Software Agent-Monitored Tutorials and Their Application to Mathematics Projects

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- *Nathan Klingbeil* Wright State University

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Fred Higgs, Robert Reid, Philip LeDuc



Big Picture and Outline

Big Picture:

- Existing experience using software agents to guide student learning in groups *for design and analysis projects*
- Latest initiative is to use this platform to *reinforce math concepts* in the undergraduate curriculum
- Idea: Some programs cannot practically apply the Wright State Model; we can use agent-monitored assignments instead

Outline:

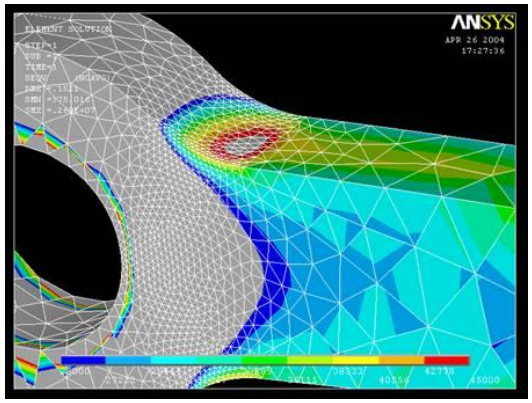
- **Previous Work and Motivation**
- **What is a Software Agent?**
- **Agent-Monitored Tutor Components**
- **Collaborative Activities Using Tutors**
  - **Thermodynamics Project**
  - **Freshman Project and Middle School Outreach *(Not Covered in this Talk)***
- **Results: Acceptance of Tutors and Social Interactions**
- **New Application: Self-Paced Math Projects**
- **Summary and Future Work**

Previous Work: Web-Based Tutors for Computer-Aided Engineering

- Integrated Computer-Aided Design and Analysis Projects
- Significant Industry-Grade Software Use
- Web-Based Tutorials Guide Software Use
- *Problem: Students Are not Engaged in the Fundamentals During Software Use*
- How Can We Increase Student Engagement in These Activities?
  - Fundamentals Emphasized in Follow-Up Assignments
- *Explore Automated Learning Interfaces via a Collaboration Between Mechanical Engineering and Computer Science*





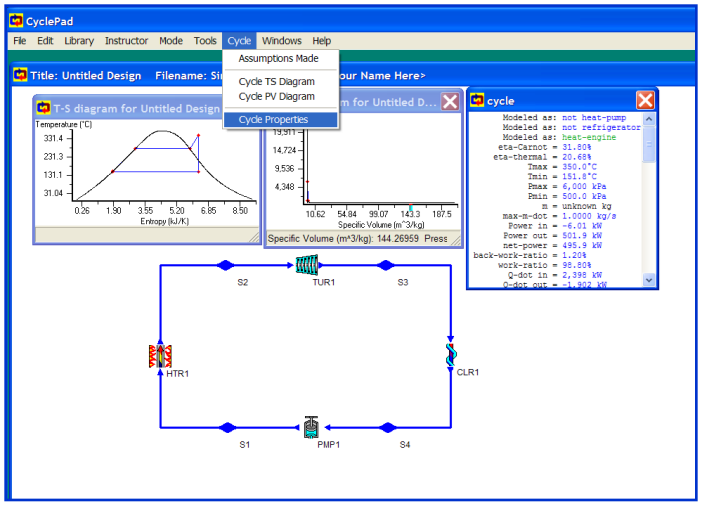


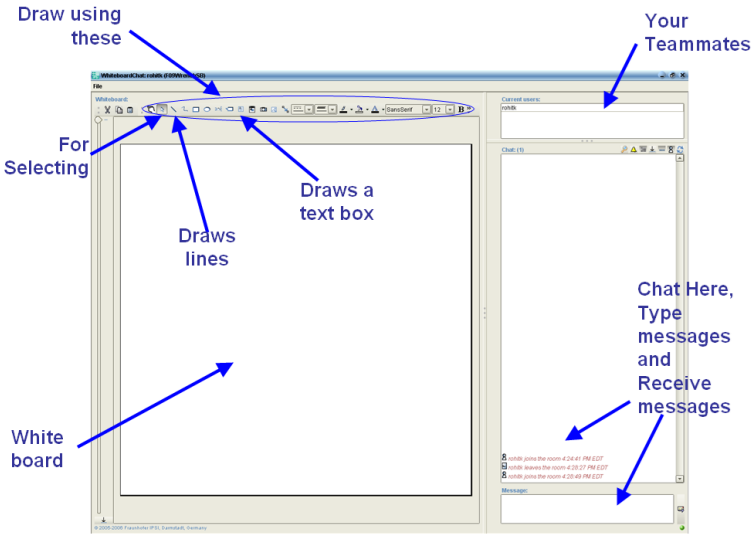
What is a Software Agent?

- **You Interact with Simple Ones When you Call Product Help Centers**
  - Only a one-on-one interaction
  - You are asked questions and only 2 or 3 responses are acceptable
  - Used primarily to filter caller inquiries, but they are getting more sophisticated
- **Our Goals:**
  - Same Idea, *but have the agent interact with multiple students in a group and encourage group interactions and thinking*
  - Agent works simultaneously with 10 or more groups, each with their own group dynamics
  - Agent searches for key words, phrases and other triggers in student text interactions and then interjects
  - Can then guide students down one of many prescribed learning pathways
  - Tutors can also show social behavior to keep students interested
- **Ultimate Goal:**
  - *Optimize our mix of faculty, grad teaching assistant, undergrad teaching assistant and software agent guiding of **collaborative** student work*

Software Agent-Monitored Tutoring Components

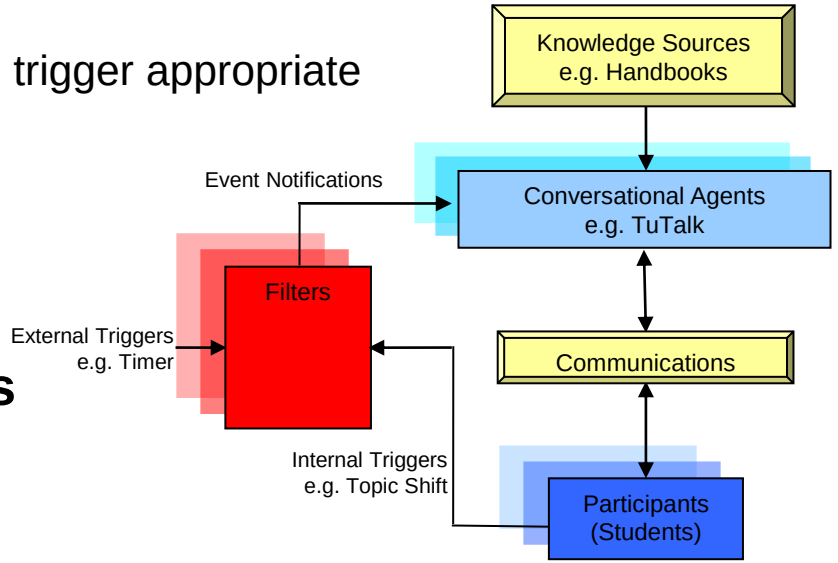
- **Software Interface:**
  - Cyclepad for Thermodynamics
    - Developed at Northwestern U.
    - Construct a Cycle, Specify Parameters Analyze Results
- **Collaborative Interface**:
  - Adapted from *ConcertChat* Platform Developed between CMU and Drexel
  - Sketching and Text Interactions
  - Each Team Member Sees All Team Drawings and Comments
- **Software Agent**
  - Based on *Basilica* programmable conversational agent platform (CMU)
  - Agent Monitors Text Interactions and Interjects with Comments, Questions, Hints, and Prompts to Guide Students
  - Drawings are not Currently Monitored





Software Agent Design

- **Two Classes of Triggers**
  - For task-related interaction (delivering instructions, lessons, hints, etc.)
  - For social interaction (including tracking the elapsed time since one team member has contributed, to trigger an interaction to get them involved again)
- **Filters**
  - Annotate and filter student messages to trigger appropriate interactive behavior
- **Three Classes of Tutor Actors**
  - For doing introductions
  - For prompting or hinting
  - For tutoring
- **Also Provide Links to Handbooks**



