## Features of Intelligent Tutoring Systems

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## AGENDA

## Motivation

Emotion in Learning

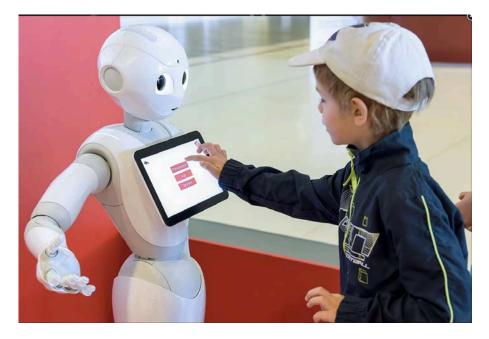
<u>Collaboration</u>

Intelligent Training Big Data for Education



## AI in Education

Using AI technology, (machine learning, natural language processing, planning, etc.) to provide realtime personalized feedback to students.



Detects whether a student's reaction to a concept follows a pattern (e.g., has a skill or a misunderstanding).

Provides an early warning for teachers and selfregulation aids for students.

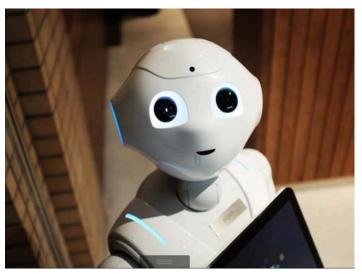
## Function of AI in Education

#### Personalized Learning

Analyze student data (course work, interactions, test scores etc.) to create a unique and customized learning path for students.

#### Real time performance tracking

Leverage AI to track performances and offer feedback tailored to each student.



First humanoid robot to be adopted in Japanese homes, a multipurpose human-shaped robot.

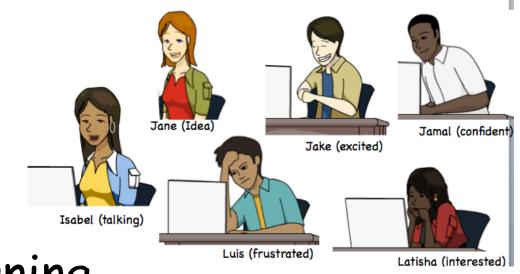
#### Customized Smart Content

<u>Customize content to suit the needs of learners</u>. Break content into easy parts, add multimedia and incorporate tests adapted to each new user.

### Intelligent Tutors

- Al-enabled software helps teach basic skills so that educators can focus on more complex topics.
- Sentient tools can take over <u>simple and social tasks</u> that teachers and aids provide today.
- One potential of AI is to <u>automate menial tasks so</u> <u>that</u> teachers will have less drudgery, e.g., grading.
- AI might provide more time for teachers to create engaging and creative activities, and work on their own professional development.

## AGENDA



#### <u>Motivation</u>

Emotion in Learning

## <u>Collaboration</u>

Intelligent Workplace Training

**Big Data for Education** 

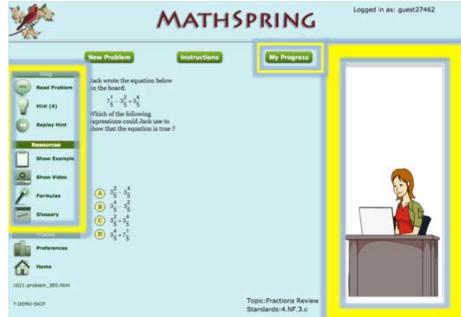
## Learning is Impacted by Emotion

- Predispositions (low self-confidence) can diminish success. Boredom reduces task performance.
- Positive emotions (confidence) have an impact on learning performance.

 D. Goleman. Emotional intelligence. why it can matter more than fq. *Learning*, 24(6):49–50, 1996.
 R. Pekrun, T. Goetz, L. M. Daniels, R. H. Stupnisky, and R. P. Perry. Boredom in achievement settings: Exploring control-value antecedents and performance outcomes of a neglected emotion. *Journal of Educational Psychology*, 102(3):531, 2010.

