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iFLYTEK

Software Robots as Facilitators of Group Discussions

Carolyn Penstein Rosé

Language Technologies Institute

Human-Computer Interaction Institute

School of Computer Science

Carnegie Mellon

With funding from the National Science Foundation



**What we
can achieve**

Where we are

Analysis

Design

What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

411CS1: the glucose will slowly change over time into light green

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412CS1: the glucose will slowly change over time into light green

411CS1: I think that there will not have as much glucose in it

412CS1: Thanks for starting a prediction, 412CS1.

TUTOR: your welcome

411CS1: I dont like this chat in being cheated

411CS1: but if the test strip is testing for glucose wouldnt the test strip stay dark green because there is more glucose than distilled water

412CS1: So is 411CS1 saying "a glucose test strip changes color when glucose is there?"

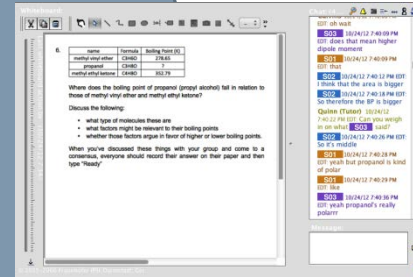
411CS1: hey SAGE

411CS1: yes I guess

411CS1: there is more glucose so the test strip would stay dark green not change to light green

412CS1: I agree, is the distilled water in the dialysis tubing

411CS1: true but the tube is filled with water which doesnt do much but glucose does change the strip



Facilitating Effect On Teachers

Automated Support For Students



- Sage on the stage?

What is the Role
of Technology in
Learning?

Students learn significantly more when interactive directed lines of reasoning replace hints.

(Rosé et al., 2001)

Tutor: Let's think about the difference between speed and velocity. A closely related distinction is that of the difference between distance traveled and displacement from the origin. Take as an example a bee flying from point A to point B by means of a curvy path. If you draw a vector from point A to point B, you will have drawn the bee's displacement vector. What does that vector represent?

Student: The bee's distance?

Tutor: The displacement vector only represents the net change in position. So it does not tell you how far the bee traveled. If you want to know how far the bee traveled, what do you need to measure?

Student: the bee's path?

Tutor: Right. Now, the bee's displacement is a vector. Is the distance a vector or a scalar?

Student: Scalar.

Tutor: So then distance traveled is the scalar counterpart to displacement. Now thinking about our analogy, what is the difference between speed and velocity?:

Student: Speed is a scalar, and velocity is a vector.

ANDES Physics Workbench - [Exs1e-Solution.FBD]

File Edit Diagram Variable View Help

A 100 kg midshipman doing Marine training is descending from a helicopter when his release mechanism jams.

What is the tension in the cable that he is suspended from?

Answer:

Diagram: A helicopter is shown on the left, with a cable extending downwards to a midshipman. A coordinate system is centered on the midshipman, with the vertical axis labeled '+Y' and the horizontal axis labeled '+X'. A green arrow labeled 'Ft' points upwards from the midshipman, and another green arrow labeled 'Fw' points downwards. The midshipman is labeled 'Mid'.

Name	Definition	X-Comp	Y-Comp
✓ mMid	mass of midshipman		
✓ Fw	magnitude of the Weight Force on mi...	Fw_x	Fw_y
✓ Ft	magnitude of the Tension Force on m...	Ft_x	Ft_y

1. mMid = 100
2. Fw = mMid*g
3. Ft = Fw
4. Fw_y = Fw * sin270
5. Ft_y = Ft * sin 90
6. Ft_y + Fw_y = 0
7. g = 9.8
8. Ft = 980

For Help, press F1

NUM 00:06:51

Insights towards an ongoing research focus...

- Effective human tutors guide students towards opportunities for reflection (Rosé & Torrey, 2004)
- Student interaction with dialogue agents lacks evidence of reflection (Rosé et al., 2003)
- Students expect to behave differently with agents than with humans (Rosé & Torrey, 2004)
- Human tutoring not always better than non-interactive support (VanLehn et al., 2007)
 - Focus shift to capturing what it is about interaction that is effective for instruction

Students as Resources

WhiteboardChat: AlexTutor (microstudy/test)

File

Whiteboard:

Current users:
AlexTutor

Chat (256)

AlexTutor 1/11/11 2:45:42 PM EST: Now discuss what you observed in the video about condition C. Compare what you observed to your predictions.