Architecture of the Collaborative Problem-Solving Interface with Conversational Agents

Second-Year Thermodynamics Project

- **Sophomore Thermodynamics Course**
  - Rankine Cycle Design Competition
    - Part of a Thermodynamic Cycles Lab (1 session)
    - Students Work in Teams of 2 with Their Partner in Another Part of the Room
    - Instructed on Effects of Changing System Variables (Temperature, Pressure) on System Output (Power, Waste Heat)
    - Goal: Increase Efficiency within Practical Constraints
    - Software Package is CyclePad (Developed at Northwestern University (Forbes et. al. 1999) to Allow Students to Construct and Analyze a Variety of Thermodynamic Cycles)



Excerpts of Interactions between Students and the Tutor

(Thermo Design Lab)

Speaker	Contribution
Tutor	How does having poor steam quality at the turbine exit effect the turbine blades ?
Student 1	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 ?
Student 1	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 ?
Student 1	no?
Tutor	Can the devices and pipes in the cycle stand if we keep on increasing the pressure ?
Student 1	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.
Student 2	so to what value do you want to change the pressure at s1?
Student 2	do we want to keep X of s3 above or below .85?
Student 1	Above
Student 2	so, if we want to increase p1 while keeping X3 above 0.85, what about 8500kpa as p1?

- **Student Responses are Not Always Clear**
- **Tutor Questions Guide Possible Responses**
- **Tutor Responds to Student1, but then Student2 Gets Involved, Tutor Stops Interjecting**

Scientific Challenge: Student/Agent Interactions

- Unlike individual learners, teams of students can ignore / abuse automated tutors

Kumar et. al. 2007a

Tutor	There will be more potential for power generation ... Where might the increased heat input go instead?
St16	this tutor is really annoying
St5	Agreed

B18	I wonder if we can mute the tutor...
B8	maybe it stopped...
Tutor	type: HELP WITH CHANGETREHEAT if you want to discuss it with me.
B8	Okay
B8	guess i was wrong about that whole tutor stopping thing.
B18	Yeah, heh

a7	so, got any ideas?
Tutor	Starting now, you have around 40 minutes to work together…
A2	hrmmm
a7	stupid tutor no one asked you for help

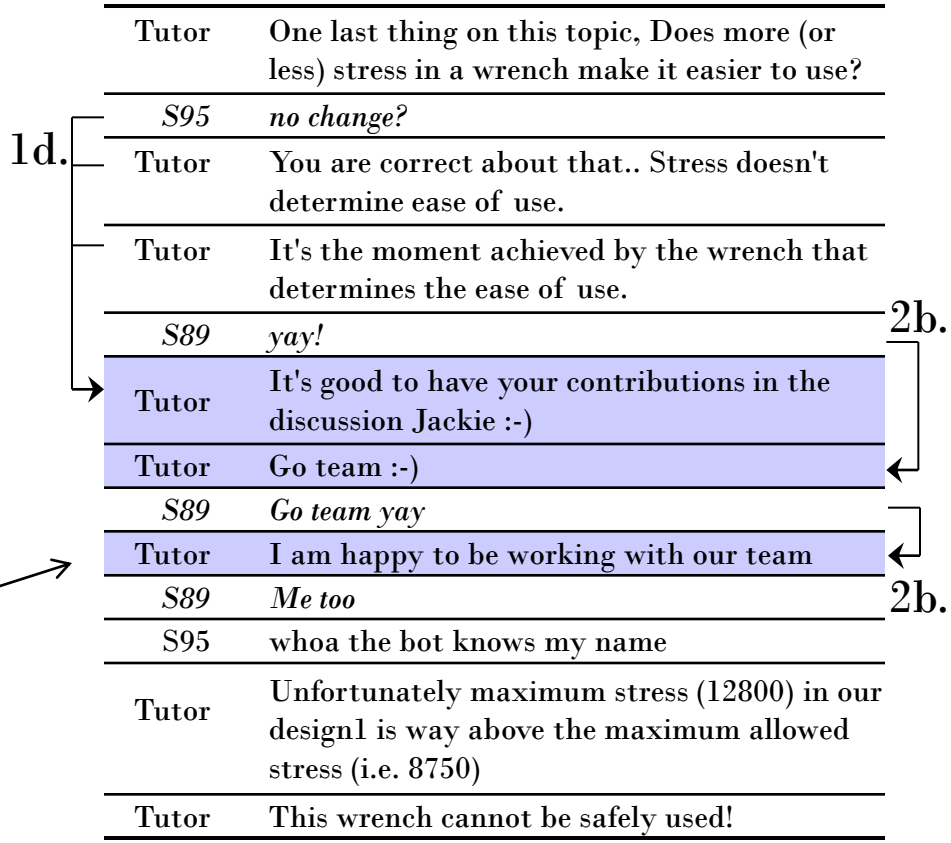
B9	hi tutor
B9	tutor, you're a jerk

- Agents lack Social Communication Skills
  - Are Better Tutor Communication Skills a Fix?

Implementation: Social Controller
(Rosé and Kumar)

- Social Behavior Triggering
  - Hand Crafted Rules
  - Social Ratio
    - Ratio of Social Turns to Task-related turns
    - Threshold: 20%

Sounds Like HAL from 2001 !



Tutor	One last thing on this topic, Does more (or less) stress in a wrench make it easier to use?
S95	*no change?*
Tutor	You are correct about that.. Stress doesn't determine ease of use.
Tutor	It's the moment achieved by the wrench that determines the ease of use.
S89	*yay!*
Tutor	It's good to have your contributions in the discussion Jackie :-)
Tutor	Go team :-)
S89	*Go team yay*
Tutor	I am happy to be working with our team
S89	*Me too*
S95	whoa the bot knows my name
Tutor	Unfortunately maximum stress (12800) in our design1 is way above the maximum allowed stress (i.e. 8750)
Tutor	This wrench cannot be safely used!

Experiment: Survey

- 7 point Likert-scale

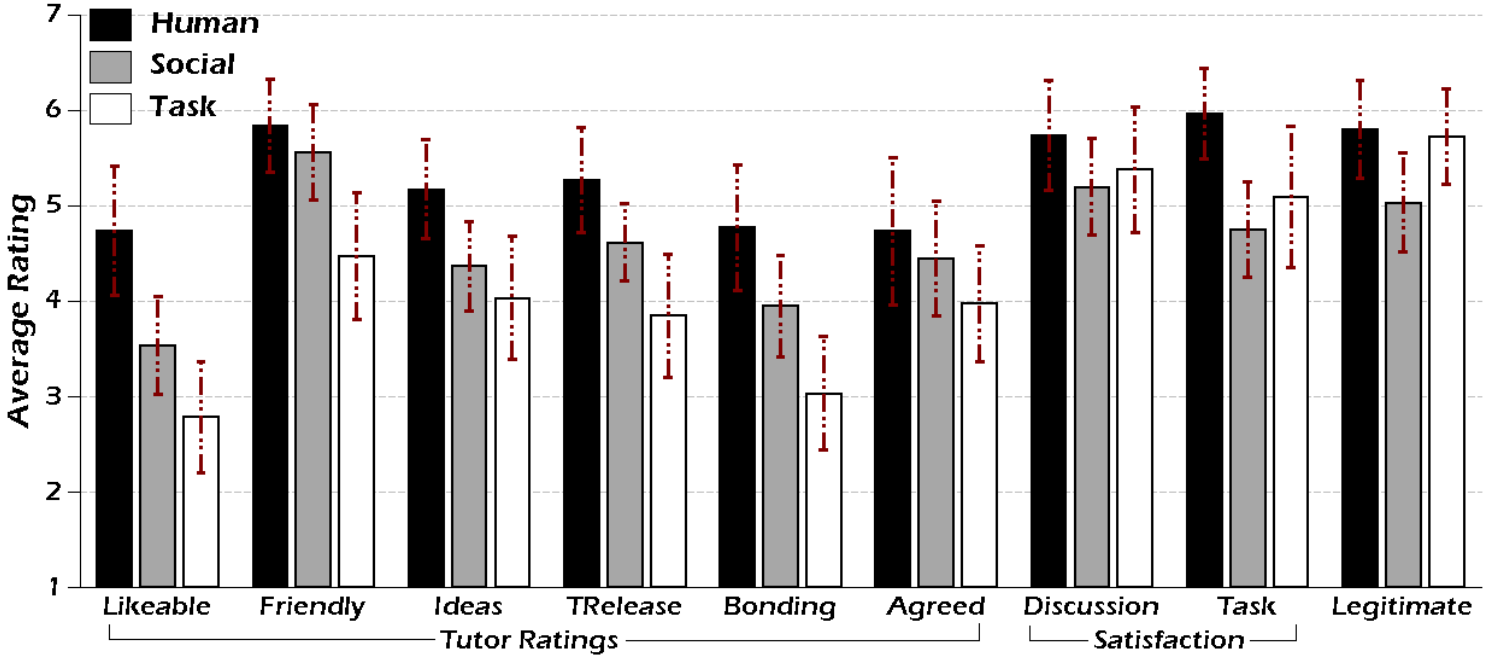
1	2	3	4	5	6	7
Strongly Disagree	Mostly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Mostly Agree	Strongly Agree

