Enhancing Scientific Argumentation with Automated Feedback in the Context of Two Earth Science Curriculum Units

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**Study 1. There are differences between the contextualized and generic HASbot feedback.**
- Classrooms were randomly assigned to two groups: 168 students (42%) received the generic HASbot and 230 students (58%) received the contextualized HASbot.
- Students in the generic HASbot condition made more revisions (M = 21.70, SD = 20.42) compared to the contextualized HASbot condition (M = 17.70, SD = 16.01).
- More revisions under the generic HASbot feedback condition achieved similar score changes with fewer revisions under the contextualized feedback condition.

**The amount of time students spend writing their initial argument increase over the course of the module.**
- Log data tracks all online activity by students and is automatically collected by servers.
- Over the course of the module, the time spent responding to argument prompts increased.
- Over time, students spent less time on revisions of their arguments.

**Year 1:** Validate automated scoring models for uncertainty-infused scientific argumentation tasks in Climate Change Module (Mao et al., 2018).
**Year 2:** Validate automated scoring models for uncertainty-infused scientific argumentation tasks in the Water Module; conduct a small scale implementation study of automated feedback with Climate Change Module (Zhu et al., 2017).
**Year 3:** Compare the effect of contextualized vs. generic feedback using within-teacher, class-level random assignment (Study 1 & Study 2); conduct an implementation study of automated, contextualized feedback with Water Module (Study 3).

**Year 4:** Ongoing: Conduct a large-scale implementation study on contextualized feedback and model feedback in Water Module.

**Two Earth Science Curriculum Modules with Automated Feedback (HASbot) on Written Argumentation**

We have added automated feedback to two curriculum modules that enable students in grades 6–12 to explore important and timely questions about our planet: “Will there be enough fresh water?” and “What is the future of Earth’s climate?” in each module, students encounter eight scientific argumentation tasks. Each argumentation task is designed as a four part item set, including: 1) a multiple-choice claim, 2) an open-ended explanation, 3) a certainty rating on a five-point Likert scale (from very uncertain to very certain), and 4) an open-ended rationale for the certainty rating. The modules allow students to run experiments and collect data using interactive simulations. Students are asked to write scientific arguments supported by both the data they have generated and authentic datasets provided. Students’ scientific arguments are scored in real-time using a rating scale. Based on their score, students are provided instant feedback on how to revise and improve their written responses. In the Water Module, additional scaffolding is presented via model-based feedback. Use of the models is analyzed with a new decision-tree algorithm and immediate, targeted feedback directs students to specific features in the model that they should explore or to actions necessary to generate meaningful data.

**Broader Impact**

Since the project was awarded in Fall of 2014, the project has achieved:
- Benefits for 1187 students and 14 teachers
- Two publications in journals:
- Four peer-reviewed publications in conference proceedings:
  - 2 Computer-Supported Collaborative Learning conference (CSSL) 2019
  - 1 IEEE Integrated STEM Education Conference (ISEC)
  - 1 IEEE International Conference on Data Mining (ICDM)

**Two Conference presentations:**
- 2 American Educational Research Association (AERA)
- 1 National Association for Research in Science Teaching (NARST)
- 2 National Council on Measurement in Education (NCME)
- 4 National Educational Association Research Association (NERA)
- 1 Society for Text & Discourse

Three papers are currently in progress for journal submission.