Student3 1/11/11 2:41:24 PM EST: I had predicted that the starch would turn dark. But I was surprised that it happened so fast.

AlexTutor 1/11/11 2:42:25 PM EST: Student2, now would be a good time to ask Student1 if he agrees with what Student3 has said, and why.

Student2 1/11/11 2:42:41 PM EST: Student1, what do you think? Were you also surprised? Please explain.

Student1 1/11/11 2:43:32 PM EST: I wasn't that surprised since it was like what we saw in Condition A. But what did surprise me was how clear the iodine solution became.

Student2 1/11/11 2:44:05 PM EST: I figured that the reason why it became so clear is that it was getting soaked into the starch and then wasn't free to come back out again.

AlexTutor 1/11/11 2:44:56 PM EST: Student3, now would be a good time to ask Student1 to rephrase what Student2 has said in his own words.

Student3 1/11/11 2:45:04 PM EST: Ok. Student1, can you tell me what Student2 meant in your own words?

Student1 1/11/11 2:46:07 PM EST: Ok, let me see if I have this right. You're saying that osmosis only happens with particles that are free. And once the iodine particles get into the cell and react with the starch, they are stuck there?

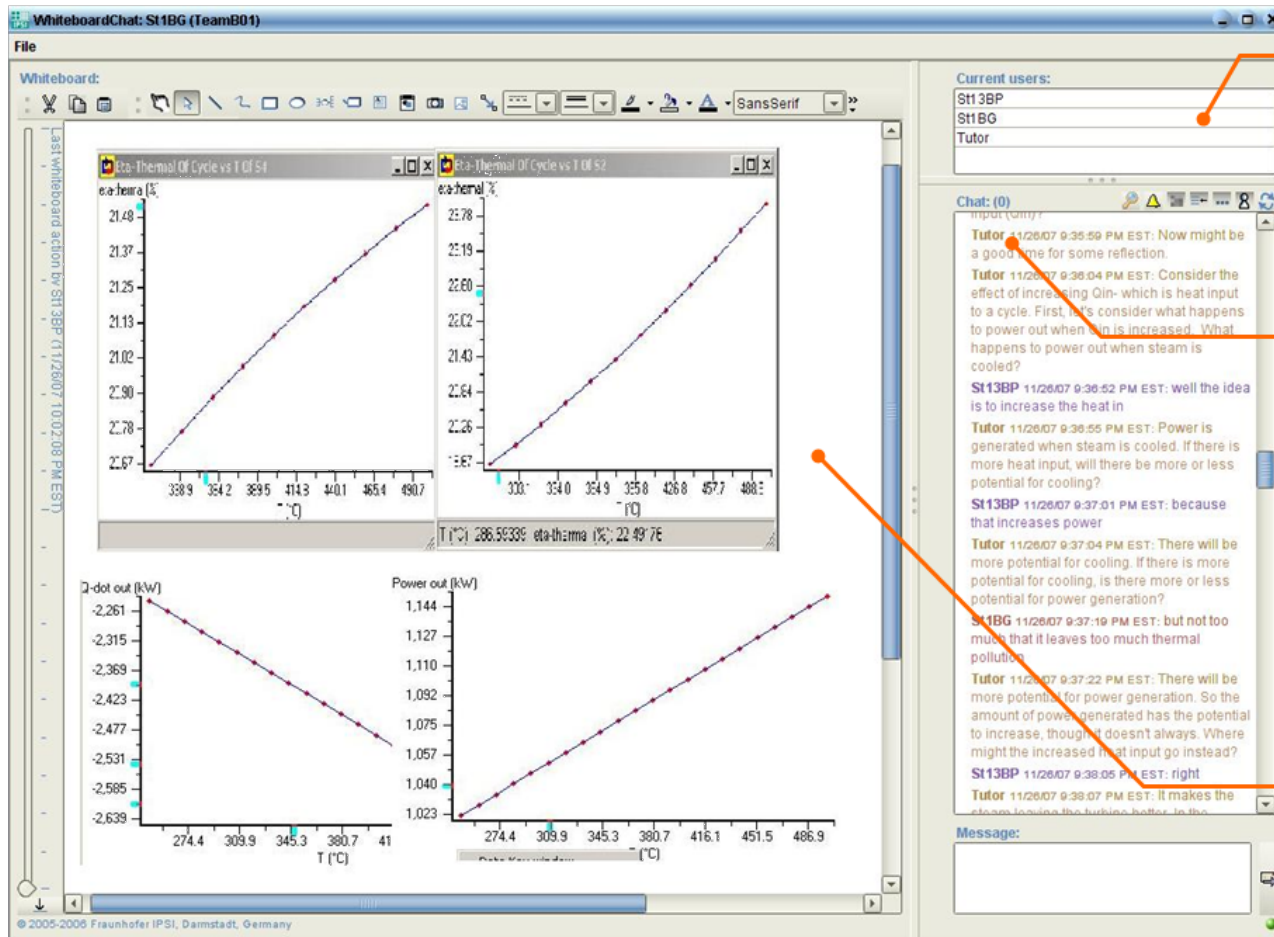
Student2 1/11/11 2:47:42 PM EST: I guess, but I'm not sure I would call iodine particles.

