Integrating an Intelligent Tutoring System into a Virtual World

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Introductions

Parvati Dev

LeRoy Heinrichs

Speakers and Participants

Xiangen Hu

Keith Shubeck
1. Complex multi-person triage in a mass casualty – Preview of the problem
2. Virtualized mass casualty simulation - VCAEST
3. Immersive virtual simulations – discussion
4. Review of Intelligent Tutoring Systems
5. Demonstration of an ITS in VCAEST
6. Creating the guidance content in an online tutor
7. Evaluation study - plans
8. Summary and discussion
CAEST
Civilian Aeromedical Evacuation Sustainment Training
Goals of CAEST

- Provide **effective training** to medical professionals on SALT Triage
- **Improve communication** between medical professionals and military during disaster situations
Mass Casualty

- Casualties
- Usually in a single incident (hurricane, aircraft accident, etc)
- Large number of casualties
- Exceed local logistic and emergency medical resources
Video from National Preparedness Network:  http://youtu.be/1mVX8Gqi_3E
SALT
• **Sort**
• **Assess**
• **Life-saving interventions**
• **Treat / Transport**

Most accepted of many diverse triage algorithms (e.g. S.T.A.R.T.)
SALT

- Sort
- Assess
- Life-saving interventions
- Treat / Transport
SALT – Background

• SORT
• Assess
• Life-saving interventions
• Treat / Transport

Step 2 - Assess: Individual Assessment

Lifesaving Interventions:
• Control major hemorrhage
• Open airway (if child consider 2 rescue breaths)
• Chest decompression
• Auto injector antidotes

Breathing? →
- Yes
  → Obeys commands or makes purposeful movements?
  → Has peripheral pulse?
  → Not in respiratory distress?
  → Major hemorrhage is controlled?
  → All Yes → Minor injuries only? → Yes → Minimal
  → Any No → Likely to survive given current resources?
  → Yes → Immediate
  → No → Expectant
- No → Dead

Delayed
SALT

- Sort
- Assess
- Life-saving interventions
- Treat / Transport
CAEST

What worked – what did not
Why was it started?
• Communication challenges during recent mass casualty disasters between civilian medical responders and military

How was it implemented?
• Didactic learning in classroom setting and live-action training scenarios

What worked, what didn't work?
• Live action training scenarios helped to ground content taught
• Logistically challenging, expensive
Perceived effectiveness of training

Koch et al. (2011)
Live training is often...

- Too expensive
- Time consuming
- Inattentive to individual learning needs
- Costly to travel to and from

Koch et al. (2011)
How can the differences in goals, roles, and expectations be bridged?

How will differences in jargon, equipment and standard operating procedures affect patient care?
VCAEST

Virtual Civilian Aeromedical Evacuation Sustainment Training
Live simulations are highly effective but very expensive…

- We need an effective, low cost alternative to live simulation training for healthcare personnel who interface with military operations in a catastrophe requiring aeromedical evacuation

Achieve this through …

- Integrating a Web-based virtual 3D environment with an Web-based intelligent tutoring system
- Low cost, easily updateable, internet-based
- Leverage proven learning technologies
- Make training widely available
- Marry realistic virtual environments with robust learning technologies
• Multi-patient scenario
• Grounds outside the hospital,
• Performance goal
  o performing the correct triage category
  o the appropriate intervention
  o selecting the appropriate mode of evacuation, air or ground
Damaged Chaotic Environment
Multiple Patients
Provide Life Saving Interventions
Assessing Patient Vitals

- Respiratory
- Capillary Refill
- Heart Rate
- Mental Health

Triage Tag:
- Contamination:
  - No __ Yes __
  - Chemical __ Biological __
  - Radiactive

- Respiration:
  - Yes __ No __

- Perfusion:
  - +2 SEC __ -2 SEC

- Mental Status:
  - Can Do __ Can't Do

- Oriented:
  - Disoriented __ Unconscious __

- Time:
  - Pulse __ B/P __ Respiration

- Time:
  - Drug Solution __ Dosage

Priority Levels:
- Priority 0: Expectant
- Priority I: Immediate
- Priority II: Delayed
- Priority III: Minor
- Priority IV: Involved
Assess Patient Vitals: Respiratory Rate
Assess Patient Vitals: Capillary Refill Time
Assess Patient Vitals: Heart Rate
Assess Patient Vitals: Mental Status
Interact with Triage Tag to Triage Patient
Open Discussion
Intelligent Tutoring Systems

Learning Theory, Efficacy of Tutoring, and Computerized Learning Environments
With normal group instruction or training, individuals will vary in terms of prior knowledge.

