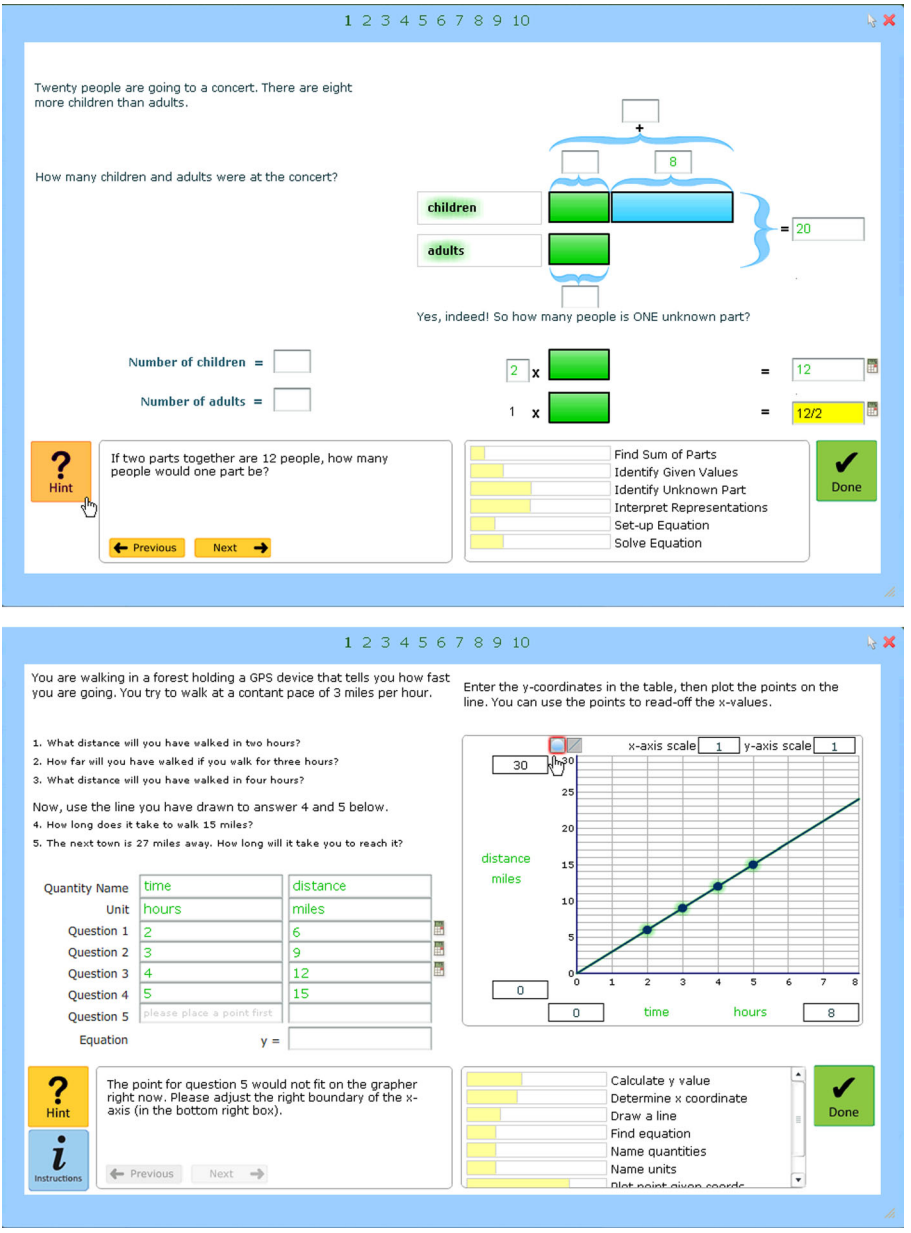
Appendix: 18 Example-Tracing Tutors

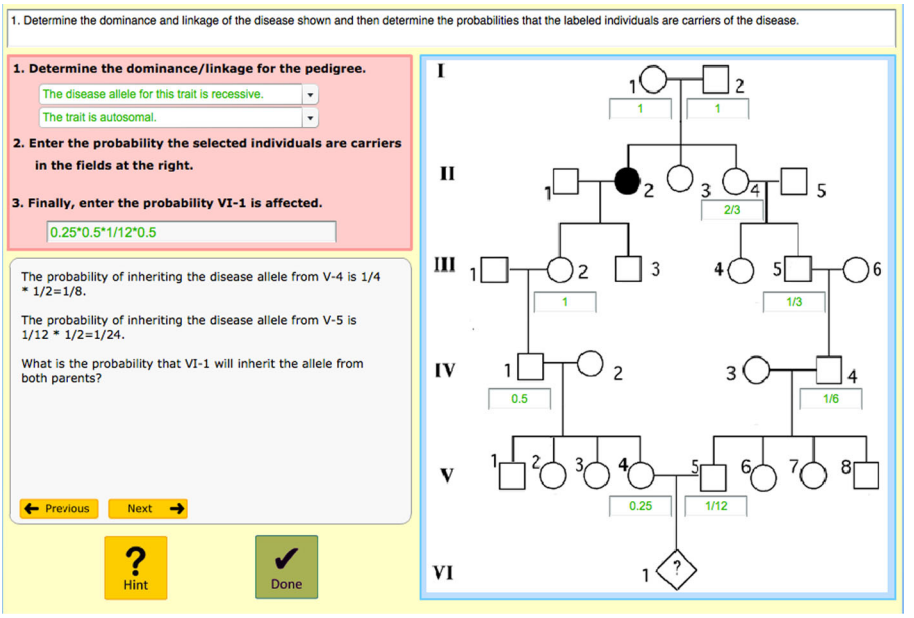
We provide screenshots of the 18 example-tracing tutors built since 2009 that are discussed in the body of the document.

