

Theory and Research for Multi-user Virtual Environments for Learning: Collaborative Complexity and Fostering Transfer in Agent Augmented Artificial Worlds

Theory and Research for Agent
Augmented Virtual Environments
for Learning:

“Heat from a Burning Fire?”

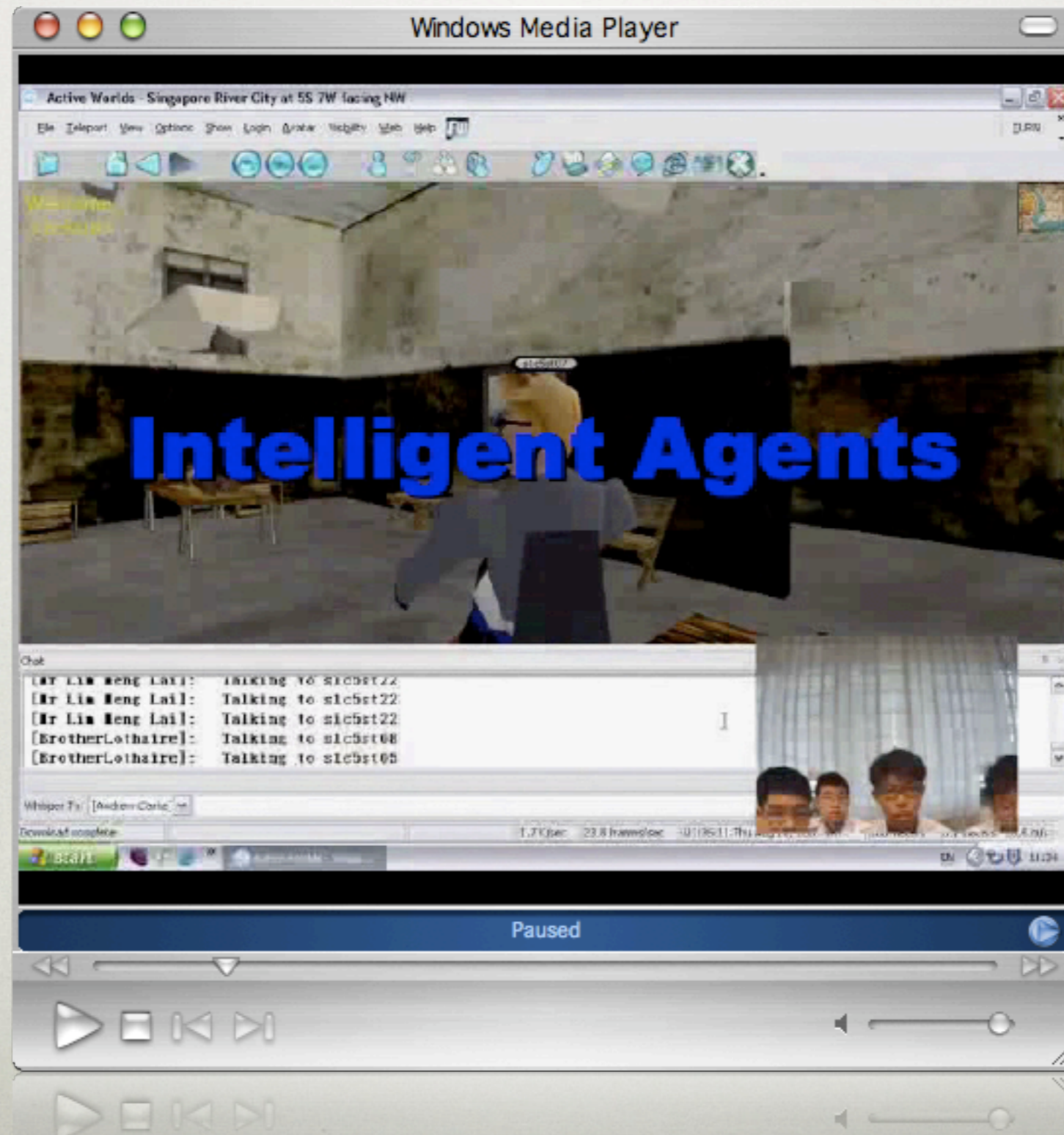
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LEARNING AND COGNITION
THE UNIVERSITY OF SYDNEY**

OVERVIEW

- Glimpse of a future learning environment?
- Research team
- Theoretical and research
- Virtual Singapura multi-user virtual environment
- Preliminary research into learning science inquiry with the VS MUVE
- Reflections and conversations

A GLIMPSE OF FUTURE LEARNING?