- Items (Burke, 1967)

Ratings about the Tutor	Q1	I liked the tutor very much.
	Q2	The tutor was very cordial and friendly during the discussion
	Q3	The tutor was providing very good ideas for the discussion
	Q4	The tutor kept the discussion at a very comfortable level socially
	Q5	The tutor was part of my team
	Q6	The tutor received the ideas and suggestions I contributed to the discussion positively
Ratings about the Activity	Q7	I am happy with the discussion we had during the design challenge
	Q8	My group was successful at meeting the goals of the design challenge
	Q9	The design challenge was exciting and I did my best to come up with good designs

- Groups: *Task* (tutor with no social interactions), *Social* (tutor with social interactions), *Human* (teaching assistants interject social comments)

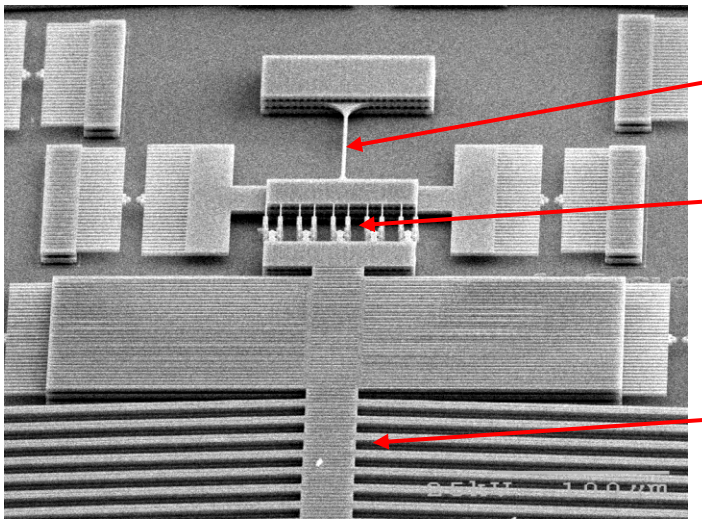
Experiment 1: Results > Perception

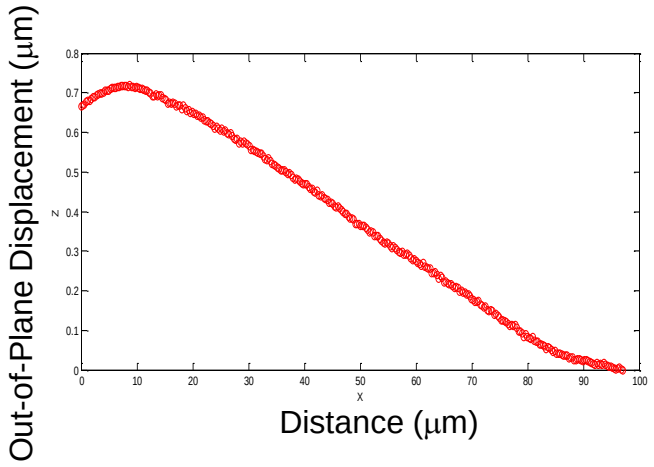


- Overall: Human condition is best, even for ratings related to the task (last 3 columns), not the tutor (first 6 columns)
- Social condition yields better tutor ratings (first 6 columns) but not better task ratings (last 3 columns)
- Point: Tutors can be made more likeable and we should pattern its interactions after human interactions

Reinforcing Mathematics Concepts in the Engineering Curriculum

- **Joint Project with U. Cal. Santa Barbara:**
  - Self-Paced Projects
  - Multiple Required Courses
  - Tie Math to Engineering Applications
  - Inspired by Wright State Model for Engineering Math Instruction
- **First Project**: Analyze Bending in a MEMS Micro-Scale Tensile Test
  - 70μm Long Tensile Specimens
  - Research Project by de Boer and Beuth
  - Use Measured Deflections to Estimate Unwanted Bending Stresses Due to Misalignment
  - Agent Helps Students (in Teams) Connect Math and Engineering Concepts

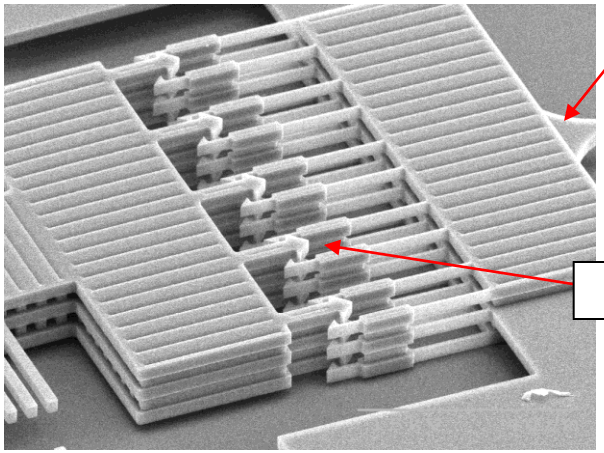


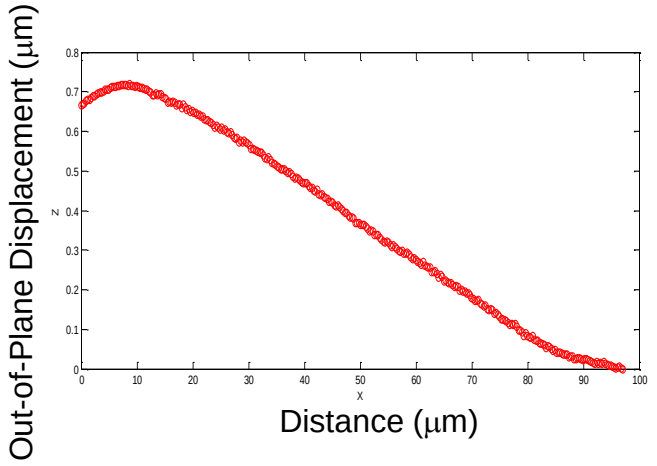


$$\frac{d^2v}{dx^2} = \frac{M}{EI}$$

Reinforcing Mathematics Concepts in the Engineering Curriculum

- **MEMS Project Math Concepts:**
  - Numerical Differentiation and Integration
    - Get an Intuitive Feel
  - Working with Experimental Data
    - Derivative Values are Noisy
- **Project Engineering Concepts:**
  - Location of Max Stress
    - It's the Location of Max Curvature
  - Identifying End Conditions
    - Do they make sense given the problem physics?
  - Research Goals:
    - Test a large numbers of polysilicon specimens to get a statistical representation of strength
    - Are bending stresses significant compared to the applied axial stress?





