Course Syllabus – IDS 6938: Intelligent Tutoring System (ITS) Design

Mondays, 6pm – 8:50pm

Fall 2016

Instructor: Dr. Robert Sottilare, bob.sottilare@knights.ucf.edu

Credit Hours: 3

Course Location: Mixed Mode - online and at TBD physical location

Office Hours: By Appointment

Course Description: Intelligent Tutoring System (ITS) Design

ITSs are artificially-intelligent systems that interact with the learner and the instructional environment to provide optimal learning experiences through real-time feedback and selection of problems/scenarios to match the learning capabilities of the individual or team under instruction. ITSs may be used standalone, integrated with existing training systems or be incorporated into traditional classroom settings.

This course is intended to support graduate students in a variety of technical disciplines including, but not limited to computer engineers & scientists, modelers, simulationists, psychologists (human factors, cognitive, perceptual), instructional designers, educational technologists, and those interested in training and learning science.

The projects associated with this course are multi-disciplinary and the tools used to author and conduct evaluations can be learned quickly by non-computer scientists.

Course Learning Objectives:

- This course will provide the theoretical basis to design effective adaptive instructional elements (programs, courses, lessons, concepts)
- This course will provide hands-on opportunities to build skills required to:
  - design and author adaptive instructional elements (courses, lessons, concepts) resulting in deployable ITSs which can be used standalone or with a human instructor in the loop
  - analyze learner data and classify/predict learner states (e.g., emotions or performance)
  - evaluate the effectiveness of ITSs and their component technologies (tools and methods)

Required Text: Building Intelligent Interactive Tutors: Student-centered strategies for revolutionizing e-learning by Beverly Park Woolf; published by Morgan Kaufmann.

Reference Texts: Design Recommendations for Intelligent Tutoring Systems series (available as free pdfs or downloadable e-books on GooglePlay)

- Volume 1: Learner Modeling edited by Sottilare, Graesser, Hu, and Holden
- Volume 2: Instructional Management edited by Sottilare, Graesser, Hu, and Goldberg
• **Volume 3: Authoring Tools** edited by Sottilare, Graesser, Hu, and Brawner
• **Volume 4: Domain Modeling** edited by Sottilare, Graesser, Hu, Olney, Nye, and Sinatra

**Week 1 Topics – Introduction (Monday, 22 August; 6pm – 7:50pm)**

- Review of Syllabus including Group Projects and Reports
- Project primer: research ethics
- Introduction to Intelligent Tutoring Systems (ITSs)
  - Elements of Intelligent Tutoring Systems
  - Human vs. Machine-based Tutoring
  - Intelligent Tutoring Genres (e.g., cognitive, dialogue-based, model-tracing, shell)
- **Homework Assignment #1 (40 points):** ITS Design is an interdisciplinary science. My goal is to help you meet your goals. Email me a short description of your experiences, strengths, and areas for development related to the topics in this course along with your goals (what you expect to get out of this course) and your primary technical discipline.
  - Due date – prior to start of next class, 29 August.

**Week 2 Topics – GIFT, LEM, and Project Discussion (Monday, 29 August; 6pm – 8:50pm)**

- **Homework Assignment #1 due prior to class.**
- Introduction to the Generalized Intelligent Framework for Tutoring (GIFT) & the Learning Effect Model (LEM) for Tutoring
- Project Discussion
  - Topics, Goals and Team Formation for Group Projects
  - Project primer: how to ask good research questions
  - Project primer: how to conduct effect size studies
- **Homework Assignment #2 (40 points):** Learner Modeling: ITSs are adaptive in that they tailor instruction based on the learning needs of the student. Identify three student attributes that might be important in driving instructional decisions by ITSs and email me a short description of why each is important along with one citation in the literature to back up each of your claims. Short paper = 200-300 words.
  - Due date – start of class, 12 September.