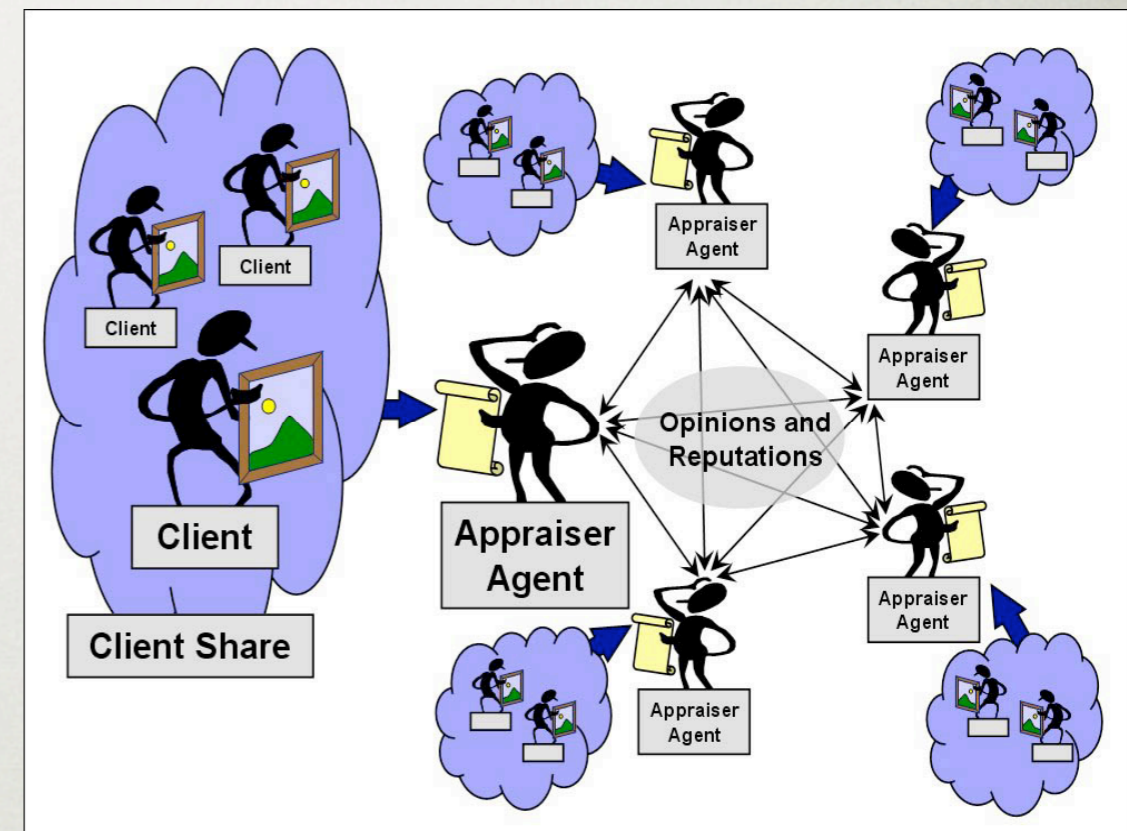


PROJECT TEAM: NOVEMBER 2006 TO APRIL 2008

- Senior researchers:
 - Michael J. Jacobson: Learning Sciences Laboratory, PI
 - Chunyan Miao: School of Computer Engineering, NTU, PI
 - Beaumie Kim: Learning Sciences Laboratory, Co-PI
 - Zhiqi Shen: Electrical and Electronic Engineering, NTU, Co-PI
 - Mark Chavez: Art, Design, and Media, NTU, Co-PI
- Research assistants: June Lee, Seo-Hong Lim, Lynn Low
- International Consultants: Chris Dede: Harvard University, Diane Jass Ketelhut: Temple University, Brian Nelson: Arizona State University
- Collaborating with:
 - Dr. Diana Ang, science education, NSSE
 - Teachers at Admiralty Secondary and Catholic High School