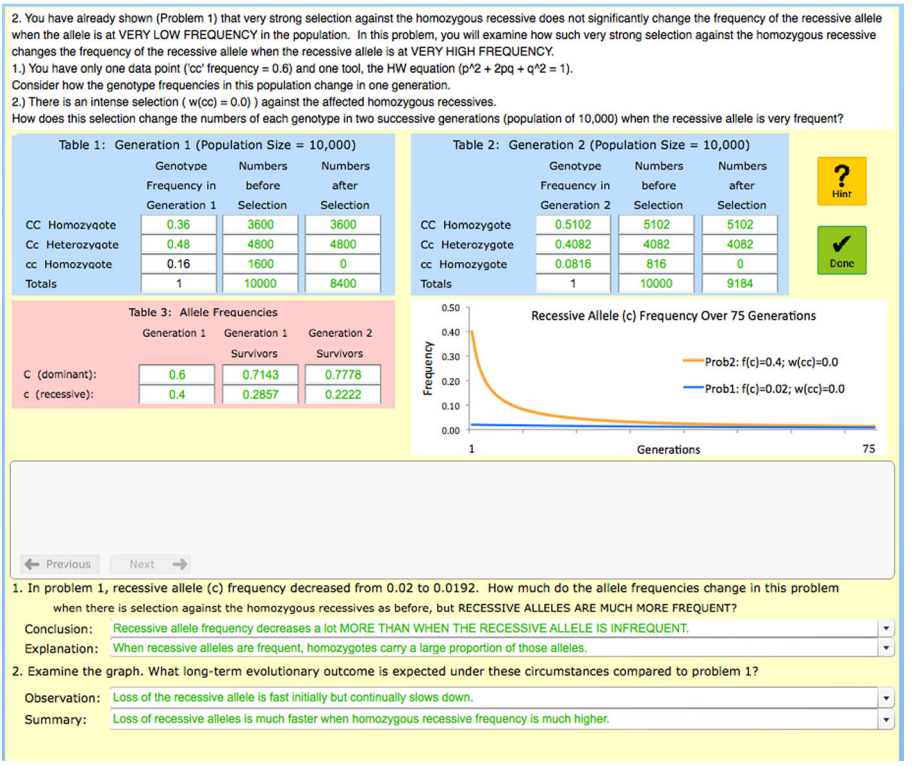
Mathtutor



Mathtutor (Aleven et al. 2009a) is a comprehensive web-based tutoring system for mathematics in grades 6 through 8.

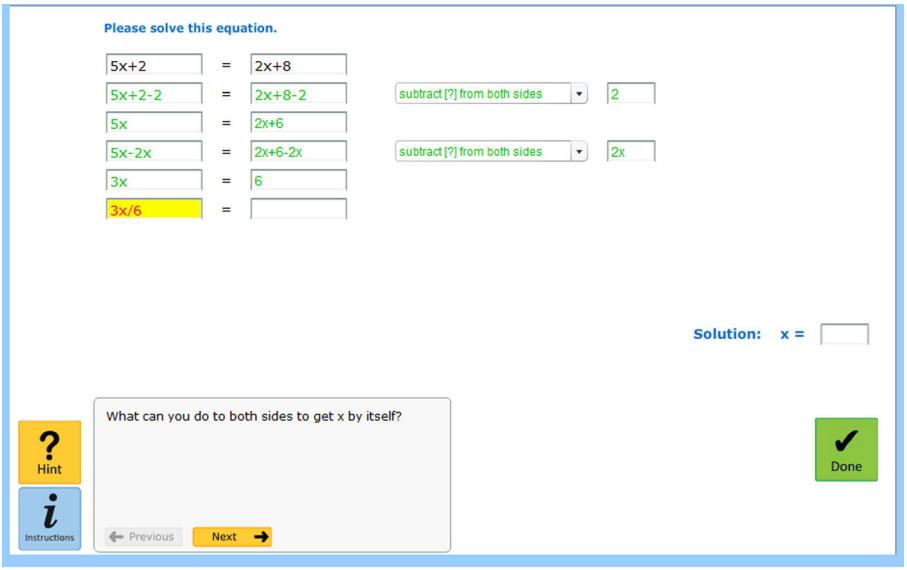
Genetics Tutor





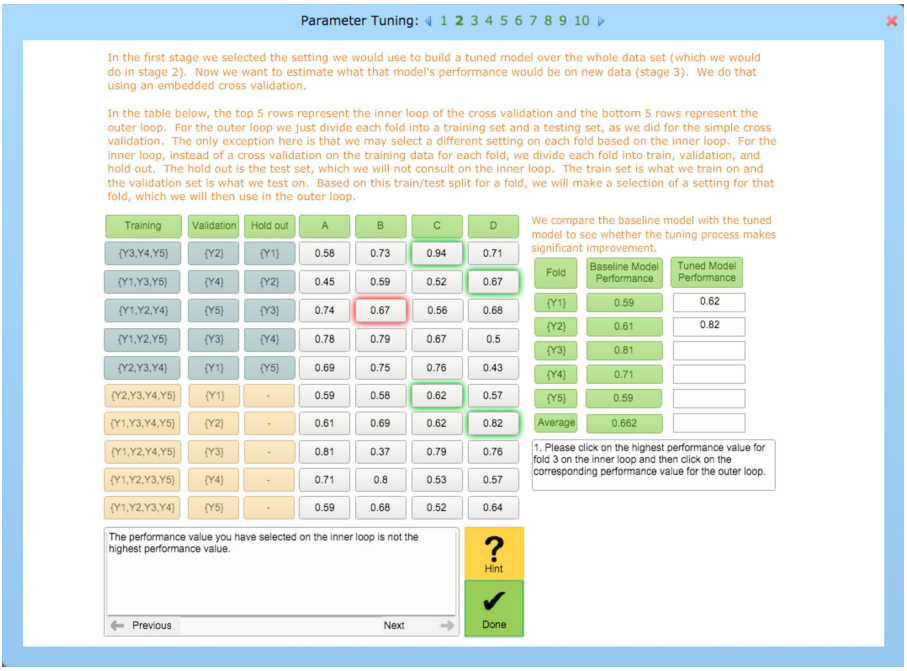
The *Genetics Tutor* (Corbett et al. 2010) covers a wide range of problem-solving activities in high-school and college-level genetics

