**Project Title:** Fostering conceptual understanding and skill with an intelligent tutoring system

**Project Web Page:** https://tzlandrew.github.io/

**Project Description:**

The research will be conducted with graduate student Kenneth Holstein and his advisor Prof. Vincent Aleven. The research will involve finding ways to increase the amount and quality of feedback given to teachers to aid them when teaching their students concepts, in this case for single-variable equation-solving.

Past research conducted by Holstein and Aleven has resulted in the creation of Lynette, the problem solving interface that students use to try and solve single variable equations, and Lumilo, a Google Glass application for the teacher that receives the data collected and analyzed by Lynette and displays it to quickly give the teacher a better understanding of who is struggling, and on what concepts.

This framework uses a knowledge-component based mastery system, continuously sending students questions on topics which they have not yet mastered until they get the questions correct enough times to declare a topic mastered. When queried about a specific student, the framework displays both the current question the student is working on, and the most recent mistake made in the concept in which they do the worst.

This project will seek to improve upon that framework to increase the amount and quality of data given to the teacher which which to make inferences about student learning. For any given knowledge component, or skill, there are several different levels of granularity involved, depending on how well the students are able to abstract the concept. As an example: in regards to subtracting a term from both sides to maintain equality, and cancel out a term on one side, students may have trouble distinguishing between variables and constants, being perfectly fine with constants, but having trouble with variables, or vice versa. They could have mastered adding both variables and constants, but only when they are non-negative, or only when the term being cancelled out is on the right side of the equation and not the left, and any permutation of the above and more.

In dynamically analyzing past student performance, this project aims to detect the proper level of granularity of the student's current understanding, and reflect this in their output display to the teacher when queried. Additionally, the project aims to provide the much-requested class overview details screen, which will have information on which subsets of students are struggling with a particular skill, what skill that is, and at what granularity the issue resides in, allowing the teacher to better coordinate group learning. Naturally, to be able to collect and display this information, it depends almost wholly on the skill granularity component. In addition, records kept of past student performance will further enhance this feedback by allowing the instructor to determine which student(s) had issues with a particular issue, and then managed to overcome it, further allowing them to facilitate group learning, and freeing the teacher for other tasks.

**Project Goals (75%, 100%, 125%):**

- 75%: Dynamically scale student learning model granularity when analyzing data to determine which to display to the teacher regarding student conceptual errors
- 100%: Efficiently determine which subsets of my students are struggling with similar issues (and what exactly are those issues?)
- 125%: Given an example of a specific error a student made, determine what other students in the class are struggling with the same issues (i.e., making "similar" kinds of errors), and what other student in the class were struggling with the same or similar issues earlier, but have since overcome the issues?

**15-300 Milestone:**

By the end of 15-300, I expect to have read through all relevant background reading, as listed in the Literature Search section of this proposal, met with Prof. Aleven and Kenneth Holstein multiple times, and familiarized myself with the software and hardware that will be used in

**Bi-weekly Milestones for 15-400**:

- February 1st: Analyze data
- February 15th: Develop features
- March 1st: Integrate features into UI
- March 22nd: Send to teachers for testing
- April 5th: Analyze data
- April 19th: Integrate tweaked/updated features into UI
- May 3nd: Send to teachers for testing

**Literature Search:**

- iBCM: Interactive Bayesian Case Model Empowering Humans via Intuitive Interaction
- Student Learning Benefits of a Mixed-reality Teacher Awareness Tool in AI-enhanced Classrooms
- Intelligent Tutors as Teachers' Aides: Exploring Teacher Needs for Real-time Analytics in Blended Classrooms
- What Exactly Do Students Learn When They Practice Equation Solving? Refining Knowledge Components with the Additive Factors Model
- OverCode: Visualizing Variation in Student Solutions to Programming Problems at Scale

**Resources Needed:**

- Access to the distributed software
- Access to a Google Glass to test the distributed software
- Access to teachers and classrooms to test system effectiveness in use