Using Intelligent Tutoring Systems as Platforms for Research in the Learning Sciences: ASSISTments

Overview

- Part I: What and why of ASSISTments
- Part II: Tour of the project website
- Part III: Examining some materials & learning more about the system
- Part IV: Evidence of efficacy
- Part V: Discussion and application to MN
Part I: The ASSISTment System

- A web-based assessment system, designed to collect formative assessment data on student math skills.
- Students are tutored on items that they get incorrect.
- Currently, thousands of students use the system.

ASSISTments in Action
Example of What Students See

Triangles $ABC$ and $DEF$ are congruent. The perimeter of triangle $ABC$ is 23 inches. What is the length of side $DF$ in triangle $DEF$?

Hmm, no.
Let me break this down for you.

Which side of triangle $ABC$ has the same length as side $EF$ of triangle $DEF$?

The original question
- Congruence
- Perimeter
- Equation-Solving

The 1st scaffolding question

Congruence
Triangles ABC and DEF are congruent.
The perimeter of triangle ABC is 23 inches. What is the length of side DF in triangle DEF?

Hmnn, no.
Let me break this down for you.

Which side of triangle ABC has the same length as side DF of triangle DEF?

What is the perimeter of triangle ABC?
- \(2x + 8\)
- \(\frac{1}{2} \times 8x\)
- \(2x + x + 8\)
- \(\frac{1}{2} \times (2x)\)

A buggy message
No. You might be thinking that the area is 1/2 base times height, but you are looking for the perimeter.
Example of what teachers see

- A buggy message: No. You might be thinking that the area is 1/2 base times height, but you are looking for the perimeter.

- The 1st hint message: Perimeter is defined as the sum of all sides of a figure.

- The 2nd scaffolding question: What is the perimeter of triangle ABC?
  - $2x + 3$
  - $\frac{1}{2} \times 2x$
  - $2x + x + 3$
  - $\frac{1}{2} \times (2x)$

- The 1st scaffolding question: Which side of triangle ABC has the same length as side DF of triangle DEF?

- The 1st equation-solving problem: $x + 3 = 8$
Part II: Tour of Project Website

- **Main page**
- **Teacher Wiki**
- **Teacher Binder Content**
- **Getting Started as a Teacher**
Part III: Learning More About the Program & Examine Materials

- Read the detailed ASSISTment description (download or read on-line)
- Examine the Teacher Manuals and other on-line information (can download)
- Examine the problem sets available at different grade levels (can download)
- Create an account if you have time (easy to do)
- Check out problem sets once you have an account

Part IV: Evidence of Efficacy -- Research Questions for US Dept of Ed

1. Does ASSISTment system work as an assessment tool?
   a. Reliably predict MCAS performance?
   b. Reliably advise teachers & students on what knowledge to focus on?

2. Does the system help enhance student learning?
   a. Does the system effectively teach as it assesses?
   b. Can teachers use the advice of this system to lead to higher student learning?
Randomized Controlled Experiments Investigating What Works are Important to Funders and the Public


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**What works best for whom?**

- **AIED 2007 experiment**


- **What type of tutoring works best for whom?**
Is more interaction helpful?

- **Scaffolding + hints** represents the most interactive experience because students must answer scaffolding questions, i.e. learning by doing.

- **Hints on demand** are less interactive because students do not have to respond to hints, but they can get the same information while solving problems as in the scaffolding questions by requesting hints.

- **Delayed feedback** is the least interactive condition because students must wait until the end of the assignment to get any feedback.
Hints only Condition

Delayed Feedback Condition

In this condition, the system behaves the same no matter what the student answers.

Students get answers and explanations after they finish all of the problems in the experiment.
Hypothesis

• If the interaction hypothesis is true, students in the scaffolding + hint condition will learn the most. Students in the delayed feedback condition will learn the least.
• The effectiveness of the interaction will depend on the difficulty of the content.

Results

• Conditions were not significantly different at pretest.
• Students learned overall from pretest to post-test ($p = 0.005$).
• Gain score averages showed a significant interaction between condition and math proficiency.
**Gain scores on a single item**

All students: the interaction between math proficiency and condition is significant.

### Implications

- Optimize learning for kids from different backgrounds.
  - Low knowledge students should get scaffolding.
  - Consistent with other interactions we have found between students
  - Could look for other ways students can differ.

Comparing Traditional PPH with Homework using ASSISTments

– Purpose: to determine if students can learn more by doing their math homework with a web-based intelligent tutoring system than when doing traditional paper-and-pencil homework.


One to one computing programs

• States such as Maine, Indiana, Michigan and Virginia, have begun to implement one-to-one computing in schools where each child gets his/her own laptop to use during school and often to take home.*
  – The Maine Learning Technology Initiative (2002-2004) supplied every Maine 7th and 8th grade student and their teachers with laptops, with 40% of the middle schools allowing students to take their laptops home.

• There are few research studies on the effects of one-to-one computing on teaching and learning
  *Bonifaz and Zucker, 2004
Triangles ABC and DEF are congruent.
The perimeter of triangle ABC is 23 inches. What is the length of side DF in triangle DEF?

Hrm, no.
Let me break this down for you.

Which side of triangle ABC has the same length as side DF of triangle DEF?

The original question
a. Congruence
b. Perimeter
c. Equation-Solving

The 1st scaffolding question
Congruence

What is the perimeter of triangle ABC?

- $2x + 8$
- $\frac{1}{2} \cdot 3x$
- $2x + x + 8$
- $\frac{1}{2} \cdot 2x$

The 2nd scaffolding question
Perimeter
23 inches. What is the length of side DF in triangle DEF?

Hrmn, no.

Let me break this down for you.

Which side of triangle ABC has the same length as side DF of triangle DEF?

What is the perimeter of triangle ABC?

- $2x + 8$
- $\frac{1}{2} \cdot 8x$
- $2x + x + 8$
- $\frac{1}{2} \cdot s(2x)$

No. You might be thinking that the area is $1/2$ base times height, but you are looking for the perimeter.

Perimeter is defined as the sum of all sides of a figure.

A buggy message
Experiment Design

- 54 5th grade students with internet at home
- 2 problem sets  
  - Number sense  
    - Which of the following is closest to the product of 397.8 * 10.3?  
  - Mixed problems  
    - 2X + 2 = 14  
      - What value of X makes the equation shown above true?
- Counterbalanced design
Results

- Students learned significantly more with web-based homework assistance with 0.6 effect size (p = 0.05).

**Results not just do to a few students**

Our worst gain score is in our WBH condition
Implications

- Results of this study are promising in that kids can learn a good deal more with homework.
- Only study of its kind we are aware of.
- Could be important to policy makers, particularly considering the popularity of one-to-one computing initiatives
- Will become more relevant as the digital divide narrows

Does an Intelligent Tutor lead to more learning than traditional classroom practice?

- Most math classrooms give a lecture and then a period of time for practice
- They showed that kids learn a lot more when getting immediate feedback from the ITS than the control of “business as usual”
- Immediate feedback is good

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Not only is ITS feedback good for learning, it’s also more motivating

- Ms. Lindquist study showing students assigned to the “intelligent tutor” conditions will spend a long time on the web site.


Does Tracking 98 Skills Help?

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106 knowledge components students are doing well:

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<th># Records</th>
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GRO Seminar Materials
Using finer-grained skill model can improve assessment.


Part V: Discussion and application to MN