Message:

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- Students can benefit from working with another student, even in the absence of scaffolding (Gweon et al., 2006; Kumar et al., 2007)
 - Alternative perspectives stimulate reflection (de Lisi & Golbeck, 1999)
- Students gain as much from a human partner as from a carefully crafted tutor agent (Kumar et al., 2007)
- Context sensitive support for collaboration is more effective than static support (Kumar et al., 2007)

Conversational Agent Based Support in Computer Supported Collaborative Learning



Students & Tutor working on designing a power plant

Tutor discusses thermodynamics concepts and makes arguments for design alternatives.

Students share results and ideas in a common workspace

Students learn 1.24 s.d. more when working with a partner and automated support than students working alone (Kumar et al., 2007)

Effective in Multiple Learning Contexts

- A decade and a half of successful **classroom studies**
 - Middle school, High school, College level
 - Urban school districts
 - Top tier and second tier universities
 - Math, Science, Engineering, Social Sciences
- **Massive Open Online Courses (MOOCs)**
 - Demonstrates that success generalizes to massive scale

- Sage on the stage?



What is the Role
of Technology in
Learning?

- Students are the key
- Teachers are the guide on the side
- Technology is just a catalyst

What is the Role
of Technology in
Learning?

What does
that look
like?

- Students need each other for support
- i.e., Students can use each other as resources
 - For knowledge
 - For scaffolding to their reasoning
 - For scaffolding to their problem solving

Principle 1

- The seeds of collaboration are passed down from student to student
- More capable students mentor less capable students who in turn mentor those just behind them

Principle 2

Iterative Development → Design Principles

- **Personalized agents** increase supportiveness and help exchange between students (*Kumar et al., 2007*)
- Agents are more effective when **students have control** over timing of the interaction (*Chaudhuri et al., 2008; Chaudhuri et al., 2009*)
- Agents that employ **Balesian social strategies** are more effective than those that do not (*Kumar et al., 2010; Ai et al., 2010*)
- Students are sensitive to agent **rhetorical strategies** such as displayed bias (*Ai et al., 2010*), **displayed openness** to alternative perspectives (*Kumar et al., 2011*), and targeted elicitation (*Howley et al., 2012*)
- **Accountable talk agents** (*Dyke et al., 2013; Adamson et al., 2014*)



**Accountable Talk
Facilitation**

Analysis

Design

What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412CS1 TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412CS1 412CS1: the glucose will slowly change over time into light green

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412CS1 412CS1: the glucose will slowly change over time into light green

412CS1 412CS1: I think that there will not have as much glucose in it

TUTOR: Thanks for starting a prediction, 412CS1.

412CS1 412CS1: your welcome

412CS1 TUTOR: I don't like the chat as being cheated

412CS1 412CS1: but if the test strip is testing for glucose wouldnt the test strip stay dark green because there is more glucose than distilled water

412CS1 412CS1: So is 412CS1 saying "a glucose test strip changes color when glucose is there?"