Lynnette – Basic Equation Solving



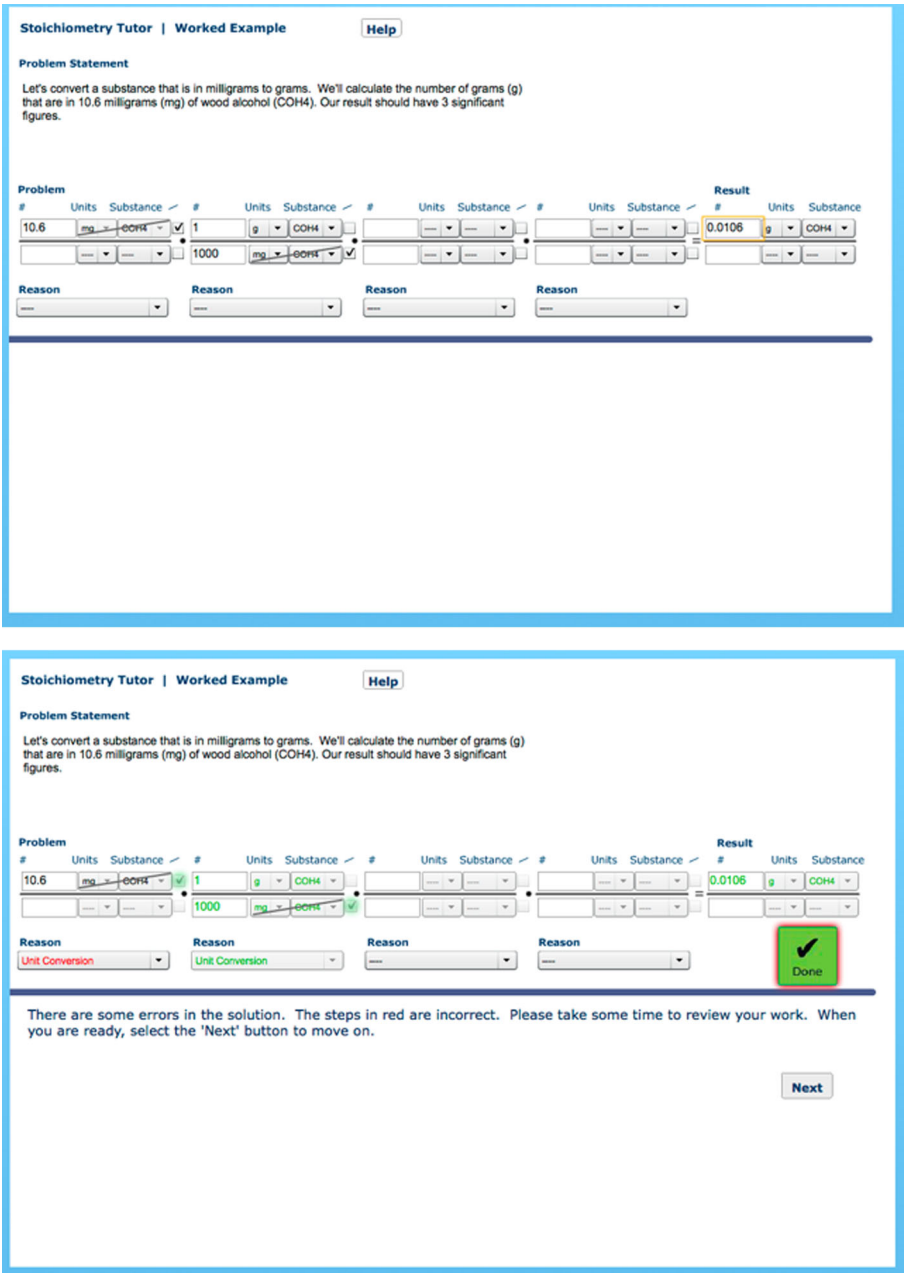
Lynnette is a tutor for basic equation solving for grades 6, 7, and 8, was originally implemented as an example-tracing version (top) (Long and Aleven 2013a, b; Waalkens et al. 2013), and was later re-implemented, also with CTAT, as a rule-based Cognitive Tutor (bottom) (Long and Aleven 2014)

The Tuning Tutor – Parameter Fitting in Machine Learning



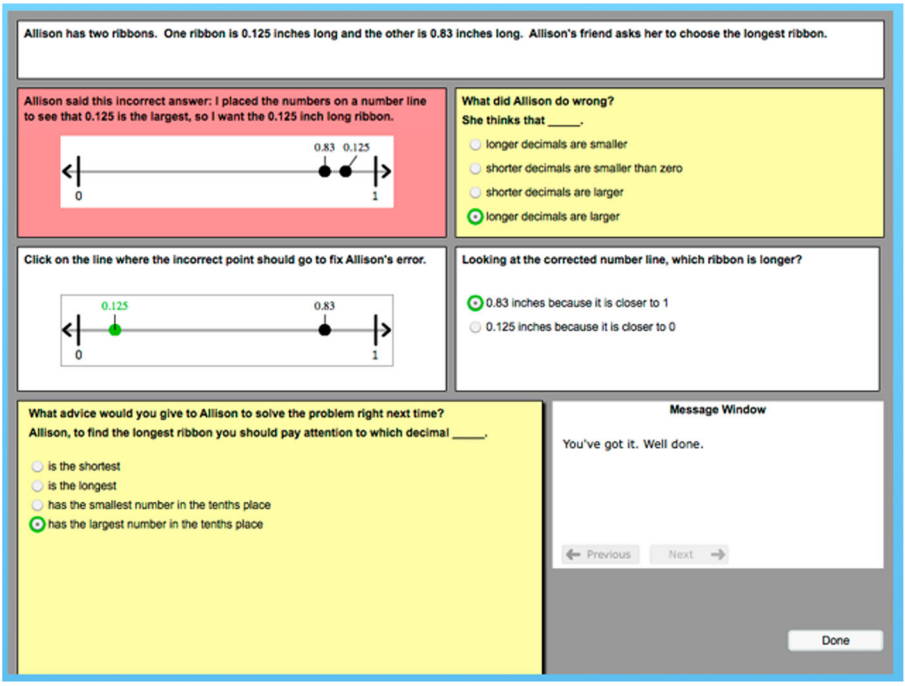
The *Tuning Tutor* helps graduate students and advanced undergraduate students learn to use cross validation to avoid overfitting when tuning model parameters. It was used at Carnegie Mellon University in a course for graduate students and advanced undergrads called "Applied Machine Learning" by Carolyn Rosé