“GOAL NET” ARCHITECTURE FOR INTELLIGENT AGENT RESEARCH

- Infuse intelligent agents into new media (virtual, mixed, mobile, and pervasive) to create new experiences and dimensions in game design and interactive narratives
- Agents represent virtual characters with human-like behaviors
- Intent to bring new dimensions of engaging experiences into virtual space and life
- Second place finish in 2006 AAMAS (International Joint Conference on Autonomous Agents and Multi-agent Systems) agent competition



LITERATURE REVIEW OF LEARNING IN 3D MUVE & GAMING ENVIRONMENTS

- Widely held assumption: 3D virtual and game environments will greatly enhance student learning (“*get warm standing next to a fire...*”)
- Literature review in 2006: Less than 5 studies documenting *significant* learning gains
- Harvard’s Chris Dede (VS collaborator):
 - “Content acquired typically is neither related to national standards for academic content nor useful if applied to real world contexts,
 - and no studies have yet established the transfer of skills mastered in gaming to life situations.”

THEORETICAL LENSES

- Learning sciences and CSCL theory & research issues
- Conceptual and methodological tools from study of *complex systems (complexity theory)*
 - Agents interact based on often simple rules
 - Micro-level order from self-organization associated with decentralized (often nonlinear) interactions
 - Emergent properties at macro-level of systems
 - Feedback interactions across and within levels of systems
- Complexity perspectives for understanding the dynamics of virtual, social network, and “real world” classroom environments (and DLAC3 themes of *participation & personalization*)

**“to show that complexity, correctly viewed, is only a mask for simplicity;
to find pattern hidden in apparent chaos.”**

- Herbert Simon (*The Sciences of the Artificial*)

RESEARCH GOALS

1. Proof-of-concept to integrate intelligent agents into an educational multi-user virtual environment
2. Examine learning of secondary science inquiry skills and science content in a MUVE
3. Investigate transfer of inquiry skills and science content knowledge to problem solving outside virtual world
4. Explore ways in which an agent-augmented MUVE might:
 - a. Enhance student learning through the use of adaptive scaffolding
 - b. Enrich the quality of the learners experience in the virtual world

GENERAL PRINCIPLES FOR VS AGENT SCRIPTS



- Employ goal net theory for agents (Shen, Miao, & Gay, 2006)
 - Goals
 - Location and situation awareness
 - Self-organizing and adaptive behaviors
- Adaptively respond based on
 - How many visits to a location
 - Activities for a particular purpose

Features of Agent Scripts (I)

- Location awareness
- Agents initiated conversations

- ◆ Example 1

- ◆ Student's question: *Where am I?*

- ◆ **Mdm Tan Kim Gek** (lady proprietor of the Chinese Medical Hall):
You are at the Chinese Medical Hall. There are maps around in the city that shows your current location. You can click on any of the labeled locations in the map to teleport to that place in the city.

- ◆ Example 2

- ◆ Student's question: *Where is the hospital?*

- ◆ **Mdm Tan Kim Gek**: You can refer to the map of the city for help. You can ALSO click on any of the labeled locations in the map to teleport to that place in the city.



Features of Agent Scripts (II)

- **Situation awareness**

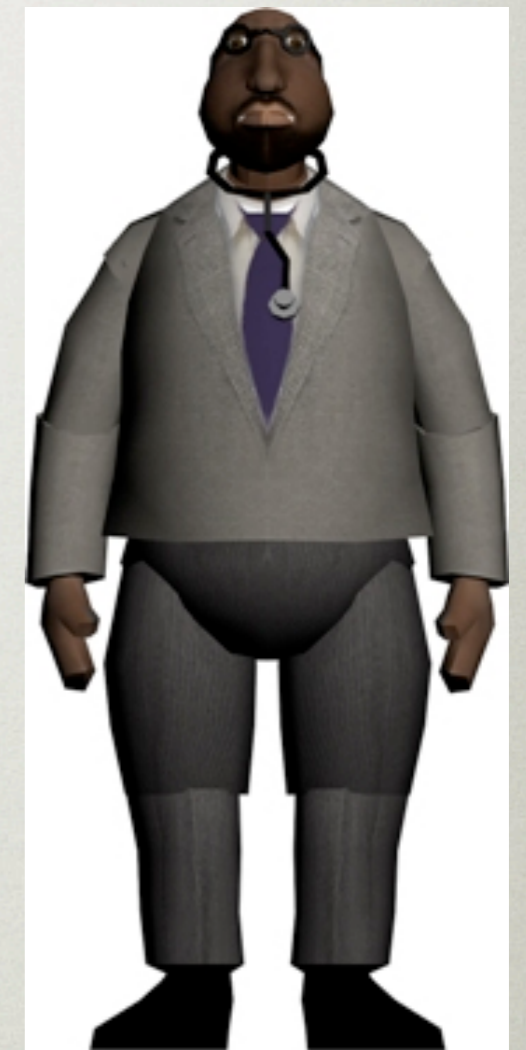
Agent monitors frequency of student interactions and responds appropriately