- One-on-one human tutoring
  - Beneficial but depends on skill level of the tutor
  - Learning may be tailored to the individual's skill level
  - Expensive
- Virtual agents comparable to human tutors
- Virtual agents can simulate learning gains comparable to one-on-one human tutoring
  - importance of pedagogical strategies
• Constructivist approach
  ▪ Learning seen as an active and social process
  ▪ Learners responsible for knowledge construction
    ▬ Expressing
    ▬ Explaining
    ▬ Question asking
• Learning environments should...
  ▪ Stimulate knowledge
  ▪ Model explanations
  ▪ Foster self-explanations
  ▪ Provide feedback for correction of misconceptions
Pedagogical Strategies used by Expert Human Tutors

- Hints
- Prompts
- Bridging Inferences
- Self-explanations
- Question Asking
  - Type of question determines the level of complexity in the answer given
  - Graesser & Person (1994) Question Asking taxonomy
    - Shallow, intermediate, and deep questions for various types of learning
Advantages of 1:1 Tutoring

• Just-in-time Feedback
  • Student misconceptions quickly dealt with

• Tutors prompt students to elaborate
  • Student self-explanations shown to provide large learning gains compared to various controls (Chi et al., 1989)

• ITSs can model expert 1:1 tutoring conversational framework
  • Provides hints, prompts, feedback to encourage elaborative self-explanations from students.
AutoTutor  AutoTutor-LITE  iSTART  Writing-Pal  iDRIVE  PKD Android  HURA Advisor  iMAP  Meta-Tutor  Guru  DeepTutor  

Cohesion
- This and That
Explorers are making an expedition to South America to find a new species of frog. As of now, this still does not have a name, but will soon.
# LEARNING GAINS

<table>
<thead>
<tr>
<th>Effect Sizes</th>
<th>Learning Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>.42</td>
<td>Unskilled Human Tutors</td>
</tr>
<tr>
<td></td>
<td>(Cohen, Kulik, &amp; Kulik, 1982)</td>
</tr>
<tr>
<td>.80</td>
<td>AutoTutor (20 experiments)</td>
</tr>
<tr>
<td></td>
<td>(Graesser and colleagues)</td>
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<tr>
<td>1.00</td>
<td>Intelligent Tutoring Systems</td>
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<tr>
<td></td>
<td>PACT (Anderson, Corbett, Aleven, Koedinger)</td>
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<td></td>
<td>Andes, Atlas (VanLehn)</td>
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<td></td>
<td>Diagnoscer (Hunt, Minstreli)</td>
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<td></td>
<td>Sherlock (Lesgold)</td>
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<tr>
<td>2.0</td>
<td>Expert Human Tutors</td>
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<td></td>
<td>(Bloom, 1984)</td>
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</tbody>
</table>
Under the hood of Intelligent Tutoring Systems

Semantic Spaces, Natural Language Processing, Sharable Knowledge Objects (SKOs), Student Model
Robust language processing of student answer requires a Domain specific semantic space.
Great Job!

Model of Learner (LCC) is updated with each answer

Semantic Analysis and Semantic Decomposition

Feedback is encoded as voice file

Total Coverage
Current Score
Relevant New
Relevant Old
Irrelevant New
Irrelevant Old

Answer Key

Student's earlier answers

Student answer
Each answer is analyzed with respect to: **prior answers & stored answer key**
Contraindications

Acute blood loss is a contraindication. A broken arm is a contraindication to air transport.
Contraindications

Types of Contraindications:

- Acute blood loss is a contraindication.
- A broken arm is a contraindication to air transport.

