Conversational Agents as Facilitators for Group Interaction

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Agenda

- CSCL and Conversational Agents
- Dimensions of Support
- How Bazaar Works
- Tales of the Bazaar
- Deploying Conversational Agents



Conversational Agents





- State-based computer
 programs
- Interact with human beings through natural language
 - text
 - speech
 - images
 - video

Dialogue systems

Collaborative Conversational Tutors

• Conversational Agents as Facilitator for Group Interaction

Facilitator Tutors

• Programming tutor - dialogue system for computer programming instruction





Collaborative Conversational Tutors



Collaborative Conversational Tutors



CSCL with Conversational Agents

- Students working with a **partner and dialogue agent** for support learn 1.24 s.d. more than individuals without support (*Kumar et al., 2007a*)
- **Personalized agents** increase supportiveness and help exchange between students (*Kumar et al., 2007b*)
- Agents that employ **social strategies** are more effective than those that don't (*Kumar et al., 2010; Ai et al., 2010*)
- Students are sensitive to agent **rhetorical strategies** such as displayed bias (*Ai et al., 2010*), openness to **alternatives** (*Kumar et al., 2011*), and **targeted elicitation** (*Howley et al., 2012*)
- Students show learning gains (*Dyke et al., 2012*) and interact more intensely (*Adamson et al., 2013*) when supported by a facilitating agent using **Accountable Talk** moves.

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Multi-Dimensional Multi Party Dialog

S02	12:57:35	noooo i think that the daddy is homozygous dominant and the mommy is heterozygous dominant. GG, Gg		
S01	12:58:22	50% of the children are white so if one parent is gg ar is Gg then this will create a 50% chance of having white	feedback	
Tutor	12:58:27	So SO1, what I hear you saying is recessive traits can be parents, but still show up in some of the children.	hidden in	
S01	12:58:35	yeah	social awareness	
S02	12:58:39	noooooooo		
Tutor	12:58:49	I wonder what S03 has to say.		
S02	12:59:10	nothing she dont care		
S03	12:59:33	shut up S02!!! i dont understand whats going on	static	~ +
S02	13:00:12	S03, its okay. just re look at the problem mamacitaaaaa	macro-script	
Tutor	13:00:22	Let's move on to the next problem		

Support for Collaborative Learning

- Support for collaborative learning can be described as scripts that scaffold and sequence the learners' interactions.
- A collaborative activity can be composed of multiple complementary scripts.

(Dillenbourg and Tchounikine, 2007)



Macro

sequence, timing, large structure of activity

• Micro

hints, feedback, support for student actions



Static

pre-defined sequences, sentence templates

• Dynamic

responsive to student behavior, context





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Basilica



- Modular event-based agent architecture
- Multiple collaborative conversational contexts
- Pioneer platform for dynamic scripting support Kumar et al, 2007, 2010

Behavior Coordination

SO1 12:58:35 yeah

SO2 12:58:39 nooooooooo

Tutor 12:58:49 I wonder what SO3 has to say.

Tutor 12:59:00 Let's move on to the next problem...

SO3 12:59:04 ...

dynamic feedback

> static macro script

Basilica Event Flow



most of the two-way links manage behavior coordination...

Bazaar



- Based on Basilica
- Simplified event flow
- Built-in coordination between behaviors

Basilica, but...



- Make implicit filter-actor pattern explicit
- Move inter-actor coordination out of each component, and into the framework



Multi-Dimensional Multi party Dialog noooo i think that the daddy is homozygous dominant and the SO2 12:57:35 mommy is heterozygous dominant. GG, Gg revoicing 50% of the children are white so if one r proposed. og and SO1 12:58:22 participation permitted Gg then this will create a 50% chanc te ba. prompt proposed, but So SO1, what I hear you saying is reces. blocked n be hidden in Tutor 12:58:27 parents, but still show up in some of the children. 12:58:35 yeah S01 participation prompt SO2 12:58:39 nooooooooo permitted Tutor 12:58:49 I wonder what SO3 has to sr social support proposed, but SO2 12:59:10 nothing she dont care blocked 12:59:33 shut up SO2!!! i dont understand whats soing on SO3 timed prompt proposed, permitted (high SO2 13:00:12 SO3, its okay. just re look at social support amaci priority) times out. rejected Tutor 13:00:22 All right, we're wrapping up. The



Output Coordinator



- Actions are proposed with a timeout (window of relevance) and a priority value
- Advisors (left by earlier accepted actions) influence the selection of incoming proposals to:
 - reserve the floor for followups
 - prefer proposals from certain sources

Output Coordinator



- Accepted proposals leave advisors that linger for a time after the proposal is enacted.
- When a proposal is accepted or rejected, it sends a callback to notify the originating component.