Stoichiometry Tutor



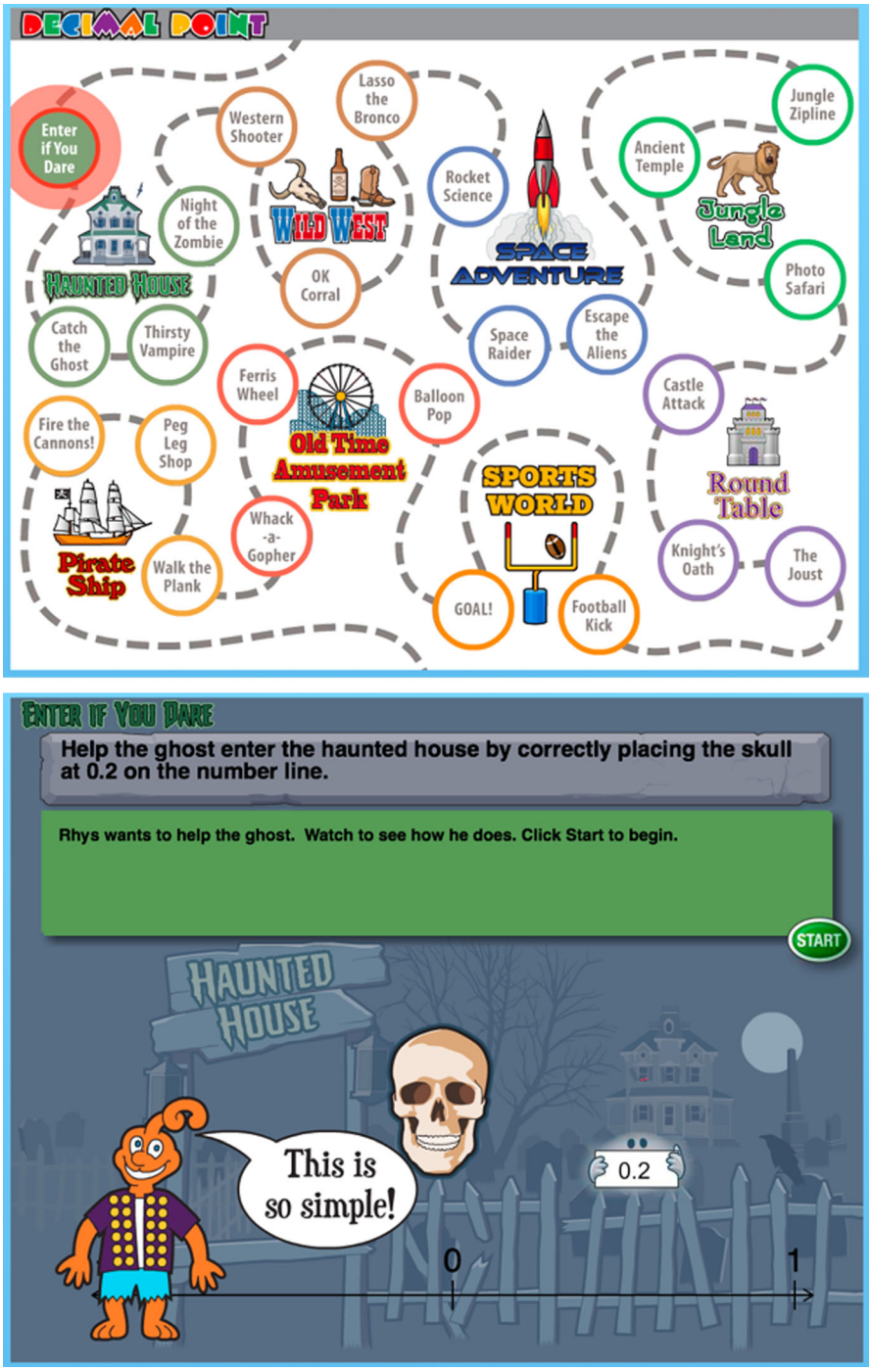
The *Stoichiometry Tutor* (McLaren et al. 2014, 2015b, 2016) supports the narrated replay of example solutions. As the steps of the problem are replayed, a flashing yellow box draws the student s attention to the next step of the worked example (top). After the worked example plays back, the student is prompted to fill out the reasons for every step, and then their solution is evaluated (i.e., delayed feedback; bottom).