#### **Students Express Emotion**

- What should a tutor do <u>in</u> <u>the moment</u> when students are frustrated, bored, etc.?
  - Increase Challenge? Decrease Challenge?
  - Provide "affective" scaffolds? What are those?
  - Suggest peer-to-peer collaboration?



How to measure changes in student affect, <u>capturing</u> <u>micro-changes</u> in student affective states after an intervention?

#### Three Responses Were Evaluated

Empathy	"Don't you sometimes get frustrated trying to solve math problems? I do."
Growth Mindset	"Did you know that when we practice to learn new math skills our brain grows and gets stronger?"
Success / Failure	"Very good, we got another one right!"

### **Dweck Growth Mindset**

- Students who believe that intelligence can be increased tend to seek out academic challenges.
- Growth mindset messages lead to improved learning
- D'Mello found successful results in Auto-Tutor using <u>Empathy</u>,

D'Mello et al., 2010

Did you know that when we learn something new our BRAIN actually changes? It forms new connections inside that help us solve problems in the future.

Pretty Amazing, eh?



#### Observations

 Students exhibited <u>higher</u> levels of <u>interest</u> and <u>valued math</u> knowledge more with exposure to more <u>empathic</u> messages.

 Students <u>valued math</u> knowledge <u>less</u> and had <u>lower post test</u> performance score, with <u>growth</u> <u>mindset</u> messages.

 Students were less learning-oriented and more <u>confused</u> with <u>success/failure</u> messages

## AGENDA

## <u>Motivation</u> <u>Emotion in Learning</u>

Collaboration



Intelligent Workplace Training Big Data for Education

#### **Collaboration Research**

**Collaboration** is **student-centered; students:** 

- are active,
- pose questions,
- explain topics/concepts to their peers,
- interact with one another.

Johnson, & Johnson, (1989). *Cooperation and competition: Theory and research*. Interaction Book Company Johnson, & Johnson (2005). New developments in social interdependence theory. *Genetic, social, and general psychology monographs, 131*(4), 285-358.

#### Collaboration

Collaboration impacts cognitive and affective outcomes:

- Increases achievement in standardized test scores as compared to control groups, with large effect sizes
- Produces novel ideas and learning gains beyond the ability of the best individuals in the group
- Produces knowledge that none of its members would have produced on their own.

Peer-to-peer interactions are vital aspects of collaboration,

 Students <u>question processes</u>, make mistakes, and <u>monitor</u> each other's reasoning.

Slavin, R., Lake, C., & Groff, C. (2009). Effective programs in middle and high school mathematics: A best-evidence synthesis. *Review of Educational Research*, *79*(2), 839-911. Slavin, R. (1990). Cooperative learning: Theory, Research, & Practice. Englewood Cliffs, NJ, Prentice-Hall.

#### **Peer-to-peer collaboration**

## MATHSPRING

Instructions

My Progress

The next activity is a special one.

You will be working with **Wendy** on **ONE** problem. **Wendy** will read the problem aloud, and your job is to use the **mouse** and **keyboard**. **WORK TOGETHER** to solve the problem.

Click 'Ok' to start solving a problem together

#### MATHSPRING

#### Instructions

**My Progress** 

In this next problem, you will work with **Amy** who should be sitting next to you, on **Amy**'s screen for **ONE** math problem.

Amy will use the mouse and keyboard. Your job is to **READ** the math problem aloud on Amy's screen.

Work together to solve the problem.

(Left) Invitation to Amy to work with Wendy (Right). Amy might wait for a short time until Wendy completed the math problem she was working on. Special roles are assigned to each student. After students solved the problem together on Amy's screen, they worked on their own computers.

#### **Team Activities**

- Team activities often increase students' interest.
- Peer-to-peer <u>activities address students' negative</u> affective states.
- Collaboration provides a boost in student math learning.
- Collaboration <u>yields higher math</u> performance and learning.