$$\frac{d^2v}{dx^2} = \frac{M}{EI}$$

Conclusions and Future Plans

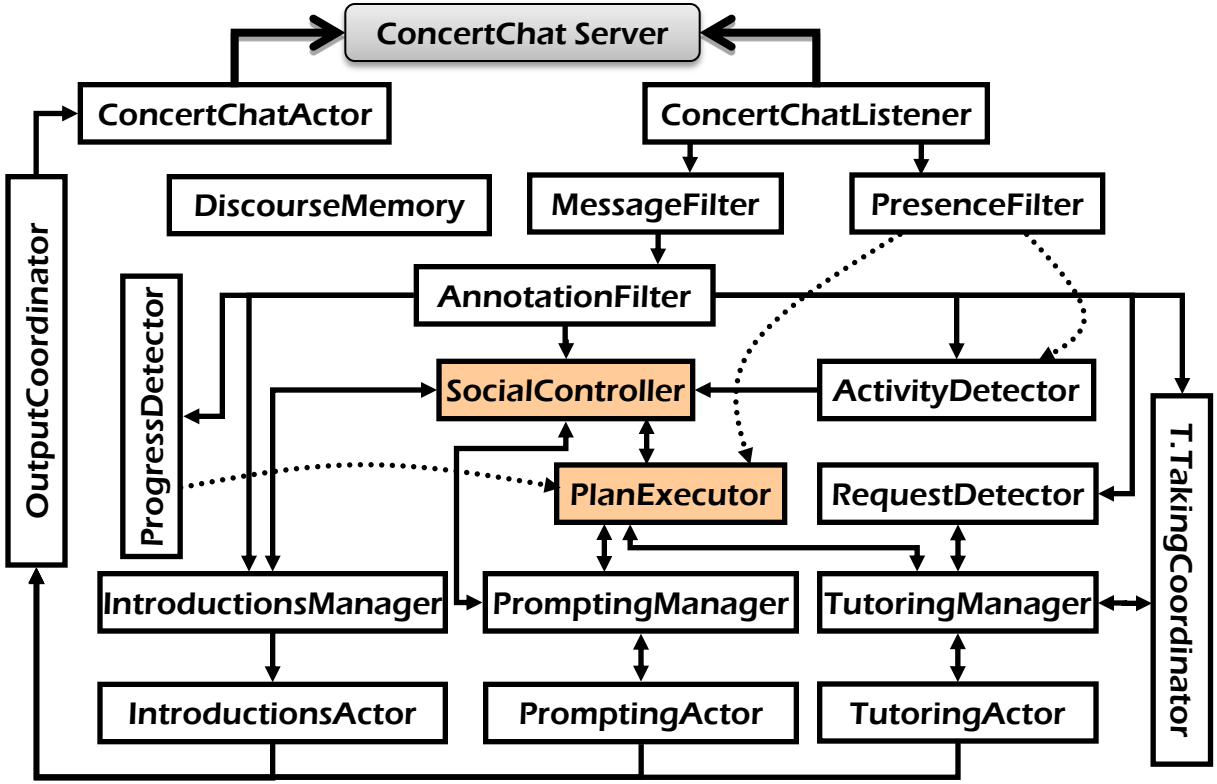
- **Collaborative Activities for Engineering Students are Beneficial from a Learning Perspective**
  - Significant learning gains of around 0.5s.d. in two different lab experiments (based on test results for students with and without tutors)

- **Socially Capable Tutors can Yield Additional Benefits in Supporting Students Learning in Teams**
  - They can definitely make the tutors more likeable
  - More progress can be made if we make social tutors more like human tutors

- **Next Steps (Math Project):**
  - ***Completed a non-tutor version of MEMS Math Project this spring***
  - ***Application of a Math Project with a rudimentary tutor at UCSB in August, 2011***
  - ***Related Freshman Project in the Fall – Motion Simulation of a 2-D Mechanism (slider-crank) with an analysis of displacement, velocity and acceleration data from the package.***
    - ***Emphasis on Analyzing and Interpreting Simulation Results***



Implementation: WrenchTalk Tutor Agent



First-Year and Middle School Projects

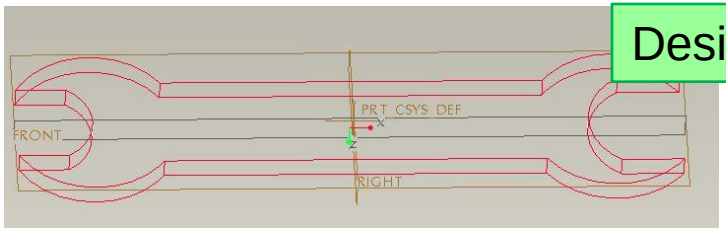
- **First-Year Project**
  - Wrench Design Competition (Spring and Fall of 2009)
    - Part of Computer Aided Engineering Labs using Pro/ENGINEER, Pro/MECHANICA and Pro/MANUFACTURING Software (3 sessions)
    - Students Work in Teams of 3 – 4 with Unknown Team Members in Other Parts of the Room
    - Only Communication is via the Chat Interface with Agent Interactions
    - Teach Relationships between Moment, Force and Stress Related to Design Goals

- **Middle-School**
  - Practical Considerations in Designing a Wrench (Fall of 2009)
    - A Simplified Version of the Freshman Project (Using the Pro/ENGINEER CAD Package)
    - Part of the CMU C-MITES Program
    - Students Work in Teams of 3 – 4 with Unknown Team Members in Other Parts of the Room
    - Activity Designed to Elicit Broad Discussions on Engineering and Product Design



Middle School Students in the Wrench Design Project

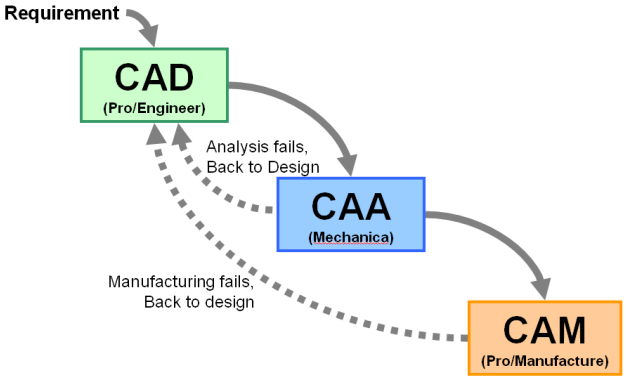
Computer Aided Engineering Lab with PTC Software

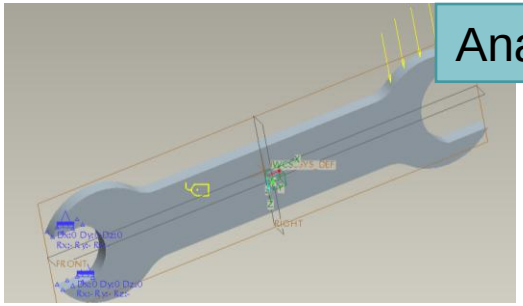


Design

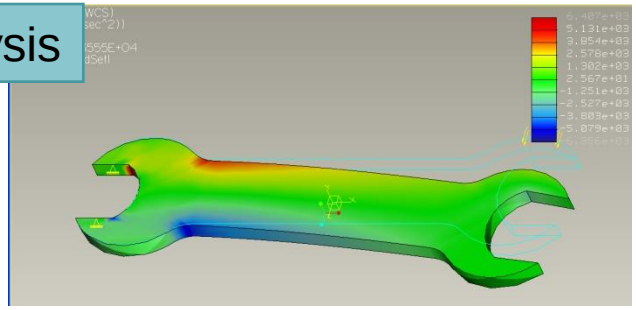


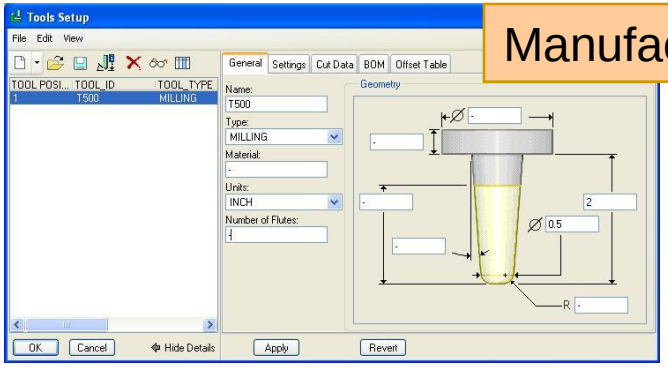
Process of Paperless Engineering



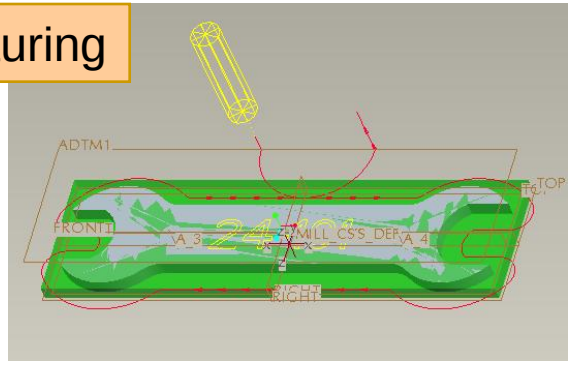


Analysis





Manufacturing



Excerpts of Interactions between Students and the Tutor (First Year Wrench Design Lab)