AdaptErrEx – Erroneous Examples



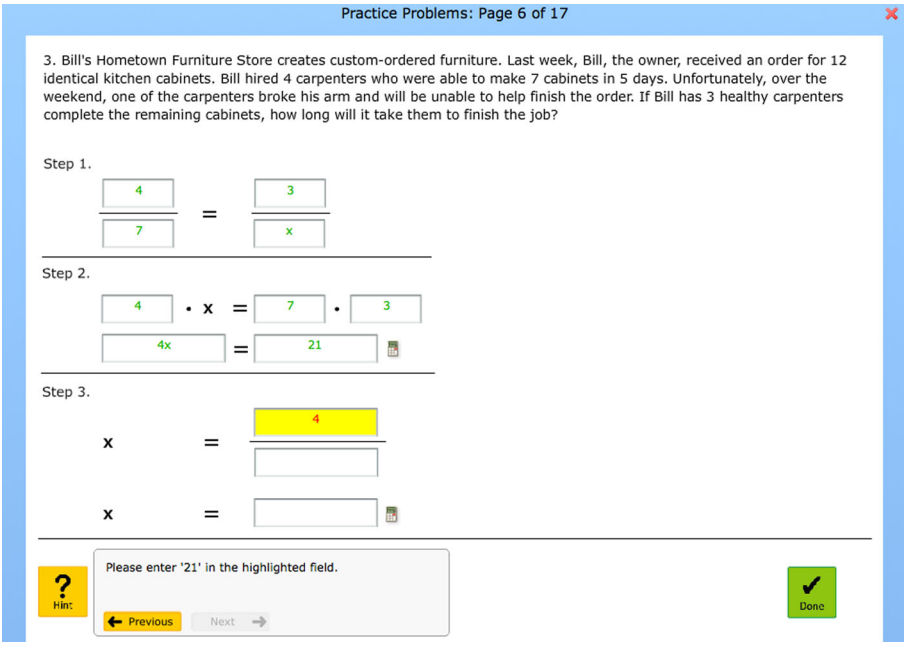
AdaptErrEx (Adams et al., 2014; McLaren et al. 2015) is an example-tracing tutor for learning decimals (part of 6th-grade mathematics) that has students identify, correct, and explain incorrect steps in worked-out problem solutions

Decimal Point: Educational Games for Learning Decimals



Decimal Point (Forlizzi et al., 2014), built using CTAT as foundation, supports game-based learning with erroneous examples to help middle-school students learn decimals

Proportional Reasoning Tutor

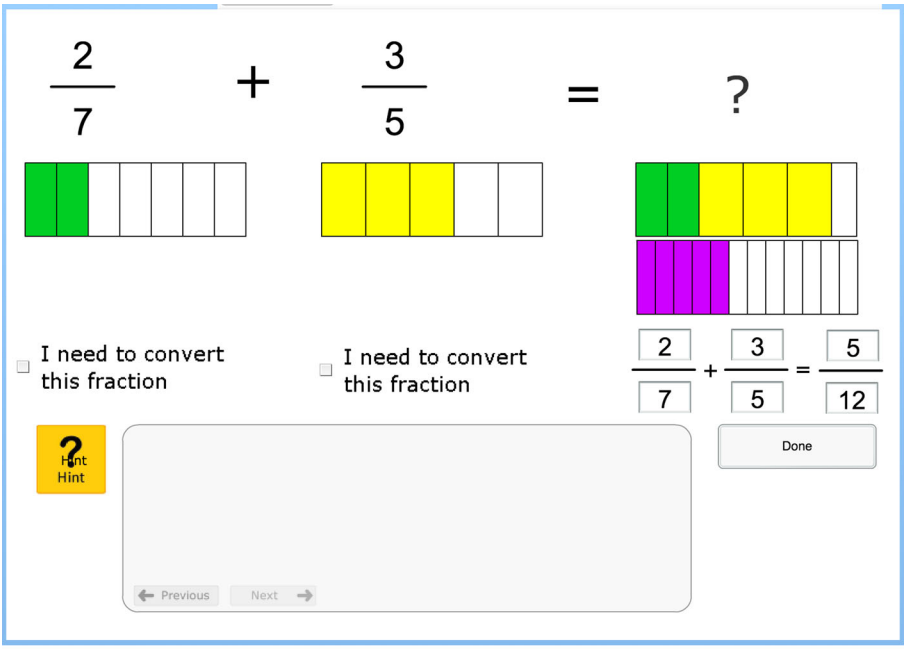


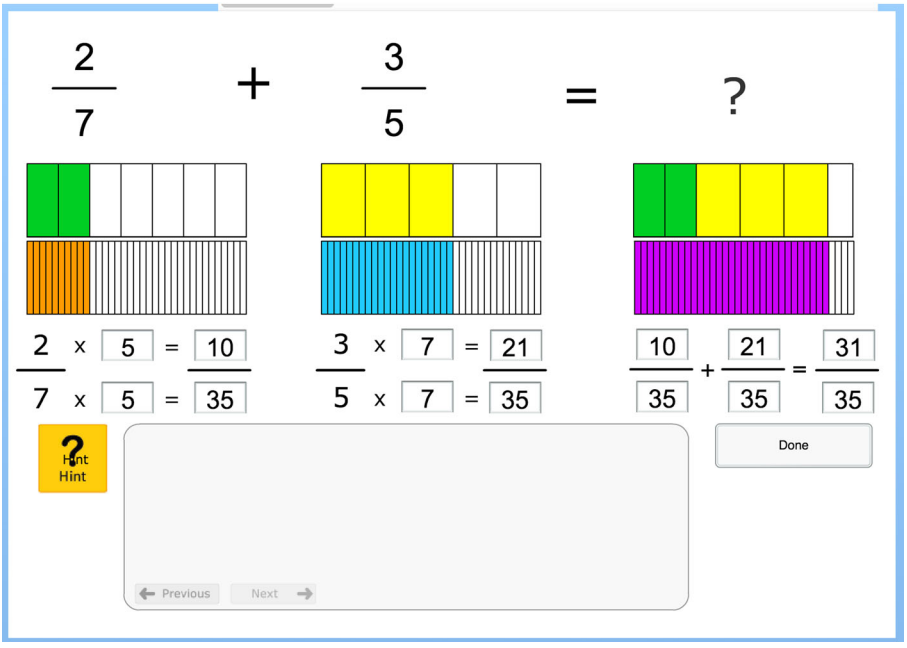
The *Proportional Reasoning Tutor* (Earnshaw, 2014) supports worked examples and tutored problems in middle-school mathematics