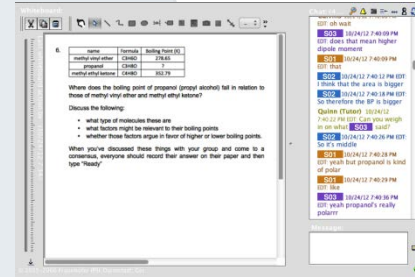
412CS1 412CS1: yes I guess

412CS1 412CS1: yes I guess

412CS1: there is more glucose so the test strip would stay dark green not change to light green

412CS1: I agree, is the distilled water in the dipstick tubing

412CS1: Yes but the tube is filled with water which doesnt do much but glucose does change the strip



Facilitating Effect On Teachers

Automated Support For Students



- It teaches students to use each other for support and scaffolding in their reasoning
- It trains students to serve as mentors to pass Accountable Talk on

What does
Accountable Talk
Accomplish?

Empirical Support for Accountable Talk

- When teachers of math, science, and reading use structured teacher-lead discussion methods...
 - steep changes in student **achievement** (*Bill, Leer, Reams & Resnick, 1992; Chapin & O'Connor, 2004*)
 - **Retention** for up to 3 years (*Adey & Shayer, 1993, 2001; Shayer, 1999; Topping & Trickey, 2007a, 2007b*)
 - **Transfer** across domains for up to 3 years (*Bill, Leer, Reams & Resnick, 1992; Adey & Shayer, 1993, 2001; Shayer, 1999; Chapin & O'Connor, 2004*)
 - Students perform better on **non-verbal reasoning** tests e.g. Ravens (*Mercer, Wegerif & Dawes, 1999*)
 - **Reasoning** itself improves (*Kuhn & Zillmer, in press; Lin et al 2012*)

Research Context

District Context: (2008-2010)

- 63% of district students performing below proficient in READING
- 56% below proficient in MATH, a large % of which are African American students

School Context:

- Failed to meet Adequate Yearly Progress on standardized tests for 5+ years

9th Grade Biology

- Year 1 – district mandated Accountable Talk professional development
 - 3 schools, 4 teachers, 108 consenting students
- Year 2
 - 1 school, 2 teachers, 113 consenting students
- Year 3
 - 3 schools (adding Math as a domain), 10 teachers, over a hundred consenting students

Analysis

Design

What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412C31: the glucose will slowly change over time into light green

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412C31: the glucose will slowly change over time into light green

412C31: I think that there will not have as much glucose in it

TUTOR: Thanks for starting a prediction, 412C31.

412C31: your welcome

TUTOR: I don't like the chat as being cheated

412C31: but if the test strip is testing for glucose wouldnt the test strip stay dark green because there is more glucose than distilled water

412C31: So is 412C31 saying "a glucose test strip changes color when glucose is there?"

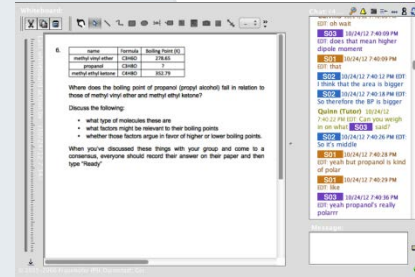
412C31: yes I guess

412C31: yes I guess

412C31: there is more glucose so the test strip would stay dark green not change to light green

412C31: I agree, is the distilled water in the dipstick tubing

412C31: Yes but the tube is filled with water which doesnt do much but glucose does change the strip



Facilitating Effect On Teachers

Automated Support For Students



Agents as Support for Group Learning

Employing Accountable Talk Practices

Whiteboard:

Condition B

Initial Observation	After 1 Hour	After 24 Hours
<p>Starch + Water</p>	<p>Iodine + Water</p>	
<p>Weight: 0.61 grams</p>	<p>Weight: 0.58 grams</p>	<p>Weight: 0.56 grams</p>

Current users:
S01
Sage (Tutor)

Chat: (1)

Sage (Tutor) 12:12:50 PM EDT: Notice how the inside and outside environments changed. Why did these changes happen?

S01 12:13:01 PM EDT: I think the starch obsorbed the iodine

Sage (Tutor) 12:13:09 PM EDT: Would another way to say that be "starch will make the iodine darker?"