Experimental Tradeoffs

	+	_
Narrow Constraints	Repeatable,Predictable, Internal validity	Behavior juxtapositions, Missed opportunities
Flexible Constraints	Adaptable,Natural exchanges,External validity	Adds error variance, Less control of time

Discussion

- Bazaar is a reusable, freely-available platform for CSCL research
- Softening timing leads to a tradeoff between internal and external validity
- Support along multiple dimensions can be coordinated gracefully

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Tales of the Bazaar

Research Platforms for CSCL



Revoicing and APT

- Can tutor-led Academically Productive Talk (APT) increase student learning?
- 9th grade Biology, groups of 3 students
- Tutor offers "Revoice" and "Say More" APT moves in response to student contributions:

S01 50% of the children are white so if one parent is gg and the other is Gg then this will create a 50% chance of having white babies

Tutor So S01, what I hear you saying is recessive traits can be hidden in parents, but still show up in some of the children.



?

2

Parents

Revoicing and APT

- Static, macro-scripted (rigidly timed) problem sequence
- Static APT micro-reminders



	Macro	Micro
Static	Type to enter text	Type to enter text
Dynamic		Type to enter text

- Dynamic social prompts (Kumar et al, 2010)
- Dynamic revoicings (APT) of student explanations: Bazaar reserves floor-space for student responses, promotes tutor follow up moves

Targeting Student Self-Efficacy

Howley, Adamson, Dyke, Rosé, 2012

- How do targeted prompts affect the self-efficacy of student participants?
- Knowledge construction dialogues delivered by "professor" tutor



- Social moves from "clueless student" tutor, plus targeted questions to high/low efficacy students
- In a time-constrained setting, overly-soft timing can mean all of the dialogues don't get started.
 - choice of priorities and timeouts is important!

Facilitating Debate

🐫 WhiteboardChat: Republicans (abc)



Facilitating Debate

- Can a balanced debate engender multi-perspective knowledge?
- Discussant participation is dynamically encouraged



- Dynamically detect the current topic and the dominating "side" of the debate.
- Facilitator/Tutor dynamically directs the conversation by introducing facts and talking points for the weaker side


Distributed Learning Environments







Massive Open Online Courses (MOOCs)





Collaboration Opportunities in MOOC environment

Asynchronous

Lack of sense of immediacy



Synchronous

Feel more involved





Two Challenges

Getting people into groups



Making a group work once it is formed





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Group Formation

- Ad-hoc
 - Pair matching
 - Rolling basis
- Transactive jigsaw





Ad-hoc Group Formation

	The bobby. Week's
	Log in with your edx username.
	Note that whenever you log in, you will be assigned to a new team.
	If the user you are matched with does not enter the room, come back to the lobby and you will be matched with someone else.
AR ASSIGNMENT: REFLECTION ON THE VISUALIZATION OF THE VORKS (EXTERNAL RESOURCE)	Username Student1

20:09	Student1	joined
20:09	System	Hi, Student1.
20:09	System	Welcome to the matchmaker lobby. Hang on for a few minutes, we'll match you up with a team as soon as enough students join.
20:09	System	Student1, you're on Team 2.
20:09	System	Your team's discussion area is ready, Student1. <u>Follow this link to join the</u> <u>discussion</u> . After you join your team's discussion area, please follow VirtualDragan's instruction there.

Group Management and Coordination

Conversational Agent Based Support

- An architecture for collaborative conversational agents **Bazaar**
- Extension for supporting synchronous group work in distributed learning environments