**Total Coverage**

**Rel & New**

**Rel & Old**

**Irrel & New**

**Irrel & Old**

**Current Score**

Attempts
Robust language processing of student answer requires a Domain specific semantic space.
A Theory of Semantic Spaces

• Hu et al. (2005)
  o Basic assumption of languages
    ▪ Concept of "layers": words, phrases, sentences, paragraphs, documents
  o Formal framework
    ▪ Language neutral
    ▪ Computational (vector-based)
  o Implementable
• Hu et al. (2005)
  o Essence of semantic space: Semantic similarity between items can be computed (numerically).
• "semantic of any item (words, phrases, etc) in a given language is embedded within its relations with other items"
Accessing ITSs in a Virtual World
Sharable Knowledge Objects (SKOs)
- A unit of knowledge (Knowledge Object)
  - implemented using an ITS
- implemented Knowledge Objects
  - as a Web service
    - allowing them to be shared with other Web applications – thus Sharable Knowledge Objects
- The 3D Virtual Environment accesses these SKOs and displays them in-world
Configure Predefined Knowledge Object in an Authoring App

Generate a unique ID for each Knowledge Object

Share SKO by sharing the ID

Access SKO via HTML Popup

SKO links embedded in Mass Casualty Persistent 3D World

Backend Analytics
- World Specific
- ATL Specific

Database of user actions

Users A,B,C Access

Authenticate Using Google App Engine

Multi User Server

Multi User Server
• SKOs are portable to new learning environments.
• SKOs are fortified by improved semantic processing algorithms to evaluate student’s natural language input.
  • Individualized domain-specific semantic processing
  • Learner’s Characteristics Curves (LCC) as student’s model that evaluates how new and relevant the student input is
• Incorporates Artificial Intelligence Markup Language (AIML) in addition to AutoTutor Dialog Advancer network (DAN) to handle Tutor-Student interaction
  • Adaptive and flexible dialog that mimics human tutoring
For this category: Patients previously labeled red with injuries incompatible with life gives the current available resources. This category is only needed if there are not enough resources available to handle demand. 

The category reserved for patients who have minor injuries that are self-limited and if not treated can tolerate delay in care without increasing their risk of mortality. These patients should be triaged as minimal. 

Patients with more than minor injuries but are able to sustain a delay in transportation. Must be re-evaluated because they are at risk of decompensating. 

Patients who: Do not obey commands, have cardio-pulmonary arrest, experiencing respiratory distress, have uncontrolled major hemorrhage, do not breathe even after lifesaving interventions.

1. gray 
2. green 
3. 
4. 
5. 

Submit
Guidance by Tutor in SKO

QUESTION TO ANSWER:
Based on what you just learned, what are the three patient categories that are used during Step 1 of executing SALT?

TUTOR INPUT RESPONSE:
Nice job!
Priority 1 patients are patients who cannot move or can barely move when given a voice command and or has an obvious life threat. You should be looking for whether or not patients are able to respond to your voice commands whether or not patients are able to walk or move and whether or not the patient has...

YOUR RESPONSE:

DIALOG HISTORY:
Priority one patients are patients who cannot give a purposeful movement and cannot walk. They have a serious life threat.

Current Progress on this Question: 43%
63%, 30%, 1%, 59%

Submit
Based on what you just learned, what are the three patient categories that are used during Step 1 of executing SALT?

TUTOR INPUT RESPONSE:
respond to your voice commands whether or not patients are able to walk or move and whether or not the patient has a serious life threat.

Answer this question for me:
Explain how patients in the priority 2 category should respond to voice commands.

YOUR RESPONSE:

DIALOG HISTORY:
Priority one patients are patients who cannot give a purposeful movement and cannot walk. They have a serious life threat.

Current Degree on this Question: 4/4

Submit

Finish
QUESTION TO ANSWER
Based on what you just learned, what are the three patient categories that are used during Step 1 of executing SALT?

TUTOR MODEL RESPONSE
Great!
Bringing everything together, Priority 2 patients are patients who are able to wave or give a purposeful movement but are unable to walk. Priority 3 patients are patients who are able to walk and respond to voice commands.

YOUR RESPONSE

DIALOG HISTORY
Priority 2 patients should be able to respond to voice commands with a purposeful movement or hand wave.

Current Progress on This Question: 75%
The question in this box is the overall question that the user is attempting to answer. The question is broad and here to guide the user’s thoughts on the topic.

An agent on the monitor displays facial expressions and some gesturing while conversing with the learner. This agent is a product of Media Semantics.

This box contains the full conversational history with the ITS. It consists of tutor conversations in RED and user contributions in BLUE.

This bar and the four percentages below it displays the user’s progress on a particular expectation.

This box is where users type their contributions. The conversation works best if complete contributions are entered.