Speaker	Contribution
Tutor	Lets talk about making the wrench easy to use.
Tutor	Are you ready?
Student 19	o yeah
Tutor	Intuitively, if you wanted to make the wrench easier to use, would you make it longer or shorter?
Student 5	longer
Tutor	That's right. A longer wrench is better.
Tutor	Why is a longer wrench easier to use though! Let's look at the concept of Moment.
Tutor	When you use a wrench to turn a bolt, do you want a higher or lower moment?
Student 16	higher
Student 13	higher
Tutor	That's right. A higher moment means the Wrench turns easier.
Tutor	We know that moment = force x length. So...

- **Interactions are More Prescribed than for Thermo**
- **Freshman Project: Discussion is Directed toward Technical Concepts of *Moment (Torque), Stress, Material Strength, Cost***
- **Middle School: Broad Considerations of *Cost, User Friendliness, Technical Improvements***



Motivation, Objectives, Participants

- ***Motivation:*** Undergraduate Engineering Programs Need Efficient Platforms for Developing Distance Learning/Collaborative Projects that Exploit Computer-Aided Engineering (CAE) Software
- ***Objective:*** Use Software Agent-Monitored Collaboration Tools and CAE Tutorial Interfaces Developed at CMU
- ***Project Participants:***
  - *Jack Beuth and Carolyn Rosé* Carnegie Mellon University
  - *Jack Zhou, Alisa Morss Clyne, Franco Capaldi* Drexel University
  - *John Stuart* Parametric Technologies Corp. (PTC)
- ***Participant Roles:***
  - Carnegie Mellon Develops Agent-Monitored Collaborative Tutorials for CAE Projects in Mechanical Engineering Courses
  - Drexel Uses CMU-Developed Tutorials in Their Courses
  - PTC Provides Their Software (Design, Analysis, Manufacturing, Product Development, etc.) to CMU and Drexel
  - Drexel and CMU Offer Combined Long-Distance Collaborative Projects
  - All Tutorials and Development Tools Available to Other Universities

Supporting Collaborative Design Activities for Engineering Students using Social Conversational Tutors

Funded by: …

Some general slides first

- Text can be used as fillers

Conversational Agents as Tutors

- **Conversational Agents**
  - Interface to machines/software/knowledge repositories
  - Use Natural Language for Interaction
    - Present right information to the right people at the right time in the right way

- **Educational Application of Agents**
  - Tutorial Dialogue Systems
    - Developed for a wide variety of educational domains (algebra, foreign languages, physics, …)
    - Manifested as text or speech based interactive agents. Some system also use embodiment
    - Shown to be effective instructional support by many studies both in one-on-one tutoring as well as tutoring teams of students
    - However, students working in teams tend to ignore and abuse the tutors more than the students working individually
      - We have attempted to address this by making socially-capable tutors

Collaborative Learning

- Social and Cognitive Benefits documented

- Piaget & Vygotsky

- Cognitive Conflict

- Our earlier research has shown learning benefits for students working in teams compared to students working individually

Slides as per order in Jack's Emails

- Freshman/C-MITES/Background Slides

  1. Wrench project timeline
  2 Freshman vs. C-MITES experiences
  3 ProE / Mechanica / ProManufacturing Screen Shots
  4. Pictures of CMITES students (I have these)
  5. Results/Conclusions, particularly ones that fed into the thermo project

- Thermo Slides Related to this Grant

  1. Timeline for thermo projects over the last few years
  2. Optimal amounts of Social behavior: Graph
  3. Social interaction strategies
  4. Images of cyclepad screen shots
  5. Images of dialogue interaction screen shots
  6. Diagram of the tutor internals (one from paper, one from proposal)
  7. Examples of interactions and dialogues between students and the tutor
  8. Misc. photos of thermo students or other misc photos
  9. Results/Conclusions/Future Plans



Development of the Wrench Design Competition

- Pilot Study conducted in Spring 2009
  - 78 students participated
  - First version of tutor and instructional materials developed and tested
  - Data collected: Student interactions with Tutors
  - Some ratings:
    - Interactive Tutors: 2.5 out of 5
    - Perceived Benefit of Design Competition: 3.4 out of 5
    - Perceived Achievement of Learning Objectives: 3.9 out of 5

- Study conducted in Fall 2009
  - 98 students participated
  - Second version of tutors with improved instruction materials used
    - First version of tutors with social capabilities
  - Systematic Evaluation conducted
    - In general, 0.51s.d. learning effect from the design competition
    - 0.71s.d. and 0.93s.d. learning effect relative to baseline for social tutors and human tutors respectively
  - Some ratings:
    - Interactive Tutors: Liking: 3.7 out of 7, Social Behavior: 4.8 out of 7
    - Perceived Benefit of Design Competition: 5.5 out of 7
    - Task Satisfaction: 5.2 out of 7

- Upcoming: Spring 2010 study
  - 112 students enrolled

CycleTalk: Rankine Cycle Design Lab

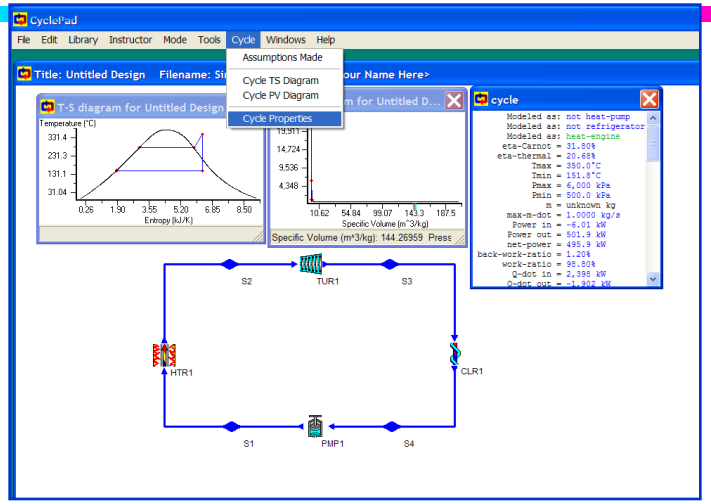
- CyclePad developed at NWU (Forbes et. al. 1999)
- 2004: Rosé et. al. (2004), Rosé et. al. (2005)
  - Cycle Pad's significant pedagogical potential tends to be underutilized when students do not receive tutorial guidance
  - Human tutoring significantly better than script-based instruction and another intelligent tutoring system (Example tracing tutors, Aleven et. al.)
- 2005: Kumar et. al. (2006)
  - Topic Analysis from Human tutoring, Development of instructional material for automated tutors, Interactive Tutors integrated with Example-based tutors
  - Evaluation with tutors shows 0.35s.d. (at CMU) learning benefit of tutors compared to reading from book (Similar result at USNA)
  - Observation: Lesser topics covered (3) compared to humans (upto 11)
- 2006: Kumar et. al. (2007)
  - Interaction with tutors as an activity in itself (to create more opportunities for topic coverage)
  - Topic selection and presentation based on student discussion
  - Results show significant effect of tutors (0.7 s.d.), collaboration (0.4 s.d.), Both (1.2 s.d.)
  - Observation: Students less engaged with tutors in teams (compared to individuals)
- 2007 & 2008: Chaudhuri et. al. (2008, 2009)
  - Tutors with Attention-Grabbing tactics to improve engagement
  - 0.8s.d. learning benefit for most-recent attention grabbing tactic
    - Allows students to say when they are ready to discuss a topic
  - Integration of tutors with Virtual Environments (Second Life) (Weusijana et. al., 2008)
- 2009: (Submitted: Kumar & Rosé, Kumar et. al.)
  - Achieving human-like response to social behavior
  - Based on experiments in Wrench design lab (Freshmen)