**Week 3 Topics – Labor Day Holiday (Monday, 5 September; no class)**

**Week 4 Topics – Machine Learning (part 1 - Monday, 12 September; 6pm – 8:50pm)**

- **Homework Assignment #2 due prior to class.**
- Machine Learning and Intelligent Tutoring Systems (Part 1)
  - Automatically build/expand learner and domain models
  - Identify learner strategies
  - Classify or predict learner states (e.g., performance, learning, affect)
  - Select optimal instructional decisions
• Uncertainty in ITSs
• Machine Learning Techniques
  ▪ Bayesian Networks
  ▪ Reinforcement Learning
  ▪ Markov Models and Decision Processes
• **Selected Reading Discussion** – be prepared to discuss: – be prepared to discuss the advantages/disadvantages of various tutors that use machine learning methods. Reference: 7.5 “Examples of Intelligent Tutors that Employ Machine Learning Techniques” in Woolf, pages 281-297.
• Project Discussion – expectations for the Project Proposal Presentations next week.

**Week 5 Topics –** Project Proposal Presentations due (Monday, 19 September; 6pm – 7:50pm)

**Week 6 Topics -** Machine Learning (part 2 - Monday, 26 September; 6pm – 8:50pm)

• Machine Learning and Intelligent Tutoring Systems (Part 2)
  ▪ Reasoning about learner knowledge
  ▪ Evaluating reinforcement learning tutors
• Project Discussion
  ▪ Project primer: demonstration of the Waikato Environment for Knowledge Analysis (WEKA) tools for learner state classification
• **Homework Assignment #3 (40 points):** Building a classifier - Using WEKA, SPSS, or another data analysis tool, analyze the primate dataset provided and develop a classifier that uses the fewest attributes to identify whether a particular animal belongs to any of three classes (prosimians, monkeys, or apes). Short answer = tool and method used for classification and rationale for selection of primate attributes.
  ▪ Due prior to next class, 3 October
• **Selected Reading Discussion** – be prepared to discuss the design tradeoffs of various ITS authoring tools. Reference: 10.3 “Where Are All the Intelligent Tutors” in Woolf, pages 394-401.

**Week 7 Topics –** Individual Learner Modeling (Monday, 3 October; 6pm – 8:50pm)

• **Homework Assignment #3 due prior to class.**
• Learner Modeling and the LEM
  ▪ Representing Learner Knowledge, Traits, and States
  ▪ Representing Misconceptions in Learner Models
  ▪ Real-Time Learner Modeling
    ▪ Methods for acquisition of learner data
    ▪ Methods for classification of learner states
    ▪ Resources for classification algorithms
  ▪ Long-term Learner Modeling
    ▪ Learning Records Stores (LRSs)
    ▪ Learning Management Systems (LMSs)
  ▪ Learner Modeling in GIFT
    ▪ Standard vs. Non-Standard Elements
• Homework Assignment #4 (40 points): Eliciting learner data - You are an intelligent tutoring system and we know from our study of the learning effect model that you need to know critical information about the learner to adapt instruction. If you adapt your instruction based on the learner’s interests, their prior knowledge, and grit, what will you ask the learner to assess those attributes. Craft 5 or fewer questions to elicit the needed information from the learner. Short answer = 5 questions and rationale for selection.
  ▪ Due date – start of class, 10 October.

Week 8 Topics – Instructional Models for ITSs (Monday, 10 October; 6pm – 8:50pm)
• Homework Assignment #4 due prior to class.
• Instructional Models (pedagogy and andragogy)
• Instructional Best Practices
  ▪ Modeling Behaviors of Human Tutors
  ▪ Instructional Models informed by Learning Theory
    ▪ Socratic, cognitive, constructivist, situated learning, social interaction
    ▪ Open Learner Models (metacognitive processes in instruction)
  ▪ Instructional Models facilitated by Technology
    ▪ Rule-based
    ▪ Decision Trees
    ▪ Agent-based (virtual humans, emotive agents, probabilistic agents)
      ▪ Dialogues (learner and virtual instructor)
      ▪ Trialogues (learner, virtual instructor, virtual student)
    ▪ Multi-Agent Architectures for ITSs
• Selected Reading Discussion – be prepared to discuss the advantages/disadvantages of various instructional models based on human tutoring methods. Reference: 4.2 “Teaching Models based on Human Teaching” in Woolf, pages 99-105.