S02 12:13:19 PM EDT: yeah, I agree

Sage (Tutor) 12:13:23 PM EDT: m-hmm

Message:

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Agent support by revoicing

Positive Effect on Student Learning



■ **Study 1:** Year 1, Diffusion Lab

- Students learn more on explanation questions in supported conditions ($F(1,46) = 4.3, p < .05$, effect size 1 s.d.)
- Students in supported conditions more active in whole group discussion ($F(2,26) = 4.2, p < .05$, effect size .75 s.d.)

■ **Study 2:** Year 2, Diffusion Lab

- Students learn more on immediate post test in Revoicing Agent condition ($F(1,74) = 4.3, p < .05$, effect size .51 s.d.)

■ **Study 3:** Year 2, Punnett Square Lab

- Students learned marginally more ($p < .1$) on delayed post-test in Revoicing Agent condition

Analysis

Design

What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412C51 TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412C51 412C51: the glucose will slowly change over time into light green

TUTOR: What changes do you think you'll see in this condition? Agree on a prediction for what you'll observe over time. "and" an explanation that everyone understands.

412C51 TUTOR: the glucose will slowly change over time into light green

412C51 412C51: I think that there will not have as much glucose in it

TUTOR: Thanks for starting a prediction, 412C51.

412C51 TUTOR: your welcome

412C51 TUTOR: I dont like the chat its being cheated

412C51 412C51: but if the test strip is testing for glucose wouldnt the test strip stay dark green because there is more glucose than distilled water

412C51 TUTOR: So is 412C51 saying "a glucose test strip changes color when glucose is there?"

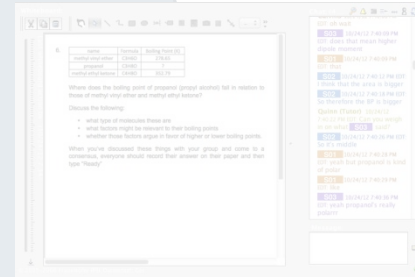
412C51 412C51: yes I guess

412C51 412C51: yes I guess

412C51: there is more glucose so the test strip would stay dark green not change to light green

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Facilitating
Effect
On
Teachers

Automated
Support
For
Students



Positive Effect in the Classroom

Does Accountable Talk Uptake Increase in the Classroom over time?

Observations of whole class teacher led discussions throughout 2 years of professional development

- Dependent Variable: Accountable Talk moves by teacher
- Independent Variables:
 - Baseline: Effect of time
 - Discussion type: After CSCL activities vs Other
 - Post-CSCL sessions significantly higher than Other (effect size **1.7 s.d.**)

