

# Computer Supported Collaborative Learning Track



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## Introduction

### Outline

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- Individual learning with technology to collaborative learning
- Vision for dynamic collaborative learning support
- Research Issues
- Recent Results
- Current Directions

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## Historical Perspective...

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- Socratic tutoring: directed lines of reasoning
  - Evidence that socratic tutoring is more beneficial than didactic tutoring (Rosé et al., 2001a)
- Socratic style implemented in Knowledge Construction Dialogues (KCDs)
  - General attempt to model effective human tutoring
  - Hierarchical structure: adaptive to student needs
  - Used to elicit reflection
  - First used to support individual learning in Physics
    - Atlas-Andes (Rosé et al., 2001)
    - WHY-Atlas (Rosé et al., 2003; Rosé & VanLehn, 2005)

## Empirical Foundation for CycleTalk

- 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
- Human tutors guide students towards opportunities for reflection (Rosé & Torrey, 2004)
- Human tutor support by effective tutors is significantly better than hint based support (Rosé et al., 2005)

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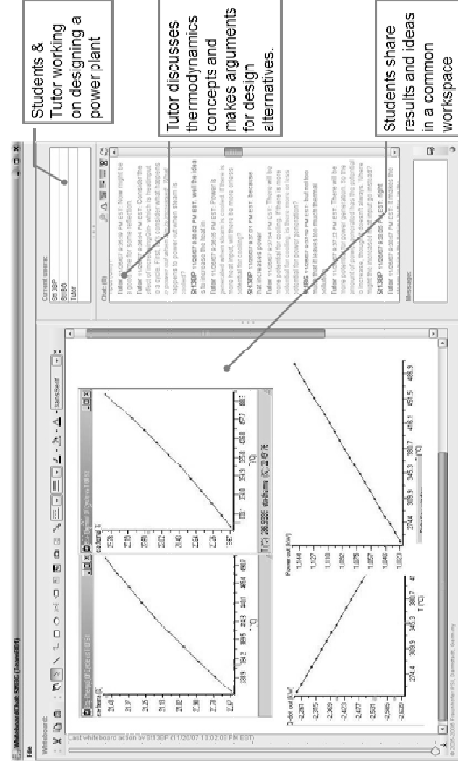
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## Towards enriching the interaction...

- Student interaction with dialogue agents lacks elaboration (Rosé et al., 2003)
- Students expect to behave differently with agents (Rosé & Torrey, 2004)
- Students can benefit from working with another student, even in the absence of computer scaffolding (Gweon et al., 2006; Kumar et al., 2007)

## VMT-Basilica



**\*\* Students learn up to 1.25 standard deviations more when interactive support is provided in the environment.**

## Example Interaction

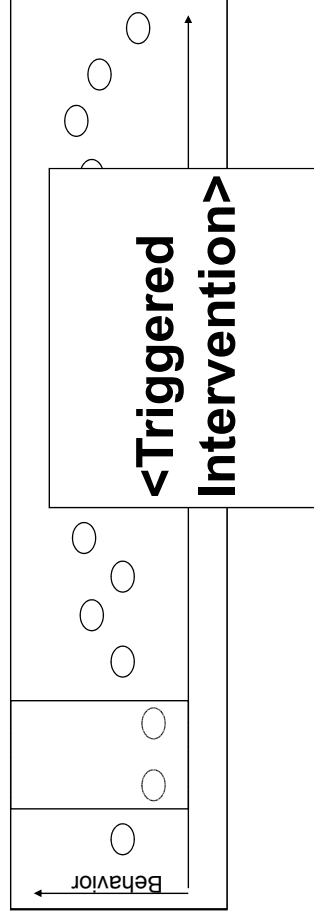
B6	so i think the best thing to go with first is to increase the pressure entering the connector
Tutor	You might want to review what you saw earlier in the sensitivity analysis investigating the effect of changing P-max on steam quality and efficiency, from the top half of page 13 in your book.
Tutor	type: HELP WITH CHANGEPMAX if you want to discuss it with me.
B1	help with changepmax
Tutor	Remember the sensitivity analysis you have completed where you manipulated P-Max and observed its effect on the efficiency of the cycle. You can refer to the figure that I have pasted onto your whiteboard for your convenience. Having seen how changing P-Max, the Maximum Pressure at the Heater Inlet, effects efficiency and Steam, do you think as a general principle the Maximum pressure should be increased ?
B6	Yes
Tutor	So the Efficiency of a Cycle increases by increasing the maximum pressure of the cycle. In addition to the effect on efficiency, what happens to the steam quality at the turbine exit if you increase the maximum pressure of the cycle ?
B6	Decreases
Tutor	So let's think for a minute about these competing effects: Increasing P-Max makes the efficiency better but the steam quality degrades. Is the steam quality at the turbine exit acceptable at the maximum allowable pressure within safety limits?
B6	No
Tutor	How does having poor steam quality at the turbine exit effect the turbine blades ?
B6	makes up wear down