Fractions Tutor

The *Fractions Tutor* (Rau et al. 2013, 2014, 2015a) supports conceptual learning of fractions in grades 4 and 5 using multiple interactive graphical representations of fractions

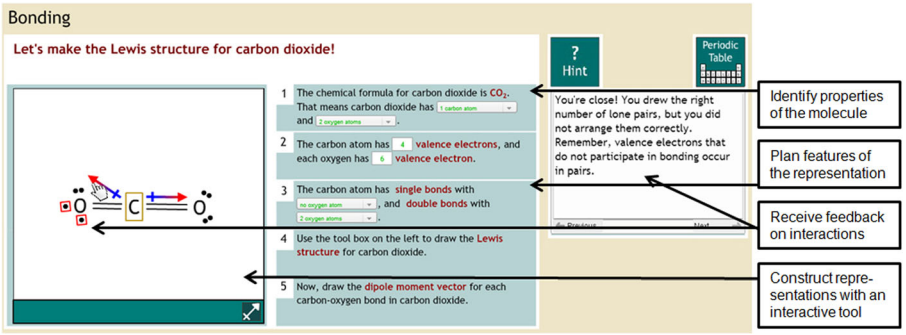
Grounded Feedback Tutor



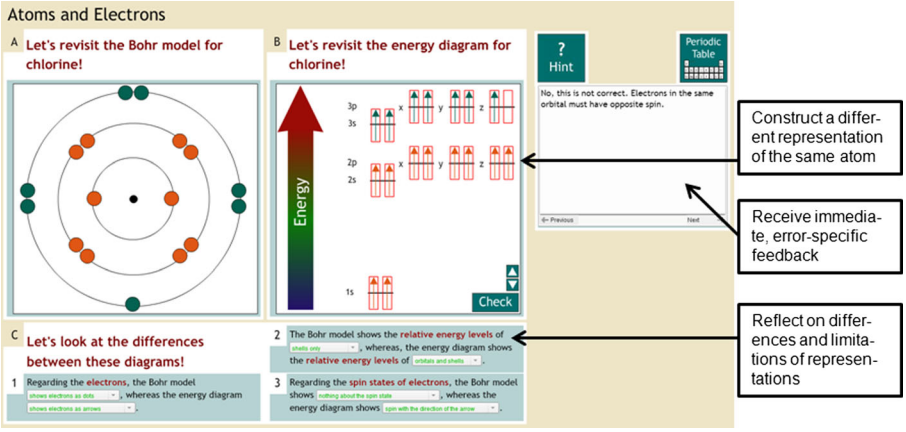


Grounded Feedback Tutor (Stampfer & Koedinger, 2013; Wiese & Koedinger, 2015) for elementary school fractions learning uses a graphical representation to provide feedback on students' solutions, instead of providing explicit correctness feedback. As the student enters a solution using numeric symbols, the fraction bars (except those representing the given fractions) are updated by the system to reflect the student input

Chem Tutor

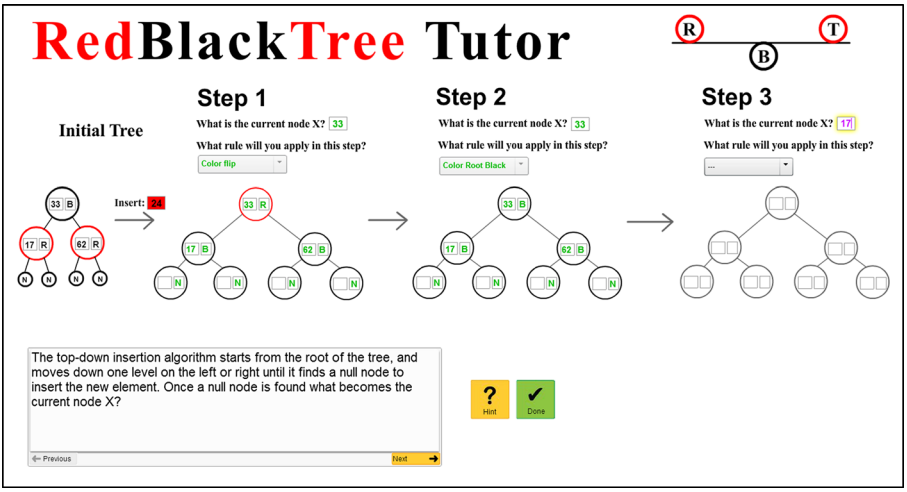


In *Chem Tutor* (Rau 2015; Rau and Wu 2015; Rau et al. 2015a, b), designed for introductory undergraduate chemistry learning, students plan and construct a graphical representation (Lewis structures), with feedback from the system



