The TRIUMPHS Project: Opportunities for History, Research, and Change in Undergraduate Mathematics Classrooms

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(Florida State University)
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Presentation Overview

Introduction to the TRIUMPHS Project

Overview of the Project Activities

Examples of Primary Source Projects

Evaluation with Research (EwR) Components

Additional Information & Resources
TRIUMPHS Project

TRIUMPHS: TRansforming Instruction in Undergraduate Mathematics via Primary Historical Sources

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- Kathleen M Clark, Florida State University
- Dominic Klyve, Central Washington University
- Jerry M Lodder, New Mexico State University
- Daniel Otero, Xavier University
- Nicholas A Scoville, Ursinus College
- Diana White, University of Colorado Denver
TRIUMPHS Project

- Funded by the National Science Foundation
- “Collaborative research project”
- Five-year, $1.5 million, 7 institution effort in the United States
- Began 1 August 2015
- Project website: http://webpages.ursinus.edu/nscoville/TRIUMPHS.html
Photos from September workshop in Denver now online!

Collaborative Research: Transforming Instruction in Undergraduate Mathematics via Primary Historical Sources (TRIUMPHS)

Mathematics faculty members and educational researchers are increasingly recognizing the value of the history of mathematics as a support to student learning. This collaborative project, involving seven diverse institutions of higher education, will help students learn and develop a deeper interest in, and appreciation and understanding of, fundamental mathematical concepts and ideas by utilizing primary sources - original historical writings by mathematicians on topics in mathematics. Educational materials for students will be developed at all levels of undergraduate mathematics courses, and will be designed to capture the spark of discovery and to motivate subsequent lines of inquiry. In particular, the student projects to be developed will be built around primary source material to guide students, including pre-service teachers, mathematics majors, and other STEM discipline majors, to explore the mathematics of the original discovery in order to develop their own understanding of that discovery. Mathematics faculty and graduate students from over forty (40) institutions will participate in the development and testing process, thereby ensuring a large national network of faculty with expertise on the use of these educational materials. The impacts of the materials and approaches to implementing them will be investigated in terms of teaching, student learning, and departmental and institutional change.

Sponsor

This material is based upon work supported in part by the National Science Foundation under Grants No. 1523494, 1523561, 1523747, 1523753, 1523898, 1524065, and 1524098. Disclaimer: Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
TRIUMPHS Information

→ Project website with projects ready for use;

Site tester information;

Additional resources.
TRIUMPHS Project: Aims, Topics, & Materials

• **Aim:** to **develop**, **test/implement**, and **evaluate** classroom materials based on primary sources ("Primary Source Projects"; PSPs) for teaching undergraduate mathematics courses
  - Plan to create 20 full-length PSPs and 30 "mini" PSPs over the course of grant project

• **Topics addressed by the PSPs range from** **pre-calculus** and **elementary statistics** to **abstract algebra, analysis, and topology**
Aims, Topics, & Materials…

- The materials allow instructors to replace standard classroom lectures with PSPs that directly engage students with the mathematics they are studying.

- Students read source texts, and through a series of exercises that are woven throughout the project, develop a fuller understanding of the mathematics they are studying.
<table>
<thead>
<tr>
<th>Full-Length PSPs</th>
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<tbody>
<tr>
<td>Understanding the Trigonometric Functions</td>
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<tr>
<td>Investigating Difference Equations</td>
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<tr>
<td><strong>Pythagorean Theorem and Exigency of Parallel Postulate</strong></td>
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<tr>
<td>Failure of the Parallel Postulate</td>
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<tr>
<td>Dedekind and the Creation of Ideals</td>
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<tr>
<td>Primes, Divisibility &amp; Factoring</td>
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<tr>
<td>Bolzano's Definition of Continuity, his Bounded Set Theorem, and an Application to Continuous Functions</td>
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<tr>
<td>Rigorous Debates over Debatable Rigor in Analysis (Monster Functions!)</td>
</tr>
<tr>
<td>Construction of Figurate Numbers</td>
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<tr>
<td>Investigations Into d’Alembert’s Definition of Limit</td>
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<tr>
<td>An Introduction to a Rigorous Definition of Derivative</td>
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<tr>
<td>Investigations Into Bolzano’s Formulation of the Least Upper Bound Property</td>
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<tr>
<td>The Mean Value Theorem</td>
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<td>Abel and Cauchy on a Rigorous Approach to Infinite Series</td>
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<tr>
<td>The Definite Integrals of Cauchy and Riemann</td>
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<tr>
<td>Mini-PSPs</td>
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<tr>
<td>Babylonian Numeration</td>
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<td><strong>Why be so critical? Origins of Analysis</strong></td>
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<td>Topology from Analysis: Making the Connection</td>
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<td>Connecting connectedness</td>
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<td>The Cantor set before Cantor</td>
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<tr>
<td>Henri Lebesgue and the Integral Concept</td>
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<td>Euler’s Rediscovery of $e$</td>
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Project Depository