## Monitoring Collaboration with Machine Learning Technology

Download tools at:

<http://www.cs.cmu.edu/~cprose/TagHelper.html>

<http://www.cs.cmu.edu/~cprose/SIDE.html>



B6	makes up wear down
Tutor	The steam condenses on the turbine blades and leads to wear and tear. What is the minimal quality of steam that we want to maintain so that the damage to the turbine is not significant ?
B6	0.85
Tutor	Steam quality should be maintained above 0.85 to avoid any damage to turbines blades during operation. So we need to balance these concerns by increasing the maximum pressure, but not enough that the quality of the steam drops below the minimum value (0.85). Are there other limitations on increasing the maximum pressure at the heater inlet ?
B6	no?
Tutor	Can the devices and pipes in the cycle stand if we keep on increasing the pressure ?
B6	20000kPa
Tutor	Beyond a particular pressure, the pipes and devices in a cycle become unsafe at risk for accident. The maximum pressure at heater inlet should be within safety constraints of the material used.
B1	so to what value do you want to change the pressure at s1?
B1	do we want to keep X of s3 above or below .85?
B6	Above
B1	so, if we want to increase p1 while keeping X3 above 0.85, what about 8500kpa as p1?

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## Core Ideas

- Identify conversational interactions that are valuable for learning
- Automatic conversation analysis
  - Facilitates learning research
  - Automates assessment of group processes
  - Enables context sensitive triggering of support
- Interactive support technologies



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## Characterizing effective collaboration: Transactivity

- Students explicitly display their reasoning
- Students orient their contributions towards previous contributions
  - May be competitive or non-competitive
  - May be representational or operational
  - May be oriented towards self or other

• **[Student1]** Well...  
U do know that  
increasing tmax and  
pmax means more  
Qin

• **[Student2]** yeah –  
but more quality –  
which means you  
get more work out of  
the turbine

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## Learning Results

- Students in accountable talk classrooms (where transactivity is elicited) learn more than students in a traditional classroom (O'Connor, Michaels, & Resnick, in preparation)
- Transactivity correlates with learning (Joshi & Rosé, 2007; Kumar et al., 2007)
  - Consistent with results in connection with elaborated explanations (e.g., Webb, Nemer, Zuniga, 2002)
- Collaboration support that increases transactivity increases learning (Wang et al., 2007)

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## Research Question:

*How must the design of intelligent tutoring technology change in order to be effective in collaborative contexts?*

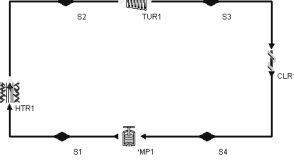
- Tutorial dialogue agents are effective for individual learning
- Desirable to use them to model conceptual depth in collaborative discussions
- Students appear to ignore tutorial dialogue agents when another human is in the environment
  - Although they learn from them!
- Dialogue agents have been seen as an interruption in collaborative contexts

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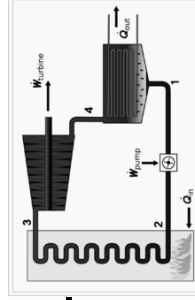
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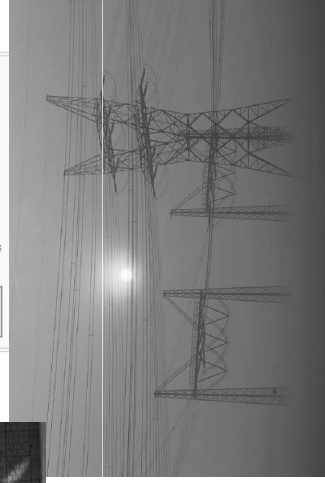
## Recent Learning Study



- Goal: Design a power plant based on the Rankine Cycle paradigm
  - Each pair turns in exactly **one** design
- Competing Student Goals:
  - **Power:** Design a power plant that achieves maximum power output
    - Motivated by economic concerns
  - **Green:** Design a power plant that has the minimum impact on the environment
    - Motivated by environmental concerns



*William Rankine*



Rankine cycles generate 80% of the electric power used throughout the world.