#### In Summary

- Peer-to-peer collaboration:
  - increases students' interest.
  - responds to students' <u>negative affective states</u>.
  - provides a boost in student math learning.
  - yields higher math performance and learning.

#### Discussion

- We refined a methodology to analyze how peerto-peer collaboration produces changes in affective states
  - − Randomized Controlled trials → Model creation/application
- Evidence that offering collaboration can lead to increased interest and excitement



#### <u>Motivation</u>

#### Emotion in Learning

<u>Collaboration</u>

Intelligent Workplace Training Big Data for Education

## The Need to Train Soft Skills

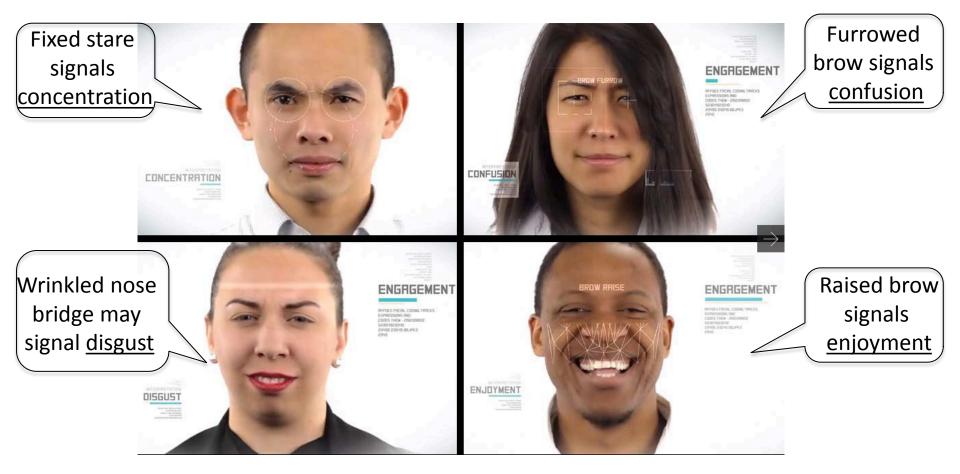
- Job growth in the United States required relatively <u>high</u> <u>degrees of social skills</u>. Jobs requiring high levels of <u>social interaction grew by nearly 12 % points</u>.
- Math-intensive but less social jobs including many <u>STEM</u> occupations - <u>shrank</u> by 3.3 % points over the same period.
- The labor market's <u>return to social skills</u> was greater in the 2000s than in the mid 1980s -1990s.
- Corporate hiring favors social skills (Gershon, 2016).
   Soft skills can make the difference between a <u>standout</u> <u>trainee</u> and one who just gets by.

#### Which Skills to Train?

Team Activities	<mark>Soft Skills Required</mark>
Receive Information	<ul><li>Listening Skills</li><li>Analytic Thinking</li></ul>
Respond to Information	<ul> <li>Ability to Communicate Effectively</li> <li>Leadership Skills</li> <li>Problem-Solving</li> </ul>
Value Others	<ul><li>Diplomacy</li><li>Flexibility</li></ul>
Organize People	<ul><li>Change-readiness</li><li>Team-building Skill</li></ul>
Characterize Activities	<ul><li>Self-awareness</li><li>Creativity</li></ul>

These soft skills are deemed to be behaviors critical to effective performance in the workforce and are suggested to be in short supply.

#### **Tracking Workers Facial Cues**



Screenshots from a video from Affectiva shows how the Affdex software tracks facial cues to infer emotions.