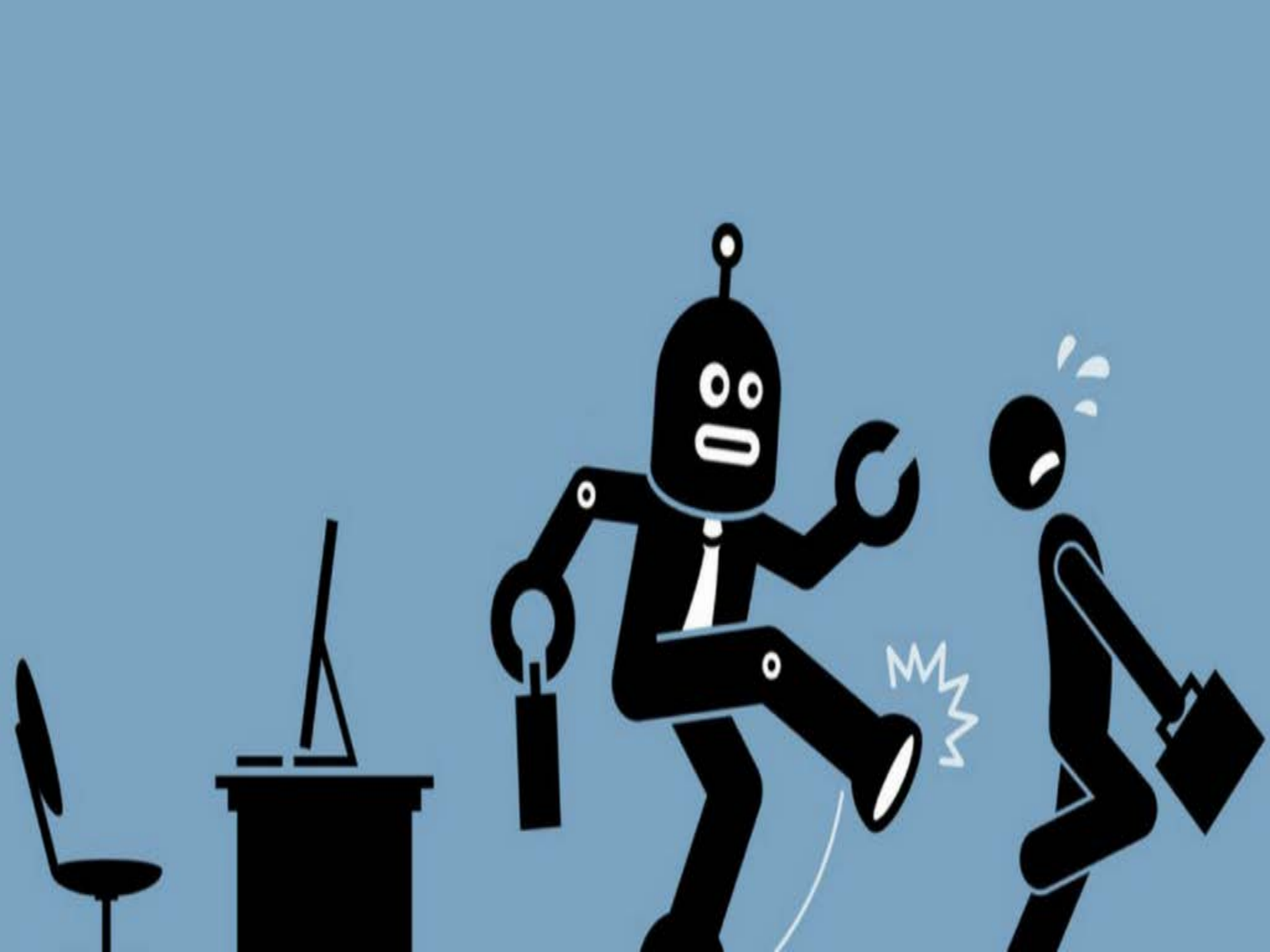
- Students are the key
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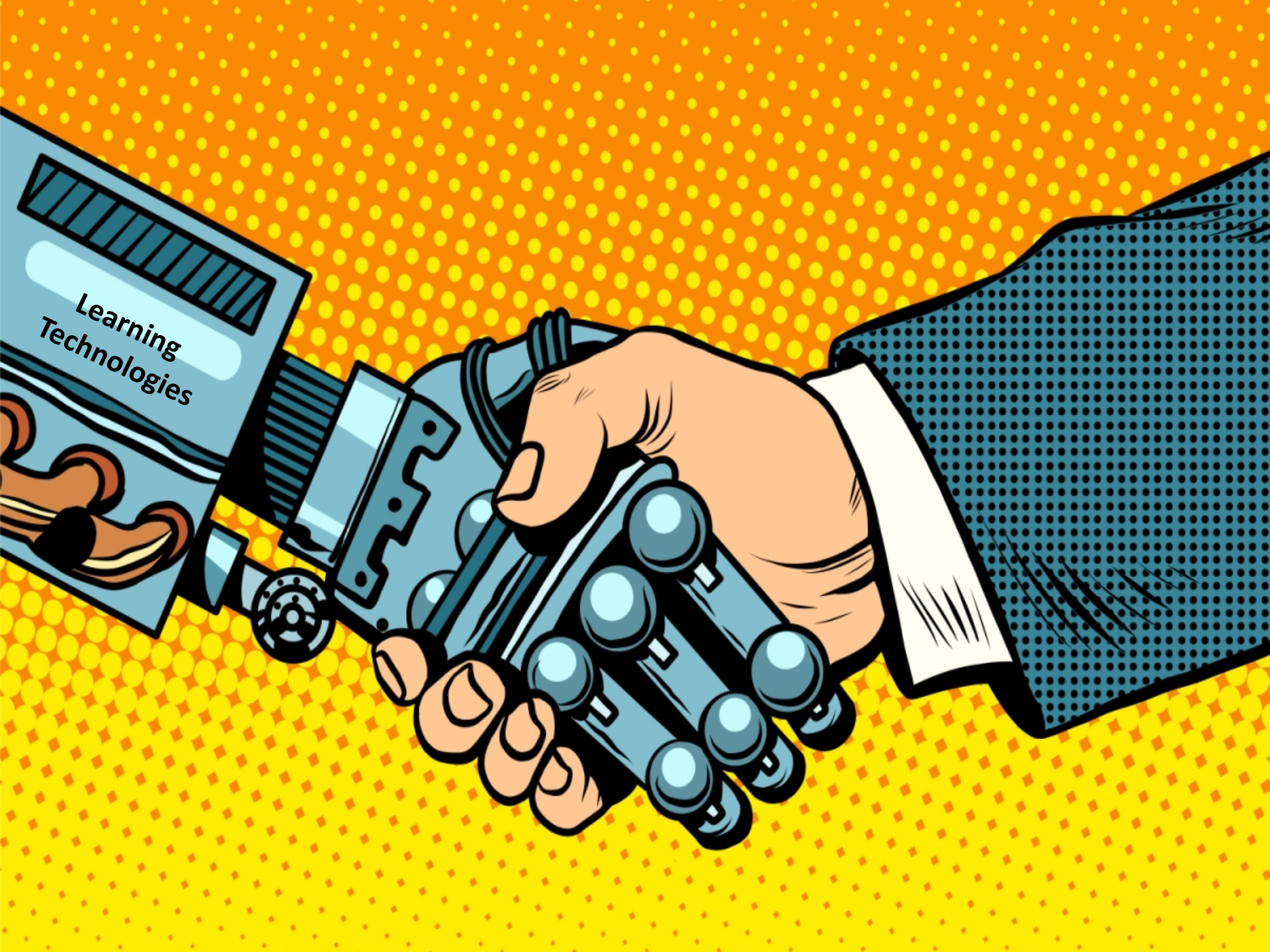
What is the Role
of Technology in
Learning?