- Dr Rajabali's greeting to a student who visits the hospital for the first time:

Hi there, June! I believe this is your first visit at the hospital. Many of the patients have very bad diarrhea, and some of their bodies had turned blue from dehydration. As my medicine is not working, I am re-examining my patients' symptoms to come up with other cures. Perhaps you should talk to my patients too.

- Dr Rajabali's greeting to a student who visits the hospital for the second time:

Hello again! The situation has not improved. I hope you are able to find out what is causing my patients to be sick. Feel free to look around or talk to the people here.



Features of the Agent Scripts (III)

- Situation awareness (II)
 - Agents monitor and keep track of whether students have seen information objects in a location.
 - **Nurse Siti (from the hospital):** *Hi there, Lynn! I have been cleaning the place up, and I hope that the clean air will help our patients get better. Remember to check out the objects in the hospital as they contain important information. There are 5 of them, including the admission records.*



VS PILOT RESEARCH

- Grade 7 (Secondary 1) students
- 3 classes (105) used VS with science inquiry module
- 6 classes (222) used a PBL paper-based version
- Bandwidth limitations: only 10 working computers



VS PILOT FINDINGS

- Naturally changing role of teachers
- Paper based comparison group scored higher on posttest than VS group
- Significant but weak group effect
- VS students and teachers very positive



STUDENT VIEWS OF LEARNING WITH VS

- “...so we don't feel bored...because the teachers just like (gave) us all the notes...then we just copy down and all that, but in “Virtual Singapura”, we get to carry out experiments ourselves, so we understand better. “
- “...it (“Virtual Singapura”) was very interesting as we not only get information from our teachers... we get to conduct experiments by ourselves, and **there were different outcomes from the others...**”
- “...the process of learning while you're playing is quite fun...you can learn better.

VS2 STUDY

- Teachers requested we do follow-up study with **all** classes in new Secondary 1 January 2008 cohort
- Paying \$S 10,000 for high speed dedicated network access to a single computer lab
- Research interests:
 - “Value added” of individual identity in virtual world as part of collaborative inquiry
 - Transfer of learning: Analogical encoding theory (Gentner et al.)
- Three post VS treatments
 - Contrast and compare science inquiry cases
 - Sequential individual problem solving
 - Reading comprehension



Think about the things that you had learnt during the last few weeks in “*Virtual Singapura*”. Please read the following two cases and see if there are any common principles.

1. *Purpura nautica*

During the Age of Discovery, scurvy became a disease among sailors. The disease was often referred to as *Purpura nautica*, as sufferers had purple (*purpura*) blotches under their skins. They would also have teeth and hair loss, sunken eyes, paleness, blindness, and most would die. In 1747, James Lind, the surgeon aboard HMS *Salisbury*, was faced with many cases of scurvy and a high death rate. He thought that the disease was related to a lack of ascorbic acid, which is found in citrus fruits, but had to prove it. What Lind did next changed the history of scurvy. As a scientist, what do you think he did?

2. Is it good to be special?

The shoe company *Steps* decided to run a free webinar (a type of web conference) to get people to be aware of shoe comfort, and be interested in *Steps*' footwear. E-mails would be sent to invite people to the webinar. When drafting the e-mails, the marketing manager noted an interesting claim, that the word “special” should not be in e-mails' subject lines. E-mails with “special” in their subject lines were avoided by people as they were seen as spam. The manager was keen to test this claim, and to find out whether differences in subject lines mattered to whether people would attend the webinar. As a market researcher, what should she do?

