Making Mathematical Reasoning Fun: Web-Integrated, Collaborative, and “Hands-On” Techniques

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ABSTRACT
Is it possible to excite students about learning the mathematical principles that underlie high-quality software? Can they use a development environment for “hands-on” experimentation with reasoning? Is this possible without displacing existing content? The answer is a resounding yes—from the experiences of professors at several institutions—but it takes the right set of pedagogical principles, reasoning tools, and “hands-on” exercises. This workshop will help educators transfer the excitement of learning how to apply mathematical reasoning in building high quality software, by adopting one reasoning concept at a time.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education—Computer science education, Curriculum

General Terms
Documentation, Reliability, Verification

Keywords
Mathematical reasoning, formal methods, collaborative learning, teaching tools

1. INTENDED AUDIENCE
The workshop will introduce a series of independent content modules that can be introduced in any course where mathematical reasoning might be taught—from introductory programming and software engineering to data structures and algorithms. They are designed to supplement, rather than replace, existing course materials.

2. PRESENTER BIOGRAPHIES
Drs. Hallstrom, Hollingsworth, Krone, and Sitaraman are PIs on an NSF-sponsored CCLI Phase II project that informs the content of the proposed workshop. The project is titled “Hands-On Collaborative Reasoning across the Curriculum” (DUE-1022941).

Jason O. Hallstrom. Dr. Hallstrom is an Associate Professor in the School of Computing at Clemson University. His research lies at the intersection of domain-specific software engineering and embedded network systems. He received an NSF CAREER award in 2008 to pursue this work, including an associated curriculum integration component. He also served as PI on an NSF CCLI Phase-I project, focused on methods and tools for teaching mathematical reasoning.

Joe Hollingsworth. Dr. Hollingsworth is a Professor in the Department of Computer Science at Indiana University Southeast. His research is focused on software component specifications and modular verification. He is also active in the scholarship of teaching computer science, where his expertise includes active-learning techniques for teaching algorithms and data structures, distance education methods, and engineering and evaluation of software components in commercial languages. He has served as an evaluation specialist on multiple NSF-funded projects.

Joan Krone. Dr. Krone is a Professor in the Department of Mathematics and Computer Science at Denison University, where she holds the Benjamin Barney Chair. Her research is focused on formal specification and reasoning and non-standard logics. Dr. Krone previously served as PI on an NSF project to establish industry partnerships that enable students to apply formal methods to real software projects. She was also site host for the 2003 Consortium for Computer Sciences in Colleges and the 2010 RESOLVE Workshop, both which focused on computer science education.

Murali Sitaraman. Dr. Sitaraman is a Professor in the School of Computing at Clemson University. His research is focused on component-based software engineering, with an emphasis on mathematical reasoning and program verification. He has a distinguished history of integrating research results into the classroom and has served as PI or Co-PI on multiple education projects funded by the NSF and the Department of Education. He currently serves as PI on an NSF CCLI Phase-II project, focused on integrating mathematical reasoning in the undergraduate curriculum.
3. MATERIALS PROVIDED

Workshop participants will receive paper and electronic copies of all lecture materials, exercises, suggested evaluation instruments, as well as information on online tutorials. Participants will also be provided with paper and electronic copies of background material on the reasoning concepts and notations surveyed, as well as recent publications detailing the teaching approach and pilot results (SIGCSE'09, ITiCSE'09, ITiCSE'12). Finally, participants will receive “Quick Start” instructions for using the web-integrated reasoning environment. Use of the environment in classrooms requires no installation by participants.

4. ROUGH AGENDA

- Workshop welcome and overview
- Introduction to mathematical reasoning
- Teaching mathematical specifications
  Test Case Reasoning Assistant
- Client-side collaborative reasoning
  Web-Integrated Reasoning Environment
- Implementer-side collaborative reasoning
  Web-Integrated Team Development Environment
- Evaluation objectives, learning outcome analysis, and instruments
- Open discussion

5. LAPTOP REQUIREMENTS

All participants are required to bring a laptop to participate in the computer-assisted exercises. The latest release of the Java Runtime Environment (version 1.5.x or greater) must be installed prior to arrival.

6. OTHER INFORMATION

The workshop materials and tools have been evaluated in several course pilots over the past five years at Clemson, Denison, and a dozen other institutions in multiple CS courses. Some details regarding the results of these pilots are presented in manuscripts published at SIGCSE'09, ITiCSE'09, and ITiCSE'12. Versions of the workshop have been presented at educator workshops at Clemson and Denison in 2009, 2011, as well as the 2012 ACM Southeast Regional Conference, the 2011 Midwest Conference, SIGCSE'11, and SIGCSE'12. The growing number of adoptees (six new ones just this year) is a testament to the importance of the workshop’s goals. Based on the success of the previous offerings in attracting educators from a diverse set of institutions, we intend to repeat the ACMSE'12 workshop, with appropriate updates to the material. This will result in a continuously improving workshop program that provides a smooth and productive experience for participants.