## Experimental Procedure

- Sophomore thermodynamics course
- 76 students randomly assigned to 1 or 4 lab sessions
- 1 lab session per Support condition
  - Students assigned to pairs randomly within conditions
  - Within each pair, one student randomly assigned to Green and one to Power

## Experimental Procedure

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- Consent form and Pre-Questionnaire (10 minutes)
- Training (15 minutes)
- Instruction on Rankine Cycles and Green Design (65 minutes)
- Pretest (15 minutes)
- Collaborative Design Exercise (40 minutes)
- Packaging up the design (10 minutes)
- Posttest and Post-Questionnaire (20 minutes)

## Experimental Manipulation

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- Help associated with concepts triggered by keywords detected in the conversation
- Pointer Hints
  - Suggestion that students think about a certain issue, with a pointer to a page in their book.
- Dialogue Agents
  - Interactive “walk through” a line of reasoning found on the corresponding page in the book

No Support	Pointer Only
Dialogue Only	Pointer+ Dialogue

## Pointer Only

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- **Student:** so i think the best thing to go with first is to increase the pressure entering the connector
- **Tutor:** You might want to review what you saw earlier in the sensitivity analysis investigating the effect of changing P-max on steam quality and efficiency, from the top half of page 13 in your book.
- ...

## Dialogue Only

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- **Student:** so i think the best thing to go with first is to increase the pressure entering the connector
- **Tutor:** Remember the sensitivity analysis you have completed where you manipulated P-Max and observed it's effect on the efficiency of the cycle. You can refer back to Figure 11 on page 13 of your booklet, which I have pasted onto your whiteboard for your convenience. You can delete it after this conversation with me if it is in your way. Having seen how changing P-Max, the Maximum Pressure at the Heater Inlet, effects efficiency and Steam, do you think as a general principle the Maximum pressure should be increased ?
- **Student:** Yes
- **Tutor:** So the Efficiency of a Cycle increases by...

## Pointer + Dialogue

- **Student:** so i think the best thing to go with first is to increase the pressure entering the connector
- **Tutor:** You might want to review what you saw earlier in the sensitivity analysis investigating the effect of changing P-max on steam quality and efficiency, from the top half of page 13 in your book.
- **Tutor:** type: HELP WITH CHANGEPMAX if you want to discuss it with me.
- **Student:** help with changepmax
- **Tutor:** Remember the sensitivity analysis you have completed where you manipulated P-Max and observed it's effect on the efficiency of the cycle. You can refer back to Figure 11 on page 13 of your booklet, which ...

## Experimental Manipulation

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## Results

- ANCOVA Model
  - Dependent Variable: Posttest score
  - Independent Variables: Dialogue and Pointer
  - Covariate: Pretest score
  - Significant effect of Pointer Hints
    - $F(1,71) = 7.5, p < .01$ , effect size .57 s. d.
    - Dialogue with and without Pointer hints, .8 s. d.

## Results

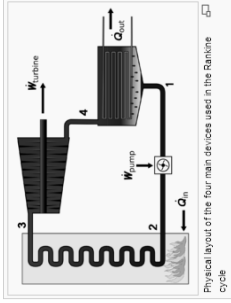
	Pretest	Posttest
Lab Session A (Pointer Hint Condition)	17.9 (5.9)	18.8 (2.9)
<b>Lab Session B (Pointer +Dialogue condition)</b>	<b>14.8 (7.0)</b>	<b>19.1 (2.9)</b>
Lab Session C (Dialogue condition)	14.4 (5.7)	15.7 (4.8)
Lab Session D (No Support condition)	17.1 (3.9)	17.3 (4.0)

	Pretest	Posttest
Lab Session A (Pointer Hint Condition)	17.9 (5.9)	18.8 (2.9)
<b>Lab Session B (Pointer +Dialogue condition)</b>	<b>14.8 (7.0)</b>	<b>19.1 (2.9)</b>
Lab Session C (Dialogue condition)	14.4 (5.7)	15.7 (4.8)
Lab Session D (No Support condition)	17.1 (3.9)	17.3 (4.0)

- Only Pointer + Dialogue has significant pre to post test gain
- Only Pointer + Dialogue is significantly better than No Support

## Findings: Comparing supported and unsupported collaboration

- Pointer + Dialogue condition was significantly better than Dialogue only
  - Effect size .8 s.d.
- Students learn significantly more from Pointer + Dialogue than unsupported condition
  - Effect size .6 s.d.
- Students in dialogue conditions displayed explicit reasoning a significantly higher proportion of the time
  - Effect size 1.33 s.d.



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## Current Directions

- Continuing to investigate social considerations for integrating dialogue agents with groups
  - Investigating how motivation orientation interacts with treatment
- Working with groups larger than pairs (Gweon et al., in press)
  - Monitoring collaboration quality from speech
  - Challenges of multi-party conversation analysis
    - Multiple interwoven threads (Rosé et al., 1995; Wang et al., 2008a,b)

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# Thank You !!!

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