Write your answers for **comparing and contrasting** the above cases on foolscap papers. Attach your responses for the questions together with this paper before submission.

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QUANTITATIVE FINDINGS

- Students in all classes performed at comparable levels on measures paper-based measures of understanding of inquiry, attitudes towards science, content knowledge
- Significant differences were found on the posttest transfer problem solving inquiry question
 - Contrast and compare group higher than other 2 groups
 - Consistent with analogical encoding theory
 - Provisional since a small effect size
- Potentially important finding suggesting that non-computer based individual learning activities might enhance learning gains from collaborative virtual experiences

OBSERVATIONS

- More “on task” student behaviors than in VS1 pilot study
- Presentations by student teams seemed much more insightful and “scientific” than presentations by the pilot study groups
 - Explained how the data reported related to the hypothesis that was proposed
 - Audience questions to:
 - Justify how data collected about water quality in the wells impacted diseases when there was no data reported on patient symptoms from the hospital
 - Justify why draining the marsh (which only reduced the number of malaria carrying mosquitoes in VS) would impact the cholera microbe counts in the drinking water wells located in completely different locations of the city
- Classroom “atmosphere” during the final student VS presentations was like a real scientific meeting, even though these Singapore students had not been “taught” how they should behave or act in scientific meetings

VS2 STUDENT INTERVIEWS

- What do you think of VS?

It is a better way to do experiment ourselves rather than a teacher telling us the answer. It is more interesting; in class it is boring (this student is comparing VS to standard classrooms that are done without using computer).

- Any suggestions for how to improve the VS program?

First, more time, right now we have to rush but with more time we could explore the environment and work at our own pace without the need to rush thru the work sheet. ...

Second, have small radar to keep track of where to go or the location of our team mates.

Third, have two different chat boxes, one for the whole class, and the other for team. The class chat box would give us more challenging ideas because it is from larger group.

Fourth, make the VS place bigger with more towns, and animations. A maze-like environment when you move and at certain point you have to answer question. Finally, with more objects in VS.

SOCIAL NETWORKS IN VIRTUAL SINGAPURA

- VS 1
 - 4 students / computer
 - Social network was their face-to-face group (did not always get along!)
- VS 2
 - 1 student / computer
 - Assigned online groups that also worked F2F
 - Social identity seemed to be the groups (presentation interactions)
 - Interesting request for a “class social network” option

SOCIAL NETWORK RESEARCH ISSUES IN 3D VIRTUAL LEARNING ENVIRONMENTS

- Is it possible to have synergies between structured online social networks in multi-user virtual environments with unstructured “informal” online social networks?

New Facebook Active Worlds plugin

- *But* what of learning in domains where learners likely have strong naive preconceptions?
- Transfer broadly construed
 - Knowledge, skills and disposition
 - Preparations for future learning

DLAC-3 THEMES

- Participation
 - VS2 structured the participation and collaboration groups and activities
 - Students still seemed quite motivated
 - Perhaps comparison is not with informal games and social networks but with traditional didactic instruction
- Personalization
 - VS accomplished this with intelligent agent technology
 - Limited in initial 2 pilot studies, but successful proof-of-concept
 - Research needed to explore personalization in terms of *content* and *self-regulated learning skills*

CONCLUSION

- Early research into learning with agent augmented multi-user virtual environments
- Grand theoretical and research challenge for virtual and social network environments:

*Moving beyond
“heat from a burning fire”*




Welcome to Virtual Singapura in 1874!




It is 1874, and for mysterious reasons, the residents of Virtual Singapura are getting sick. The Governor of Virtual Singapura has commissioned you and your teammates to travel back in time to find out what is causing their health problems.



Click on  to access the online tutorial.



Click on  to access your online lab book.



Chat

lynn. (to my team) ye
 [Dr Rajabali]: Hi again.
 [Dr Rajabali]: I hope you have spoken to some of my patients.
 [Dr Rajabali]: Feel free to ask me if you need help.
 [Dr Rajabali]: Talking to lynn

Whisper To [My Team]

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