#### Primary message



(a) AU4 BROW LOWERER

(b) AU15 LIP CORNER DEPRESSOR



(c) AU18 LIP PUCKERER

(d) AU24 Lep Presson

 Facial expressions for women and men differ systematically during learning, that is, men and women have different ways of affectively expressing internal states (moments of mental effort and uncertainty)

 Gender specific models may support students more effectively

> Alexandria Vail, Joseph Grafsgaard, Kristy Boyer, Eric Wiebe, James Lester, UMAP 2016

#### Facial Expression Differences by Gender



(a) AU4 BROW LOWERER

(h) AU15 LIP CORNER DEPRESSOR



(c) AU18 LIP PUCKERER

(d) AU24 LIP PRESSOR

- Female students tended to express AU15 (Lip Corner Depressor) more frequently than male students.
- Male students were more likely to express AU4 (Brow Lowerer), AU18 (Lip Puckerer) and AU24 (Lip Pressor).

\* investigated whether these differences arose due to other characteristics (incor

	Females	Males
AU4 BROW LOWERER	$-0.536 \pm 0.418$	$-0.133 \pm 0.566$
AU15 LIP DEPRESSOR	$-0.499 \pm 0.296$	$-0.786 \pm 0.281$
AU18 LIP PUCKERER	$-0.510 \pm 0.590$	$0.136 \pm 0.556$
AU24 LIP PRESSOR	$-0.353 \pm 0.358$	$-0.051 \pm 0.386$

#### Predicting Learning from Facial Expression

Are Facial Action Units predictive of learning gain in male and female students? Trained a step-wise regression model to predict learning gain.

Normalized Learning Gain =	$R^2$	p
+0.6508 * AU2 OUTER BROW RAISER	0.2209	0.009
+1.2120 * AU9 Nose Wrinkler	0.1109	0.003
+1.7156 * AU12 LIP CORNER PULLER	0.1591	0.006
-0.7100 * AU20 LIP STRETCHER	0.0908	0.005
-0.9414 (Intercept)		1.000
Leave-One-Out Cross-Validated	$R^2 = 0.5$	817

Normalized Learning Gain =	$R^2$	p
-0.6628 * AU5 Upper Lid Raiser	0.1199	0.010
+0.1747 (Intercept)		1.000
Leave-One-Out Cross-Validate	d $R^2 = 0.1$	199

4 facial expressions are significantly predictive of learning gain in female students.

Only 1 facial expression is significantly predictive of learning gain in female students.

#### Facial Expression Differences by Gender

Discussion

- AU15 (Lip Corner Depressor), AU18 (Lip Puckerer) and AU24 (Lip Pressor) maybe associated with negative affect, and maybe indicative of moments of mental effort and uncertainty.
- AU4 (Brow Lowerer) has been acknowledged as a key indicator of mental effort or confusion in learning context, which is further reinforced here.

#### Discussion

- Different facial expression features important for predicting learning in male and female students.
- Interpretations of why AUs are predictive, e.g. Upper Lid Raiser (AU5) is the only AU found predictive of learning for male students
  - Male students opened eyes while being overwhelmed in the learning task
  - Widened eyes corresponded to greater amount of reading, but this was associated with extraneous cognitive processing resulting in less efficient learning
  - Eye widening was performed to stave off boredom

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Intelligent Workplace Training

Big Data for Workplace Training

## Big Data in Workplace Training

Big Data . . .

- Identifies trainees with similar <u>learning difficulties</u> and gender <u>differences</u>.
- Tracks trainees' <u>behavior</u> by seconds: requests for help, <u>carelessness</u>, <u>guessing</u>, etc.
- Is <u>essential</u> to advance online instruction.
- Supports trainers to <u>offer help</u>, change course material or compliment the student.
- Helps <u>interpret</u> what trainees and trainers do in the <u>classroom</u>.