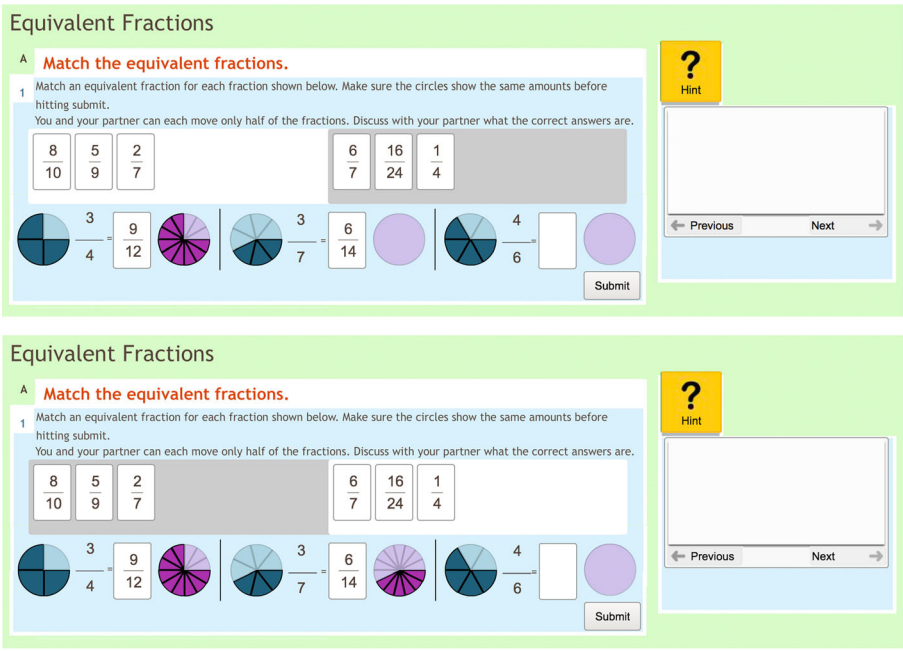
Given one representation, students construct a different kind of graphical representation of the same atom and are prompted to reflect on the differences and limitations of the two visual representations

RedBlackTree Tutor



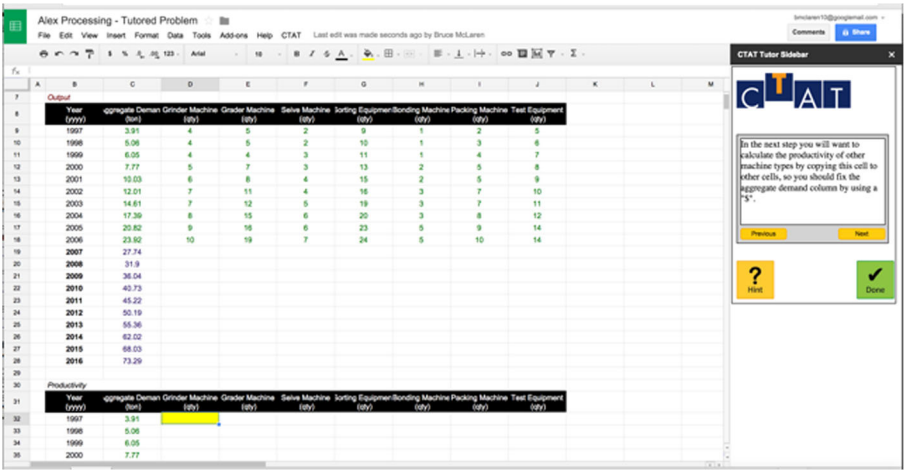
The *RedBlackTree Tutor* (Liew & Xhakaj, 2015; Xhakaj, 2015; Xhakaj & Liew, 2015) helps students learn an algorithm for building red-black trees, a common data structure in computer science

Tutor for collaborative learning of fractions



Elementary school students (grades 4 and 5) use the *Collaborative Fractions Tutor* with a partner; each partner has a different role, with a different view of the problem and different available actions (Olsen et al. 2014a, b, under review)

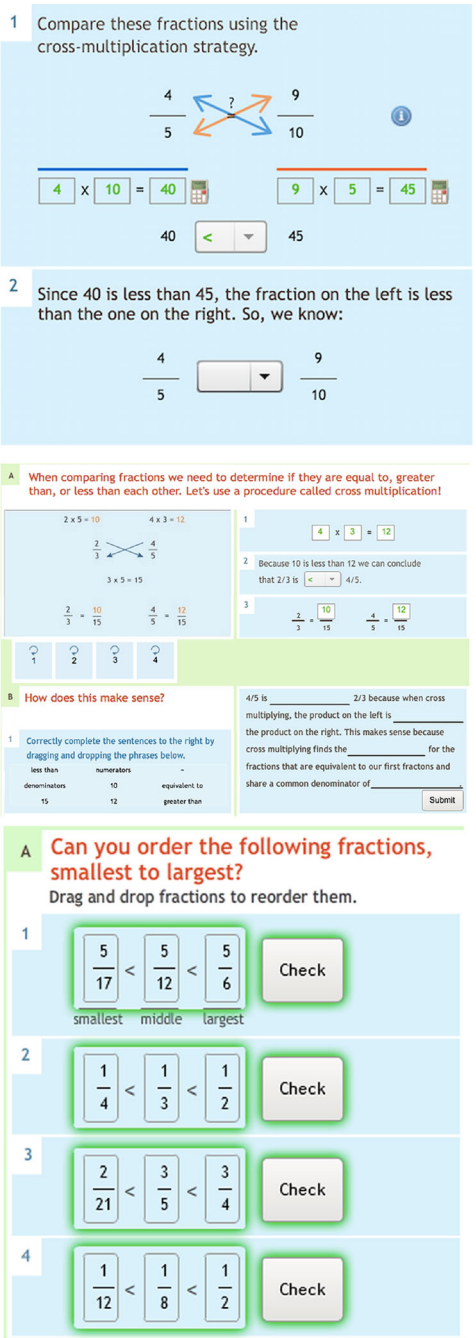
Tutor for Business Modeling with Google Sheets