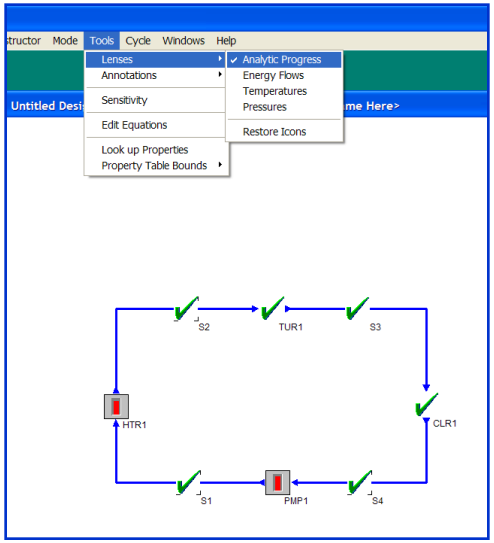
Social Interaction Strategies

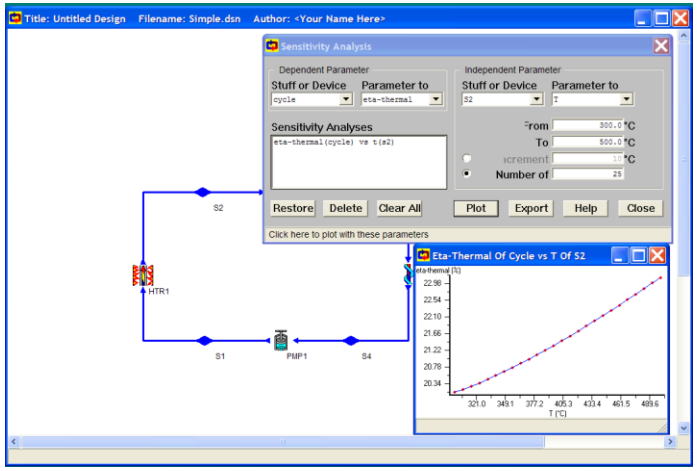
- Eleven Social Interaction Strategies developed
  - Based on Three Positive Social-Emotional Interaction Categories

1. *Showing Solidarity:* Raises other's status, gives help, reward
1a. Do Introductions: Introduce and ask names of all participants
1b. Be Protective & Nurturing: Discourage teasing
1c. Give Reassurance: When student is discontent, asking for help
1d. Complement / Praise: To acknowledge student contributions
1e. Encourage: When group or members are inactive
1f. Conclude Socially
2. *Showing Tension Release:* Jokes, laughs, shows satisfaction
2a. Expression of feeling better: After periods of tension, work pressure
2b. Be cheerful
2c. Express enthusiasm, elation, satisfaction: On completing significant task steps
3. *Agreeing:* Shows passive acceptance, understands, concurs, complies
3a. Show attention: To student ideas as encouragement
3b. Show comprehension / approval: To student opinions and orientations

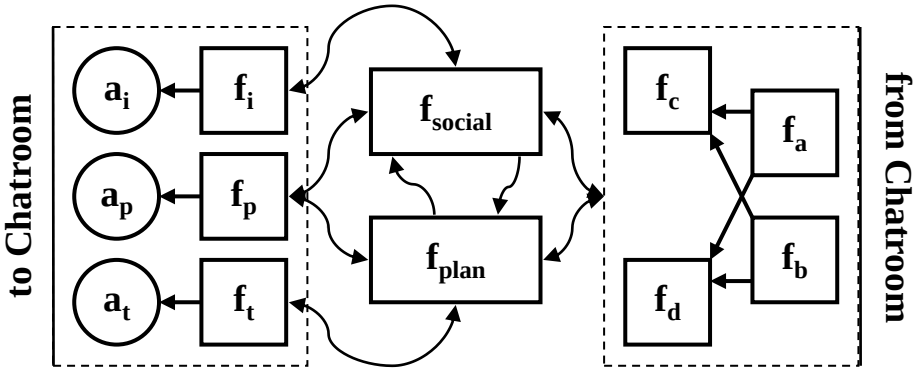
CyclePad: Thermodynamic Cycle Simulator





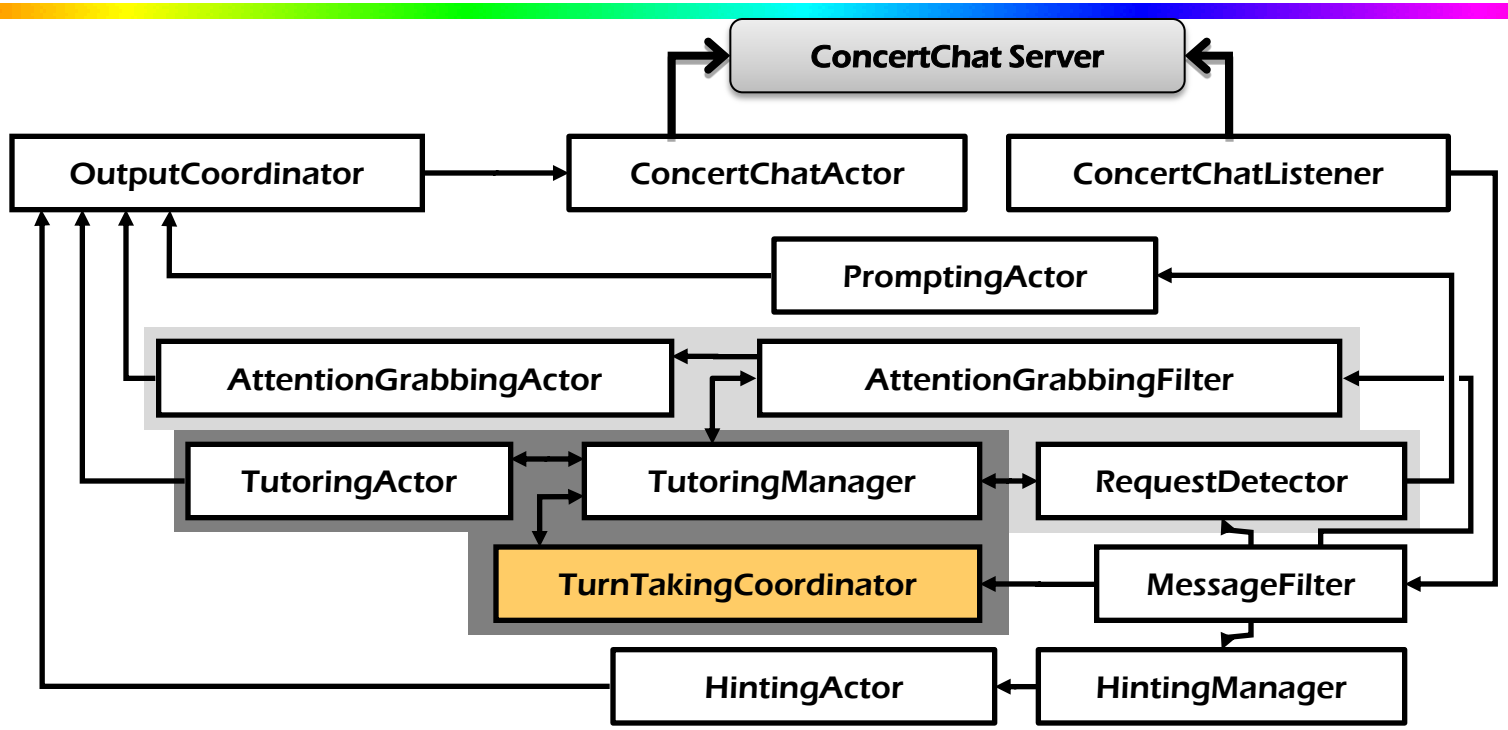


Tutor Design (Using Basilica Architecture)