Into the future...

The World Economic Forum estimates that up to 5 million jobs may be lost to disruptive labor changes by 2020







Learning
Technologies

Mob Programming

A Whole Team Approach



By Woody Zuill and Kevin Meadows



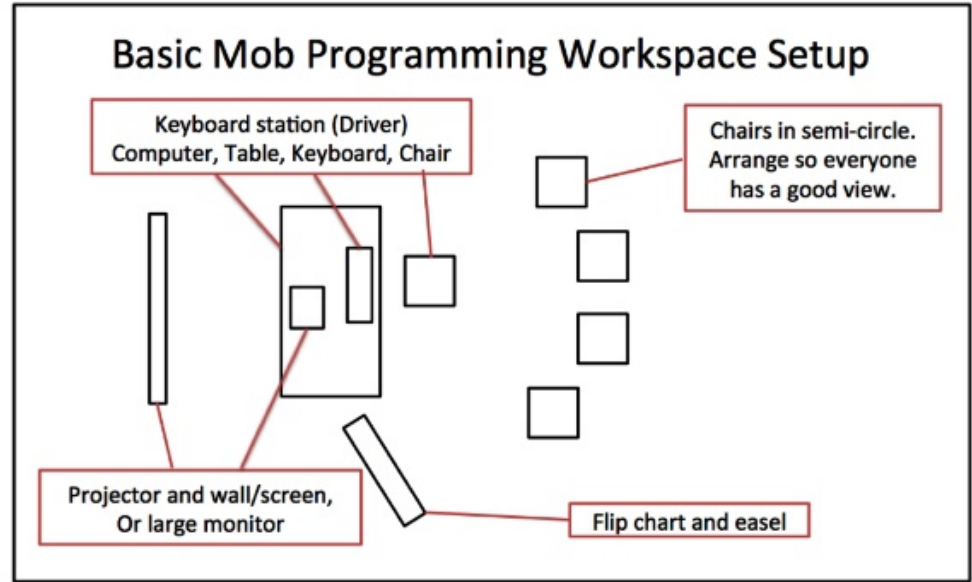
Basic Mob Programming Workspace Setup

Keyboard station (Driver)
Computer, Table, Keyboard, Chair

Chairs in semi-circle.
Arrange so everyone
has a good view.