MATHEMATICS AND COMPUTER SCIENCE FACULTY
RESEARCH PROJECTS

Department Chair: April Kontostathis

Browse the Mathematics and Computer Science Faculty Research Projects Collections:
Transforming Instruction in Undergraduate Mathematics via Primary Historical Sources (TRIUMPHS)

- Abstract Algebra
- Analysis
- Calculus
- Complex Numbers
- Differential Equations
- Discrete Mathematics
- Geometry
- Linear Algebra
- Number Theory
- Pre-calculus and Trigonometry
- Statistics and Probability
- Topology
TRIUMPHS: Overall Plan

• Develop and rigorously test classroom materials to teach standard topics in the university undergraduate mathematics curriculum through primary historical sources,

• Train faculty to implement them, to promote their use as widely as possible through widespread dissemination via conference talks and training workshops, and

• Study diverse aspects of their implementation and efficacy.
The Evaluation with Research (EwR) Component will provide formative and summative evaluation for TRIUMPHS to aid in the understanding of:

* How student **mathematical world views** evolve;

* How / in what ways do individual PSPs may **promote student learning of the meta-discursive rules** that govern mathematical practice; and

* How to **support faculty in developing expertise implementing** this instructional approach
Sample Research Questions

“Student Change” Piece

• RQ1a: In what ways does the use of PSPs influence mathematics students’ beliefs and perceptions about mathematics?

• RQ1b: In what ways does the use of PSPs influence mathematics education students’ beliefs and perceptions about mathematics?

• RQ1c: In what ways does the use of PSPs influence other students’ (taking Calculus II and below) beliefs and perceptions about mathematics?
• RQ2a: What is the potential of a given PSP (specifically the original source material within the PSP) to promote the learning of meta-discursive rules in mathematics?

• RQ2b: What is the potential of a given PSP to promote student reflection on meta-rules in conception formation?

[Sfard (2001): meta-rules include those rules that underlie the uniquely mathematical ways of defining and proving; rules that regulate and guide interpersonal exchange and self-communication; the way symbolic tools should be used in the given type of communication, etc.]

• RQ3: In what ways does student engagement with PSPs influence student retention in mathematics?
“Faculty Expertise” Piece

• RQ4: What faculty characteristics may predict or explain which faculty and graduate students choose to attend training workshops and to implement PSPs?

• RQ6: In what ways does the use of PSPs change instructors’ (and graduate teaching assistants’) approach to teaching other topics/courses?
# Data Sources
(Sample for “Student Change” piece)

<table>
<thead>
<tr>
<th>Students</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>Pre-Course Survey</td>
<td>Pre-Course Survey</td>
</tr>
<tr>
<td><strong>PSP student work</strong></td>
<td>Post-Implementation Report (per PSP)</td>
</tr>
<tr>
<td>Post-PSP Survey (for max of 2 per course)</td>
<td>Post-Implementation Report (per PSP)</td>
</tr>
<tr>
<td>Post-Course Survey</td>
<td>Post-Course Survey</td>
</tr>
</tbody>
</table>

** Student “matched set” requires each of the above. **

**Note: Collect 10% -20% of participating students’ work.**

(Interviews possible.) (Interviews possible.)
TRIUMPHS Information

Project website with projects ready for use;

Site tester information;

Additional resources.
TRIUMPHS Information

Project website with projects ready for use;

Site tester information;

Additional resources.
Thank you!

• Questions about being a site tester of a PSP?
  Contact Janet Barnett
  (janet.barnett@csupueblo.edu)
  and Dominic Klyve (klyved@cwu.edu)

• Please direct questions/comments on the EwR aspect of TRIUMPHS to:
  Kathy Clark
  kclark@fsu.edu