unifies social interaction



analyzes learning paths conditioned on social network





Data Infrastructure

into uniform interface







Data Infrastructure unifies social interaction into uniform interface

Learning Analysis

analyzes learning paths conditioned on social network





- MOOCDB
- DiscourseDB

Data Infrastructure

unifies social interaction

into uniform interface

• DataStage





Learning Analysis

analyzes learning paths conditioned on social network











Data Infrastructure unifies social interaction into uniform interface

Learning Analysis

analyzes learning paths conditioned on social network





- Survival models
- Recurrent neural networks
- Graphical models



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48



Three Cycles



Data, Analytics, and Learning

UTArlingtonX - LINK5.10x Ended - Dec 22, 2014

8-9 week long



Big Data in Education

TeachersCollegeX - BDE1x Ended - Aug 26, 2015



courses





DavidsonX - D001x Ended - Dec 11, 2015







Group Work : Collaborative Reflection Task

Discussion		Information	mc_mooc_week199
VirtualErland	3:13:21 PM		
Our goal is to do our best to guide you through this course to get the maximum benefit it has to offer. It would be helpful to us hear specifically what your expectations are going forward so we can better offer guidance along the way. Any comments or feedback for us?	to		
јк	3:13:42 PM		
Hi Shenal			
Shenal Cooray	3:14:06 PM		
I'm joining the course from Switzerland			
јк	3:14:26 PM		
I'm joining the course from Colombia			
Tanguy T has joined the discussion.	3:15:11 PM		
VirtualErland	3:15:13 PM		
Welcome, Tanguy T Please join our discussion to get acquainted and think about what we learned this week. We have discussed [what goals you might have for your participation in this course, how well the course content matches expectations] Currently we are discussing what expectations you have for the remainder of the course Please join in.			
Shenal Cooray	3:15:17 PM		
I like the course so far - based on the pre-test, I see that we are going to get deep into the Medicinal Chemistry. I liked that we started off with some non-scientific stuff			
		Want to share an image? Pas	te its URL here!

Share Image URL

Kind of prompts

Prompt 1: Reflect on the structure of the dual-layer structure of the course. **Describe your experience** of coming to understand different course elements.

Prompt 2: For today's exercise, **please pick and tell a problem that prediction modeling or behavior detection could be used for. It could be something relevant to your work**, or it could be something you just think is nifty. It could also be the same problem you picked last week, or a new problem. *shrugs* It's all good. My example would be predicting if a student is gaming the system, in online math homework. Now your turn.

Prompt 3: The liver is a primary organ for drug metabolism. In cases of drug overdoses, the liver is often at risk to be damaged by drug metabolites. Discuss in general terms how the liver can be vulnerable to the metabolites that it makes.











Collaborative interaction supported by a virtual agent

Making the group work once it is formed

- Knowledge construction dialogues
- Academically Productive Talk moves
- Other facilitation moves like consolidation

Pilot studies in a fake meteorology course on edge edX for - An Exploratory Study: Assisting Synchronous Chat in a MOOC through Agent Facilitation Moves

WEATHER MOOC

- Watch a video on introductory concepts to meteorology
- Synchronous chat collaboration with a group of people and an agent
- Give a short quiz on the concepts

INTRODUCTION TO METEOROLOGICAL CONCEPTS Low Pressure Centers PRESSURE 2:53 / 2:53 SPEED 1.0x **D** DISCUSSION CHAT (EXTERNAL RESOURCE) (1.0 points possible) Chat Room IMAGE MAPPED INPUT (1/1 point) Press the left mouse button over the area of the map above where you would expect to find the coolest temperatures. Check Show Answer

Discussion		Information
VirtualCarolyn	8:16:51 PM	
I noticed that you are talking about low pressure wind direction. If you want to che knowledge on low pressure wind direction with me say 'LET'S DISCUSS ABOUT lo pressure wind direction' and I will ask some questions on it.	eck your w	
Oliver	8:17:11 PM	
LET'S DISCUSS ABOUT low pressure wind direction		• Q R.
Germán	8:17:11 PM	
let's discuss about low pressure wind direction		X X
VirtualCarolyn	8:17:11 PM	
Will you like to answer some questions related to low pressure and wind direction ?		Key: Cold front Low-pressure Cold front center Warm front High-pressure
		Direction front moves center
Germán	8:17:15 PM	Precipitation
yes		Location

Micro script

- Detecting topics being talked about
- Starting KCDs on request by participants
- Academically Productive talk moves
- Consolidation moves

Keith M

Now that we know more about the direction of winds in High and Low pressure centers, it's neat to look at a wind map and check our understanding

VirtualCarolyn

8:39:01 PM

I noticed that you are talking about low pressure wind direction. If you want to check your knowledge on low pressure wind direction with me say 'LET'S DISCUSS ABOUT low pressure wind direction' and I will ask some questions on it.

Keith M

8:42:36 PM

8:42:37 PM

I guess I've been commandeering the chat. VirtualCarolyn, why don't we talk about wind direction in low pressure centers

VirtualCarolyn

I noticed that you are talking about high pressure wind direction. If you want to check your knowledge on high pressure wind direction with me say 'LET'S DISCUSS ABOUT high pressure wind direction' and I will ask some questions on it.

Keith M

LET'S DISCUSS ABOUT low pressure wind direction

VirtualCarolyn

8:42:41 PM

8:42:39 PM

Will you like to answer some questions related to low pressure and wind direction ?