This box contains the ITS’s responses to the users contributions. It will provide feedback to user contributions and give hints to help complete their answer.
Authoring within ITSs

Creating Sharable Knowledge Objects (SKOs)
Components of SKO scripts

- Content: Scripts guide natural language conversation between learner and SKOs
  - Expectation-Misconception Tailored Dialog.
  - Guided by established effective learning principle
• Authoring effective SKOs requires the author to use pedagogical learning strategies
  • Expert tutoring strategies
    • Scaffolding
    • Question Asking
    • Modeling

• Two main phases for authoring SKOs
  • Information Delivery
  • Assessment Creation
Presenting content to the student via animated agents
- Limiting seductive details
- Using animated agent actions to direct student attention to important graphs/images
- Scaffolding, reinforcement strategies for designing script for agent
- Using Dual Code and Multimedia effects
  - Information should be delivered via multiple modalities
- Insert brief quizzes to keep students engaged (Testing Effect)
You have just learned how to sort patients into one of three priority categories. You will now learn how to execute the second and third steps of SALT, the assessment and life-saving interventions steps.
• Several assessment types
  • multiple choice
  • fill in the blank
  • matching
  • essay
  • self-reflection

• Important to choose the right assessment type for the material being taught
  • Multiple Choice, fill in the blank and matching are effective with shallow level knowledge
  • Essay, Self-reflection are effective with deep level knowledge
Doing a Reflection quiz

Reflection Question Title: Contraindications

Spoken Text for Avatar:

Now, let's review the content we just covered. Please do your best to recall the relative contraindications I told you about. Be sure to complete each of your responses with a period.

Reflection Answer (100 words or less):

pneumothorax. severe anemia. sickle cell. acute blood loss. tracheostomy.
<table>
<thead>
<tr>
<th>Turn</th>
<th>Type</th>
<th>Relation</th>
<th>[0, 1]</th>
<th>Feedback from Avatar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CS</td>
<td>near</td>
<td>0.9</td>
<td>Very good! Please move on to the next contraindications.</td>
</tr>
<tr>
<td>1</td>
<td>CS</td>
<td>near</td>
<td>0.5</td>
<td>Great!</td>
</tr>
<tr>
<td>1</td>
<td>CS</td>
<td>near</td>
<td>0.2</td>
<td>Doing well so far!</td>
</tr>
<tr>
<td>2</td>
<td>IN</td>
<td>near</td>
<td>0.3</td>
<td>Sorry, that is not correct.</td>
</tr>
<tr>
<td>2</td>
<td>CS</td>
<td>near</td>
<td>0.5</td>
<td>Great!</td>
</tr>
<tr>
<td>2</td>
<td>C3</td>
<td>near</td>
<td>0.9</td>
<td>Very good! Please move on to the next contraindications.</td>
</tr>
<tr>
<td>2</td>
<td>IO</td>
<td>near</td>
<td>0.5</td>
<td>You might be repeating something wrong!</td>
</tr>
<tr>
<td>2</td>
<td>RN</td>
<td>less than</td>
<td>0.8</td>
<td>Great Job! You're on the right track!</td>
</tr>
<tr>
<td>3</td>
<td>RN</td>
<td>less than</td>
<td>0.8</td>
<td>You're on the right track! Keep it up!</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>near</td>
<td>0.6</td>
<td>Doing well so far!</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>near</td>
<td>0.9</td>
<td>Very good! Please move on to the next contraindications.</td>
</tr>
</tbody>
</table>
Try to recall as many contraindications to Air Transport as you can.
<table>
<thead>
<tr>
<th>Expectation</th>
<th>Hint1</th>
<th>Hint2</th>
<th>Hint3</th>
<th>Hint4</th>
<th>Ideal Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary for expectation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Which contraindications to Air Transport have to do with the patient's equipment, or the equipment the patient requires?</td>
</tr>
<tr>
<td>Number of words: 17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Semantic Answer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pneumothorax, tracheostomy, pacemaker, jaw immobilization, circumferential casts.</td>
</tr>
<tr>
<td>Number of words: 7</td>
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<td></td>
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</table>
Many of the contraindications to Air Transport that have to do with patient equipment have to do with the increased air pressure during flight.
Early Evaluation Results

... evaluation studies will be conducted in April 2014


Intelligent Tutoring in Virtual Worlds

• The goal
  – build a bridge between medical and first responder personnel

• Live simulation training very effective
  – but expensive and logistically complex

• Virtual environment used to create the training environment and scenarios

• Intelligent tutoring added to replace the loss of face-to-face training

• System will be evaluated in April to assess efficacy of VW and ITS
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Web site:

http://www.clinispace.com
http://clinispace.com/products/mass_casualty.html