- **Two controllers**
  - F_{plan}: For task related interaction (delivering instructions, lessons, hints, etc.)
  - F_{social}: For social interaction (as per the strategies listed earlier)
- **Filters (F_a – F_d)**
  - Annotate and filter student messages to trigger appropriate interactive behavior
- **Actors**
  - A_i: For doing introductions
  - A_p: For prompting
  - A_t: For tutoring

CycleTalk Tutor Agent



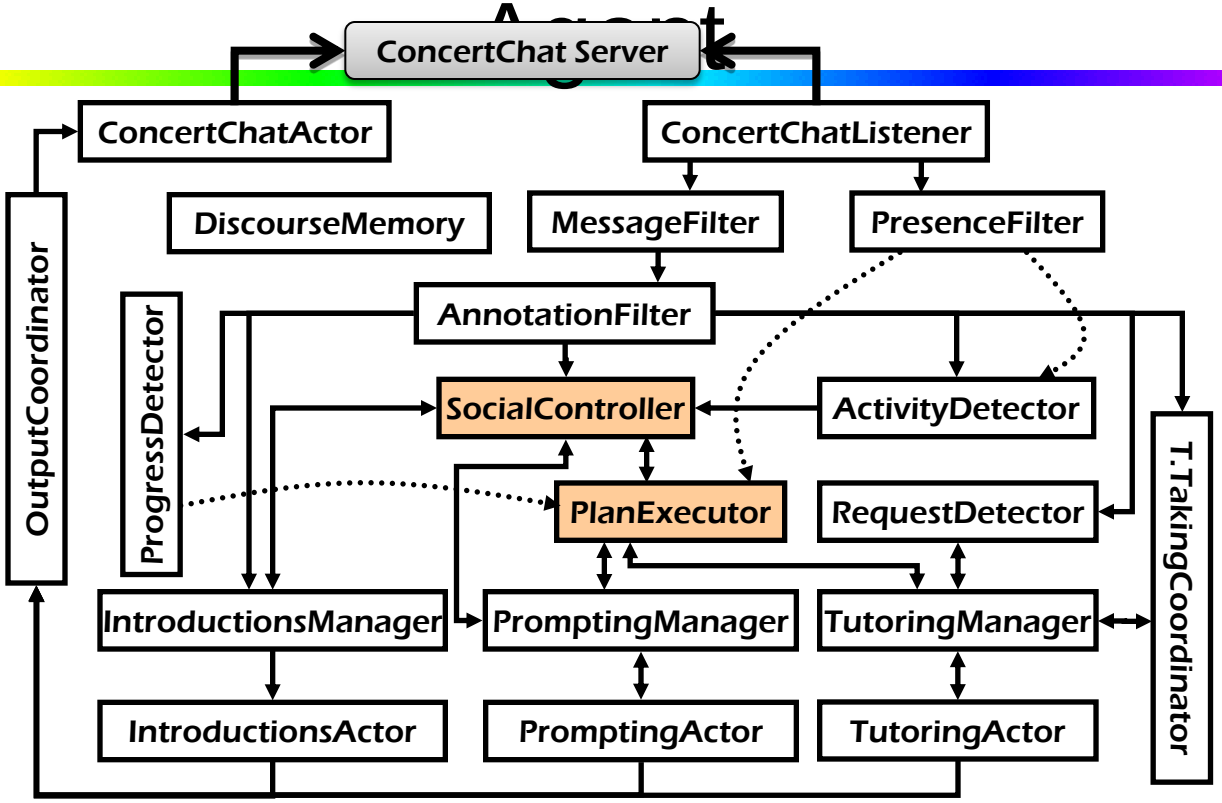
- Implements Turn-taking rules suitable for Tutoring situation
  - Wait for responses from students
  - Prioritize between correct/incorrect/irrelevant responses

Social Interaction Strategies

Based on Bales' Interaction Process Analysis (1950) in Small Groups

1. Showing Solidarity: *Raises others' status, gives help, reward*
1a. Do Introductions: *Introduce and ask names of all participants*
1b. Be Protective & Nurturing: *Discourage teasing*
1c. Give Re-assurance: *When student is discontent, asking for help*
1d. Complement / Praise: *To acknowledge student contributions*
1e. Encourage: *When group or members are inactive*
1f. Conclude Socially
2. Showing Tension Release: *Jokes, laughs, shows satisfaction*
2a. Expression of feeling better: *After periods of tension, work pressure*
2b. Be cheerful
2c. Express enthusiasm, elation, satisfaction: *On completing significant tasks*
3. Agreeing: *Shows passive acceptance, understands, concurs, complies*
3a. Show attention: *To student ideas as encouragement*
3b. Show comprehension / approval: *To student opinions and orientations*

Implementation: WrenchTalk Tutor Agent

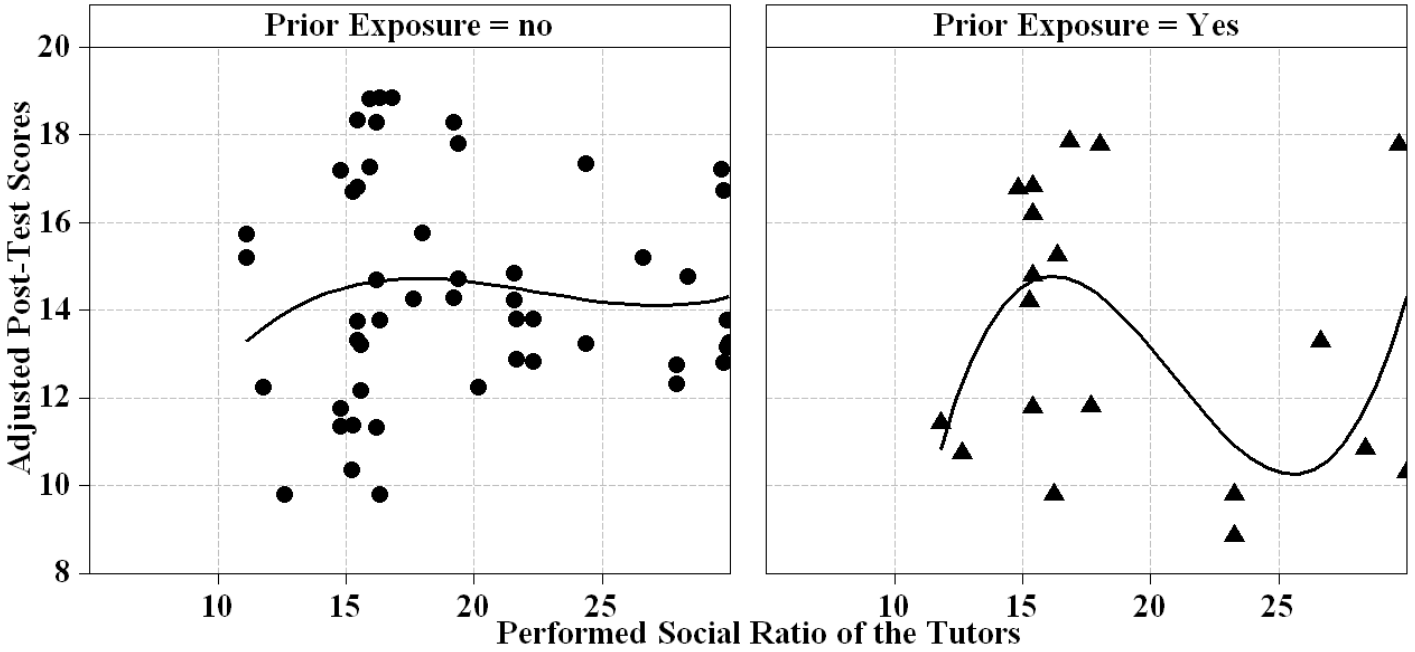


- Two primary controllers
  - PlanExecutor > Executes Task-related steps
  - SocialController > Triggers Social Behavior
- Controllers regulate each other > By Blocking

Optimal Amount of Social Behavior

- Right amount of social behavior displayed by tutors is beneficial in collaborative learning situations
  - Keeps Instrumental and Expressive needs of the group fulfilled

- Excess of it becomes a distraction
  - Empirical studies on optimal amount of social behavior by tutors



Scientific Challenge: Student/Agent Interactions

- Unlike individual learners, teams of students can ignore / abuse automated tutors

Tutor	There will be more potential for power generation ... Where might the increased heat input go instead?
St16	this tutor is really annoying
St5	Agreed

Kumar et. al. 2007a

A20	wow that tutor is annoying
A13	Yeah
A13	STFU tutor!