New Facilitation Move - Summarization

- Why?
 - \circ $\,$ Provide frame of reference to new entrants in the chat discussion
- How ?
 - By agent
 - mention list of topics covered
 - By other participants
 - agent requests other participants
- When ?
 - At-least two new topics have been discussed
 - by other participants
 - Else
 - by agent

Consolidation move requested by agent

Arka has joined the discussion.	9:23:43 PM
VirtualCarolyn	9:23:45 PM
Welcome, Arka Can any one of you provide a summary of our discussion till now to Arka	
can any one of yoo provide a sommary of oor discossion dathout to rand	
Germán	9:24:16 PM
we were talking about the intersection of cold and warm fronts and the chance of precipitation at this intersection	
Natty	9:24:20 PM
hinarka we have been talking about cold fronts and precopitation	
VirtualCarolyn	9:24:20 PM
I noticed that you are talking about warm front precipitation. If you want to check y knowledge on warm front precipitation with me say 'LET'S DISCUSS ABOUT warm precipitation' and I will ask some questions on it.	our front
Tomit	9:24:37 PM
Lets not dicsuss about warm front precipitation	
Arka	9:24:41 PM
thanks guys	
Arka	9:24:58 PM

Consolidation move made by agent

diving has joined the discussion.8:08:20 PMVirtualCarolyn8:08:21 PMWelcome, diving
We have been discussing on topics like [low pressure temperature, cold front
temperature, warm front temperature]
Please join in.8:08:21 PM

VirtualCarolyn

10:03:09 PM

Welcome, Gaurav

Can any one of you provide a summary of our discussion till now to Gaurav

Yohan

0:03:28 PM ED

but i don't know it means F has high chance of rain

Guest 241750266

10:03:56 PM ED

well Yohan just explained that the chance of precipitation is lower behind a warm front because it leaves warm air and warm air expands rather than condenses

Guest 241750266

10:04:59 PM ED

I think that the low pressure might increase the chance of rain at F, but at C the air is warmed up

Yohan

0:05:07 PM EI

Guest 241750266 mentioned earlier that there is a high chance of rain at F.

VirtualCarolyn	9:46:49 PM ED1
Others, do you agree or disgree with Manmeet ?	
Guest 241750266	9:47:10 PM EDT
l agree with manmeet too, good input	
Yohan	9:47:44 PM EDT
what's the numbers in the map by the way?	
Gaurav	9:47:55 PM EDT
I think wind speed	

VirtualCarolyn	9:32:10 PM EDT	
We can talk about cold fronts and temperature in a detail.	little more	
VirtualCarolyn	9:32:10 PM EDT	
Can you explain why the temperature is cooler behind a cold front? Feel free to refer to points on the map.		
Cassie T	9:32:18 PM EDT	
Decause a cold front brings cold air with it		

Because a cold front brings cold air with it



Empirically Grounded Design Principles

Group formation

Ad Hoc pairwise matching

Ad Hoc but a single continuous chat room welcoming students into the chat on a rolling basis

Oliver Ferschke, Diyi Yang, Gaurav Tomar, Carolyn P. Rosé: '*Positive Impact of Collaborative Chat Participation in an edX MOOC*', in: Proceedings of the 17th International Conference on Artificial Intelligence in Education (AIED), Madrid, Spain, 2015.



Empirically Grounded Design Principles

Group management & coordination

- Conversation summary by agent or participants
- Tracking students' activity (presence and participation) and topics covered
- Detecting and handling goalless interactions

Gaurav Tomar, Sreecharan Sankaranarayanan, Xu Wang, Carolyn P. Rosé: '*Coordinating Collaborative Chat in Massive Open Online Courses*', in: Proceedings of the 12th International Conference of the Learning Sciences (ICLS), Singapore, 2016.



Empirically Grounded Design Principles

Group management & coordination

Non-adaptive timing of activity prove fast for large groups and slow for small groups Adaptive timings and delays for the prompts based on the number of students in the chat room Students with no peers Knowledge construction dialogs by agent for students with no peers



Survival Modeling

Survival Model

Regression model that captures the changes of probability of survival over time

$$S(t) = \Pr(T > t) = 1 - F(t) = \int_0^\infty f(x)d(x)$$

Hazard Ratio

$$\lambda(t) \coloneqq \lim_{dt \to 0} \frac{\Pr\{t < T \le t + \Delta t | T > t\}}{dt}$$



- Proportional log odds model capturing probability at each time point that a student will drop out at the next time point
- Hazard ratio indicates how much more or less likely a student is to drop out based on how many standard deviations higher or lower a factor's value is than average