#### Log Data from Online Tutor

studId	emotion	level	explanation	tin
29077	Interest	3	its ok	20
29075	Interest	4	I had trouble in the last few problems	20
29014	Excitement	4	BECAUSE I ACTUALLY AM FEELING AS IM LEARNING	20
29073	Interest	5	Because math is my favorite subject and it's interesting solving new problems.	20
28993	Excitement	5	Cause	20
29004	Excitement	3	I am kind of excited because I am provided a lot of tools that can help me sole the problem	20
29075	Interest	5	I have been doing better	20
29018	Interest	3	its too hard!	20
29077	Excitement	4	its 0k	20
28998	Excitement	1	When people want to learn, they want to at less have fun while learning.	20
29000	Interest	3		20
29014	Excitement	5	l got it right	20
29006	Interested	4	because math is alright	20
29073	Interest	5	It is interesting solving new problems.	20
28991	Excitement	1	I am not feeling excited because math is not fun.	20
29016	Excitement	3	because well this is very not that hard then i tought i thought it was going To be very wierd then you	20

#### Large Data Sets

#### EventLog Table of a Math Tutoring System. 571,776 rows, just in a year time.

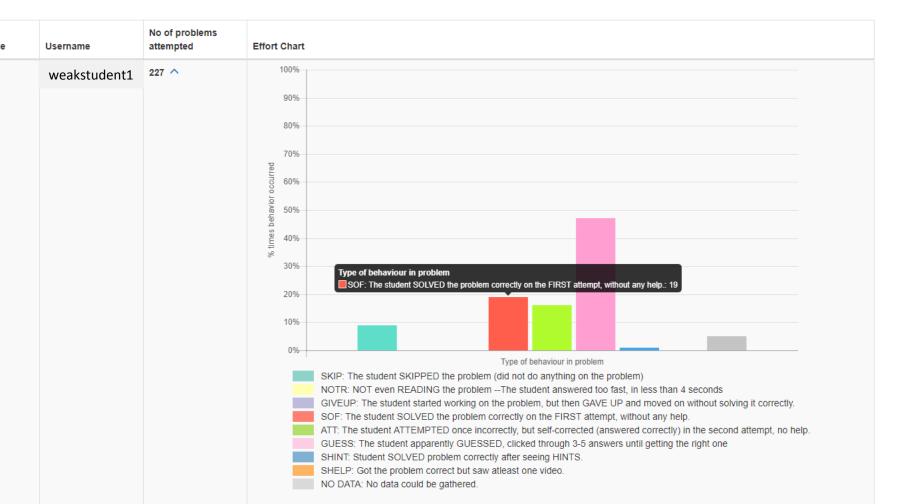
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#### **Questions Trainers Ask**

- How much trainees **KNOW**, **GAPS** questions
- ACTING and TRAINEES EFFECTIVELY questions
- How to have trainee become effective LEARNERS (Self-regulation/metacognition) questions
- Trainees' **MOTIVATIONS** questions
- Tech. EFFECTIVENESS and ENGAGEMENT with technology questions

#### **Output to Trainees**

#### Teachers can discern a strong/weak student



#### **Report Per Problem Topic**

#### Class Summary Per Student Per Topic

table shows problem set-w	vise performance of students of this class.
Mastery Range	Grade/Color Code
).75 or Greater	Grade A (Excellent)
etween 0.5 and 0.75	Grade B (Good)
etween 0.25 and 0.5	Grade C (Needs Improvement)
).25 or Less	Grade D (Unsatisfactory)

Showing 1 to 4 of 4 entries

Student Name

- Each cell shows [number solved on first attempt / number problems solved] along
- · Cell wherein students have attempted 10 or more problems are color coded.

Username

HannenOrange1 📶

HannenOrange2

HannenOrange3 📶

HannenOrange4 📶

HannenOrange5 📶

HannenOrange6 HannenOrange7 📶

· Click on the cell to get the complete "Mastery Trajectory" for given student and pro

Angles

problemset



## Features of Intelligent Tutoring Systems

## **Any Questions ?**

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# Gender Differences in Facial Expressions of Affect During Learning

#### Vail et al.,

2016 Conference on User Modeling Adaptation and Personalization. ACM, 2016.

Alexandria Vail, Joseph Grafsgaard, Kristy Boyer, Eric Wiebe, James Lester