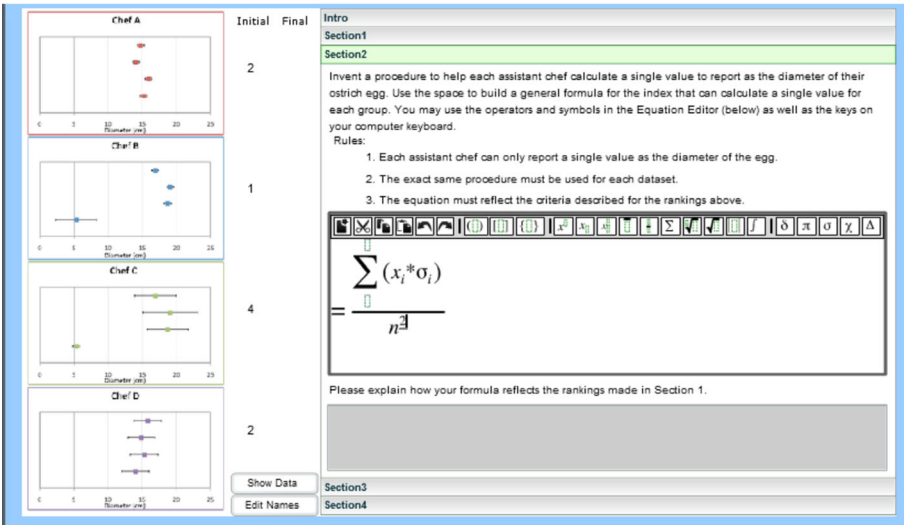
An example-tracing tutor build by McLaren and colleagues, embedded within Google Sheets, provides guidance with business modeling problems

Fractions Tutor version that supports Sense Making, Induction/Refinement, and Fluency Building

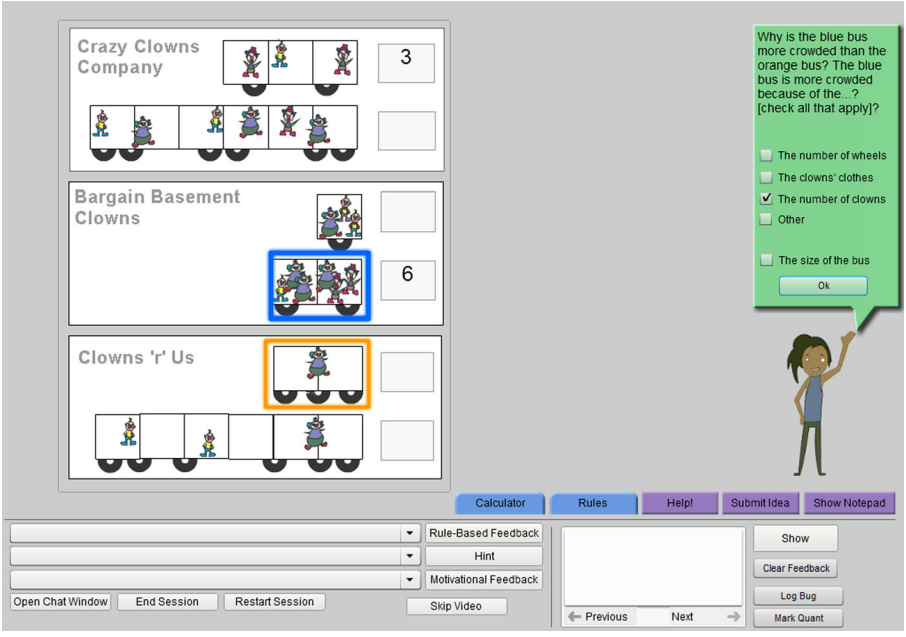
A new version of the Fractions Tutor (Doroudi et al., 2015) has activities targeting each of the three main learning mechanisms identified in the Knowledge-Learning-Instruction framework (KLI; Koedinger et al., 2012) induction and refinement (IR) (top), sense-making (SM) (middle), and fluency (F) (bottom)



Tutors for Guided Invention activities

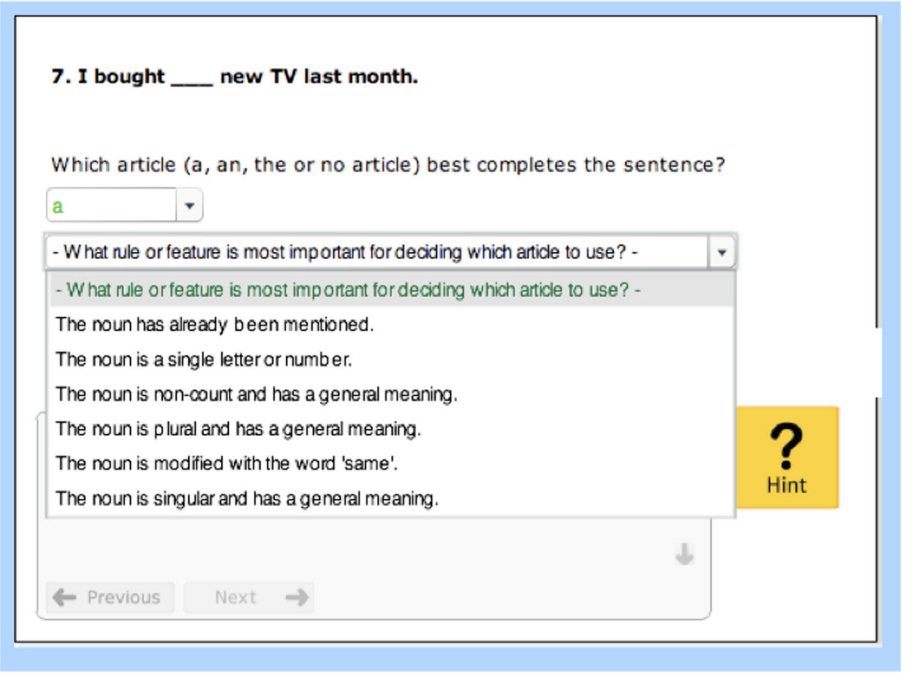


A tutor by Roll et al. (2010) provides guidance during invention activities



CTAT was used to create a tutor for guided invention activities with a Wizard of Oz interface (Chase et al., 2015); CTAT s collaborative tutoring facility enabled separate roles and capabilities for student and wizard.

The Article Tutor



Version of the *Article Tutor* (Wylie et al. 2011) that supports self-explanation