Summary of my ongoing research in Educational Technology

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Area: Computer based training for spatial skills

- PhD Student: Kapil Kadam (ET, July 2010+)
- Research Question: Does the use of computer based 3-D modeling tools (such as Blender) help to improve Spatial Visualization skills?
- Solution Approach:
  1. Pick a Spatial Visualization skill – Mental Rotation (MR) ability.
  2. Show that improving MR ability is desirable; from literature.
  3. Design a Blender training module specifically targeted towards improving MR ability of 1st year Engg. students; using ID principles.
  4. Show that the module could cause improvement; using arguments.
  5. Do quantitative experiments to determine its efficacy and causality; using standardized MR tests.
  6. Repeat steps 1-5 for other student groups, other spatial skills.

Area: Scaffolding for vernacular learners for programming skills

- PhD Student: Yogendra Pal (ET, July 2010+)
- Research Question: What scaffolding should be provided to non-English medium students who are learning programming concepts and skills?
- Solution Approach:
  1. Pick a topic from an established programming curriculum – Recursion.
  2. Pick a scaffolding strategies that could be suitable for Hindi medium students learning recursion; using scaffolding theory.
  3. Design various C++/Java programming training modules for Hindi medium students in 1st year Engg.; using ID principles.
  4. Do quantitative experiments to determine its efficacy; using a concept inventory for programming tests.
  5. Repeat steps 2-4 for other scaffolding strategies and treatment modes.
  6. Repeat steps 1-5 for other topics in Programming.

Area: Evaluating question repositories for similarity and fairness

- PhD Student: Rekha Ramesh (ET, Jan 2012); Co-guide: Dr. Sasikumar (CDAC)
- Research Question: How can we identify if one exam question is 'similar' to another? Can we automate the process of determining similarity?
- Solution Approach:
  1. Pick a course – data structures.
  2. Pick questions papers from various established sources and manually determine the similarity between various questions; by expert rating.
  3. Design a program to automatically determine similarity; using domain ontologies, cognitive levels; content types.
  4. Do quantitative experiments to determine the efficacy of the program; using confusion matrix.
  5. Repeat steps 1-4 for other courses; check for robustness.
  6. Repeat steps 1-5 for other parameters, such as evaluating 'fairness' of a question paper wrt syllabus and learning objectives of a course.

Area: Methodology for generating counter-examples for Algorithms

- PhD Student: M Jagadish (CSE, July 2010+)
- Research Question: How to effectively teach the skill of generating counter-examples to greedy algorithms?
- Solution Approach:
  1. Pick an area – Graph theory.
  2. Show that generating counter-examples to greedy algorithms in this area is a desirable and non-trivial skill; from literature.
  3. Design a method for generating counter-examples; using extremality.
  4. Show that the method is applicable to a sufficiently large set of problems and hence it is worth teaching; using enumeration.
  5. Do experiments to determine how well can students learn and apply the method, in-classroom; using qualitative and quantitative methods.
  6. Repeat steps 5 for other treatment modes, such as online.

Area: Student models for adaptive tutoring systems

- PhD Student: R Ramkumar (IITB-Monash, Jan 2010+); Co-guide: Prof. Sahana Murthy
- Research Question: How do we determine the affective state of a student from the performance log data in an ITS (Intelligent Tutoring System)?
- Solution Approach:
  1. Pick an affective state – Frustration, and an ITS – Mindspark.
  2. Operationalize the definition of Frustration for Mindspark; using theory from psychology literature.
  3. Build a student model and verify it; using observations and data mining.
  4. Modify Mindspark (perform Adaptation) to mitigate Frustration; using theory from psychology literature.
  5. Do experiments to determine the efficacy of the adaptation; using observations.
  6. Repeat steps 1-5 for other affective states, such as Boredom.

Area: Designing educational visualizations

- PhD Student: Sameer Sahasrabudhe (YCMOU, July 2009+); Co-guide: Prof. Sahana Murthy
- Research Question: How to incorporate principles from graphics design, animation design, interaction design and multimedia design, while creating the storyboard for an educational visualization?
- Solution Approach:
  1. Show that there is a need for creating a template that can ensure a systematic application of 'good' design principles; using literature.
  2. Operationalize principles from the above domains in the context of an interactive learning object (LO); using theory and arguments.
  3. Design a template to be followed by ID writers for storyboarding of LOs; using ID principles.
  4. Iterate till the template is usable for ID writers and animators; using DBR.
  5. Create LOs and do usability experiments with students to determine the efficacy of the LO creation process; using system usability scale.

Area: Framework for building an ITS

- MTech [2011-2012]: Vikash Kumar, M Rajashekhar, Chandra Pal, Praveen Dhanala
- Goal: Development of a system (back-end and front-end) which:
  - Enables an Instructor to create modules based on various teaching-learning strategies, for a given subject.
  - Implements the adaptation logic for each strategy.
  - Performs student modeling.
  - Behaves as an ITS when interacting with a Student.
- Teaching-learning strategies supported:
  - Socratic questioning
  - Guided discovery
  - Scaffolding
  - Game-based learning
- Subjects supported: Programming (prototype stage).

Graduated Students

- MTech [2010-2011]:
  - Neelamadhav Gantayat - Automated construction of domain ontologies from lecture notes
  - K Vijaya Kumar - Automated tagging to enable fine-grained browsing of lecture videos
  - Souman Mandal - Problem-based-learning tool as a plugin for Moodle
  - Jayanth Tadinada - Interactive tutoring system for high-school geometry
- MTech [2009-2010]:
  - Ganesh Narayana Murthy - Adaptation of CDEEP lecture videos to mobiles
  - J Manoj - System for transmitting CDEEP videos over low bandwidth networks
  - Mohammed Nazeem - Unicast-Multicast gateway for tunneling lectures from any CDEEP studio to VSAT network
  - Harshad Inarkar - Application layer multicast for reducing load on CDEEP VOD server
  - Rohit Gujrati - Modeling the CDEEP system using system dynamics

- **See www.cse.iitb.ac.in/~sri/students for abstract and thesis details.**