Projector and wall/screen,
Or large monitor

Flip chart and easel



```
index.js
90 };
91
92 const handlersp = {
93   'LaunchRequest': function () {
94     this.emit('GetFact');
95   },
96   'GetNewFactIntent': function () {
97     this.emit('GetFact');
98   },
99
100
101 },
102 'GetFact': function () {
103   // Get a random space fact from the space facts list
104   // Use this.t() to get corresponding language data
105   const factArr = this.t('FACTS');
106   const factIndex = Math.floor(Math.random() * factArr.length);
107   const randomFact = factArr[factIndex];
108
109   // Create speech output
110   const speechOutput = this.t('GET_FACT_MESSAGE') + randomFact;
111   this.emit(':tellWithCard', speechOutput, this.t('SKILL_NAME'),
112 },
113 'AMAZON.HelpIntent': function () {
114   const speechOutput = this.t('HELP_MESSAGE');
115   const reprompt = this.t('HELP_MESSAGE');
116   this.emit(':ask', speechOutput, reprompt);
117 },
```

Environment Members

- ReadWrite
 - You (online) RW
 - aaron (online) RW
 - rob (online) RW

Group Chat

Chat history is stored on the environment and can be both read and modified by ReadWrite members.

You 7 minutes ago
Hey Aaron, can you jump in here quick and look at these variables?

aaron 6 minutes ago
Sure, looking now

aaron 5 minutes ago
Ok, I've fixed the variables. Let's test it

You 4 minutes ago
thanks, before testing i want to show it to Rob real quick

rob 2 minutes ago
Looks ok. I don't see my Star trek facts though 😊

Enter your message here

Online team members

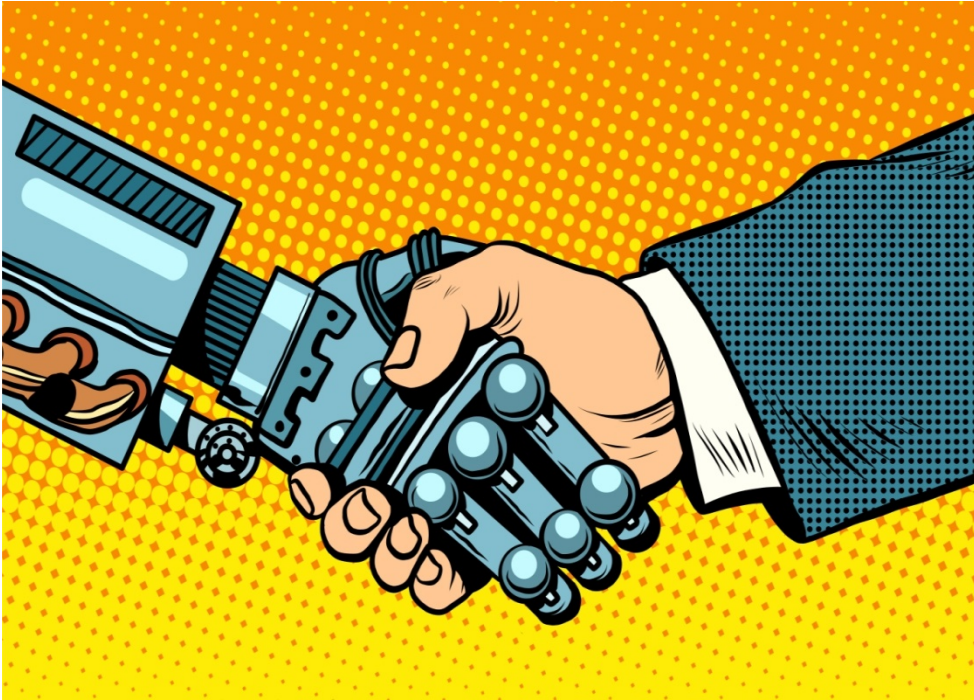
Access control

Team chat

Track team inputs

Online Course Pilot

- 120 students total divided into unique teams of 4-5 at three time points
- At the initial time point teams received training in OMP practices
- At second two time points teams engaged in group work using OMP
- Correlational evidence suggests that adherence to OMP is associated with:
 - Role appropriate conversational behavior
 - More equal division of labor regardless of prior knowledge or skill
 - More time on concept-oriented reflection
 - No decrease in grades or increase in time-on-task



Questions?



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THANKS