Positive Impact of Chat Participation on Dropout

Survival analysis

- students who made at least one attempt to participate in a chat during the first 6 weeks
- unit of analysis: each 2 day period

Dependent variable:

• drop = 1 on the last 2 day time window when at least one click was recorded (0 otherwise)

Control variables

- clicks on videos
- clicks on discussion forums

Independent variables:

• Participation in

Independent Variable	Hazard Ratio	P Value
Video Clicks	2.38	P < .0001
Forum Clicks	.51	P < .0001
Match Attempts	2.33	P < .0001
Match Success	.44	P < .01
Interaction between	.76	P < .05
Match		



Positive Impact of Collaborative Chat in MOOCs

- Assess impact of chat participation on dropout along the way using a survival analysis
 - Unit of analysis: each 2 day period
 - Dependent variable: Drop = 1 on the last active time period (0 otherwise)
 - Control variables: Number of clicks on videos and number of clicks on discussion forums
 - Independent variable:
 - Participation in collaborative chat reflection activities





MEDICINAL CHEMISTRY THE MOLECULAR BASIS OF DRUG DISCOVERY

produced by DAVIDSONX

ongoing /

NML

in partnership with UNOVARTIS

INSTITUTES FOR

BIOMEDICAL RESEARCH

Facilitator Tutor

Multi-Stream Mixed Initiative Planning **Dialogue System** for Computer Programming Instruction

Best Presentation Award at CMU Student Research Symposium, 2015

69









Mixed Initiative Planning

- User initiative
- System initiative

Multi Stream

- natural language dialog between student and system
- o continuous stream of code written by the student

Multi-Stream Understanding



← → C 🗋 localhost:8081/cloudcoder/#exercise?c=1,p=7

nthCircularPrime :

Δ.	-
5.7	-
0.4	

nthCircularPrime :		<< Back Log out
Discussion	userstudy2	 //A circular prime number is a number that remains prime on any cyclic rotation of its digits. //For example, consider 197. Its rotations are 197 (itself), 971, and 719, and //all of these are prime, so 197 is a circular prime. //The first several circular primes are: 2, 3, 5, 7, 11, 13, 17, 31, 37, 71, 73, 79, 97, 113, 131, 197,
What else?	^	5 //With this in mind, write a class nthCircularPrime whose main method 6 //takes a non-negativenumber as an input argument n and prints onth circular prime number. 7 //The list is 8 based so attricularPrime(0) returns 2
root	4:13:47 PM	<pre>8 - public class nthCircularPrime { 9 10</pre>
Tam writing the code to test primaity		<pre>//Method to check the primality of a number 12 - public static int isPrimeInteger(int n){ 13</pre>
VirtualCarolyn Let's finish going through the plan together fi we'll get to writing code.	4:14:06 PM rst, and then	13 Int j = 2; 14 while (j <= n / 2) 15 { 16 if (n % j == 0) 17 { 18 return 0; 19
root It was easy to write this method	4:15:18 PM	19 20 21 22 return 1;
root I have done that before	4:15:24 PM	<pre>23 } 24 25 public static void main(String[] args) { 26 } 27</pre>
VirtualCarolyn	4:15:48 PM	28 }
Great! You've written a method to check prim Let's move on to the next section.	e numbers.	
From the problem definition I can to check	see that I need	
Send Message		
		4
Bazaar + Cloudcoder

Browser-Based Application	
Leah 1:42:21 PM I think there's something wrong with how I'm iterating up to the number	Assignment Instructions
VirtualCarolyn 1:42:55 PM I see that you're working on your method to determine if a number is prime. 1:43:07 PM VirtualCarolyn 1:43:07 PM Your iterator should go up to, but not include, the target number. 1:43:22 PM Oh! Now I see what's wrong! 0 Send Message I'm Ready	Programming Buffer
Test Cases	

Dialogue Management Model

- Decides on type and timing of system's dialog moves using both dialog and code streams
- Novelty is in using knowledge of student's code to inform tutoring

Agent Component Network



Agent Component Network





Agent Component Network





Questions?



gtomar@cs.cmu.edu cs.cmu.edu/~dadamson/bazaar







Scripted Support: From Synchronous to Ubiquitous

- edX platform lacks support for pervasive chat interactions.
 - Building this support in our ongoing collaboration with edX.
- Opportunities for embedding Bazaar interactions
 - Instantaneous reflection/discussion chat
 - Breakout Groups from Discussion Forums Unhangouts + Bazaar
 - Video/Activity centric discussions