B18	I wonder if we can mute the tutor...
B8	maybe it stopped...
Tutor	type: HELP WITH CHANGETREHEAT if you want to discuss it with me.
B8	Okay
B8	guess i was wrong about that whole tutor stopping thing.
B18	Yeah, heh

a7	so, got any ideas?
Tutor	Starting now, you have around 40 minutes to work together…
A2	hrmmm
a7	stupid tutor no one asked you for help

B9	hi tutor
B9	tutor, you're a jerk

- Agents lack Social Communication Skills
  - Need to be better communicators

Conclusions and Future Plans

- **Collaborative Activities for Engineering Students are Beneficial from a Learning Perspective**
  - Significant learning gains of around 0.5s.d. in two different lab experiments
- **Socially Capable Tutors can Yield Additional Benefits in Supporting Students Learning in Teams**
  - Human tutors shown to be better both for learning as well as perception metrics
  - Automated tutors with social interaction strategies show comparable learning benefits, but not perception benefits
- **Recent Work Reports on the Optimal Amount of Social Behavior Tutors Should Display**
  - Additional Result: Students with prior exposure to tutors are more easily distracted if social behavior is excessive
- **Next Steps**
  - Mimic human-level social behavior in terms of
    - Triggering social behavior at the right time
    - Interleaving social and task related behavior
  - Further study of when/how students respond to social behavior display by tutors

Collaborative Activities

- **Freshmen**
  - Wrench Design Competition
    - Part of Computer Aided Engineering labs (3 sessions)
    - Students work in teams of 3 – 4
    - Instructed on relationships between Moment, Force and Stress during this activity
- **Middle-School/High-School**
  - Practical Considerations in Designing a Wrench
    - Part of CMITES program
    - Students work in teams of 3 – 4
    - Designed to elicit discussion on engineering and set the stage for demonstrating the underlying challenges
- **Sophomores**
  - Rankine Cycle Design Competition
    - Part of a Thermodynamic cycles lab (1 session)
    - Students work in teams of 2
    - Instructed on effects of changing system variables (temperature, pressure) on system responses (power, waste heat)

C-MITES Middle School Project

- **Quotes from Two Parents**:
  - (My son) thought it was great that what he learned at the class applied to his 7th grade Tech Ed class in school. He felt he had an advantage over his classmates because he was able to apply what he learned at C-MITES to the school classroom.
  - (My son) took this class and he said it was one of the best classes because:
    - it inspired him to think about what careers would use this technology
    - how the technology could be used to design medical devices
    - he enjoyed working with the technology, and enjoyed seeing how the technology works



Wrench Design Activity



Rapid Prototyping



Wrench CNC Machining

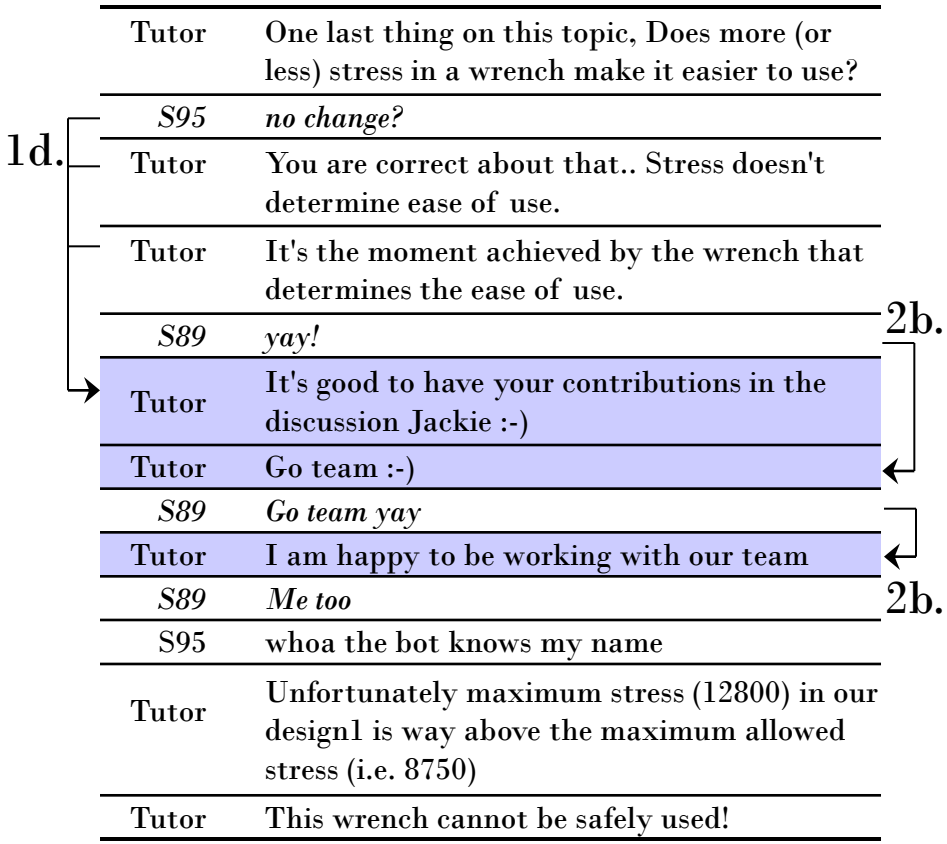
Wrench Lab Conclusions

- **Tutors with Human-like Social Capabilities**
  - Have significant learning benefit (0.93s.d)
  - Perceived by students to be significantly better than tutors without social capabilities

- **Our next step: Explore further use of tutors with human-like social capabilities**
  - First step is based on the observation that Human Tutors displayed social behavior more often than our software-based tutors
  - Develop and compare tutors that display *different amounts* of social behavior
  - There may be an optimal amount of social behavior

Implementation: Social Controller
(Rosé and Kumar)

- Social Behavior Triggering
  - Hand Crafted Rules
  - Social Ratio
    - Ratio of Social Turns to Task-related turns
    - Threshold: 20%



Tutor	One last thing on this topic, Does more (or less) stress in a wrench make it easier to use?
S95	*no change?*
Tutor	You are correct about that.. Stress doesn't determine ease of use.
Tutor	It's the moment achieved by the wrench that determines the ease of use.
S89	*yay!*
Tutor	It's good to have your contributions in the discussion Jackie :-)
Tutor	Go team :-)
S89	*Go team yay*
Tutor	I am happy to be working with our team
S89	*Me too*
S95	whoa the bot knows my name
Tutor	Unfortunately maximum stress (12800) in our design1 is way above the maximum allowed stress (i.e. 8750)
Tutor	This wrench cannot be safely used!

Experiment: Survey

- 7 point Likert-scale

1	2	3	4	5	6	7
Strongly Disagree	Mostly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Mostly Agree	Strongly Agree

- Items (Burke, 1967)

Ratings about the Tutor	Q1	I liked the tutor very much.
	Q2	The tutor was very cordial and friendly during the discussion
	Q3	The tutor was providing very good ideas for the discussion
	Q4	The tutor kept the discussion at a very comfortable level socially
	Q5	The tutor was part of my team
	Q6	The tutor received the ideas and suggestions I contributed to the discussion positively
Ratings about the Activity	Q7	I am happy with the discussion we had during the design challenge
	Q8	My group was successful at meeting the goals of the design challenge
	Q9	The design challenge was exciting and I did my best to come up with good designs

- Groups: *Task* (tutor with no social interactions), *Social* (tutor with social interactions), *Human* (teaching assistants interject social comments)