Week 9 Topics – Domain Modeling & Assessments (Monday, 17 October; 6pm – 8:50pm)
• Dimensions of Domain Models: complexity, definition, and alignment
  ▪ Complex processes
  ▪ Well defined and ill defined tasks
  ▪ Alignment of Behaviors in Tutoring and Work Environments
• Representing cognitive domains (e.g., problem solving, decision-making, optimization)
• Representing affective domains (e.g., value judgments)
• Representing psychomotor domains (e.g., individual sports, physical tasks)
• Representing social domains (e.g., team sports, collaborative tasks)
• Assessments: Formative, Interim, and Summative Assessments
• Project Discussion
  ▪ Project primer: how to author effective assessments
• Selected Reading Discussion – be prepared to discuss the principles and methods for evaluating ITSs. Reference: 6.1 “Principles of Intelligent Tutor Evaluation” in Woolf, pages 183-200.

Week 10 Topics – Authoring ITSs (Monday, 24 October; 6pm – 8:50pm)
• Elements of ITS Authoring
  ▪ Learner Model Configurations
- Domain Model Configurations
  - Defining Course Flow
  - Defining Course Learning Objectives or Concepts
  - Authoring Surveys, Checks on Learning and Assessments (Tests)
- Usability Heuristics for ITS Authoring Systems
- Project Discussion
  - Project primer: GIFT Authoring Tools
- Homework Assignment #5 (40 points): User Experiences (UXs) - The ability to tailor interfaces to support user roles and tasks play a large part in the success of user experiences (UXs). Identify a product, perhaps one that you use regularly, and identify the strengths and weaknesses of the interface design with respect to Nielsen’s (1992) Usability Heuristics. Short paper = 250-500 words.
  - Due prior to next class, 7 November

Week 11 Topics – Project Workday (Monday, 31 October; no class)
- Individuals/groups work independently on project presentations and reports

Week 12 Topics – Team Tutoring and Educational Data Mining (Monday, 7 November; 6pm – 8:50pm)
- Homework Assignment #5 due prior to class.
- Project Discussion
  - Project primer: Conducting a meta-analysis
- Team Tutoring Meta-Analysis
  - The Seven C’s – Communication, Cooperation, Coaching, Cognition, Conflict, and Conditions
  - Team Performance, Learning, Satisfaction and Viability
- Modeling Teams
  - Representing Team Roles and Behaviors
  - Representing Team Tasks
- Big Data Analysis Methods
  - Comparing and contrasting ITS technologies (tools and methods)
  - Comparing one learner to other learners
  - Comparing groups of learners
  - Comparing instructional methods
  - Understanding population norms
- Project Discussion
  - Project primer: Demonstrations of Big Data Analysis Tools: SPSS, Excel, AMOS and RapidMiner

Week 13 Topics – Project Workday (Monday, 14 November; 6pm – 8:50pm)
- Individuals/groups work independently on project presentations and reports
Week 14 Topics – Project Presentations and Reports due (Monday, 21 November; 6pm – 7:50pm)

Week 15 Topics – Project Demonstrations due (Monday, 28 November; 6pm – 7:50pm)

Grading Rubric:
The following weighting will be applied to homework and project assignments as follows:

- Homework Assignments (5 assignments X 40 points each = 200 points = 20% of your grade)
- Group Project Proposal Presentation (1 presentation X 100 points = 100 points = 10% of your grade)
- Group/Individual Project Presentation (1 presentation X 200 points = 20% of your grade)
- Group/Individual Project Report (1 report X 400 points = 40% of your grade)
- Group/Individual Project Demonstration (1 group demonstration X 100 points = 10% of your grade)
- Total Possible Points = 1000 points

Letter Grades:
Based on the total from each of the assignments in the Grading Rubric above, letter grades will be assigned as follows:

- A = 90 – 100% (900 – 1000 points)
- B = 80 – 89.9% (800 - 899 points)
- C = 70 – 79.9% (700 - 799 points)
- D = 60 – 69.9% (600 - 699 points)
- F = 0 – 59.9% (0 - 599 points)