Open Education Resources and Technologies in Mathematics 19w2268

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1 Background and Summary

The BIRS Workshop on Open Education Resources and Technologies in Mathematics brought together champions of Open Education Resources (OER) in Alberta, along with leading experts from other institutions in Canada and the United States.

In Alberta and beyond, there is a growing number of mathematics educators involved in creating, modifying, and adopting OER for the academic (and financial) benefit of their students. We convened this workshop to address a significant barrier to development of high quality OER; namely, that many of the people working in this area are doing so independently, unaware of similar efforts elsewhere.

Another issue we hoped to address is awareness of new and exciting software platforms for authoring and publishing OER. As LaTeX is the dominant paradigm for mathematical publishing, including publication of open textbooks, most open textbook authors choose LaTeX as their authoring tool of choice, either out of habit, or due to lack of awareness of other options. While LaTeX allows for beautiful typesetting of mathematics, it is limited to output in PDF format. The use of PDF for textbooks is good for printing, but not for the increasingly large proportion of students who choose to access their course materials electronically. A major problem with PDF is that it typically scores poorly on accessibility tests, since it lacks features available in formats such as HTML for persons with visual impairments, including alt-text descriptions for images, screen reader support for equations, and scalability. Accessibility and student preference are two factors driving the need for high quality mathematical textbooks in HTML. An HTML textbook works well on a larger selection of devices with varying screen sizes. It also allows for the inclusion of interactive content, such as applets, live code, and computer-graded homework problems.

With these two issues in mind, participants in the workshop were given the opportunity to learn about the efforts of their colleagues at other institutions in the OER realm, and they also were able to learn about the most recent developments in some of the most cutting-edge open education technologies.

There were three primary technological themes represented at the workshop:

- The PreTeXt system for open textbook authoring and publishing.
- Online assessment tools, including WeBWorK and STACK.
- The Jupyter notebook system for online coding and scientific computing, and the PIMS Syzygy service.

Taken together, these tools form a robust ecosystem of open, interactive, online content with the potential for transformative enhancement of postsecondary mathematics education.

In keeping with the workshop's goal of introducing participants to each other and to some of the recent technology developments, presentations were kept brief and informal, with most time set aside for working groups. We saw three different types of working groups form:

1. *Getting started* — the workshop offered an opportunity for participants with no prior experience to learn the basics of working with tools such as PreTeXt and Jupyter.

2. *Roundtable discussions* — groups of participants got together to form discussion groups dealing with topics ranging from challenges in OER publishing to curriculum issues in elementary linear algebra.

3. *Technical* — the workshop also provided an opportunity for participants who are active in the development of open education technologies to meet in person to work out software bugs and technical problems.

2 PreTeXt

The PreTeXt system [1] is an XML vocabulary, together with processing tools, that allows one to author open textbooks with a single set of source files that can be processed into several different outputs, including HTML, LaTeX, and ePub. PreTeXt is undergoing rapid, community-based development, with new features added on a regular basis.

At the BIRS workshop, we heard from Rob Beezer, creator of PreTeXt, about some recent (and exciting) developments, including support for worksheets, lecture slides, and improved accessibility, including output to Braille.

Accessibility is a key feature of PreTeXt, along with interactivity features in HTML, such as embedding of WeBWorK problems and GeoGebra applets. Alex Jordan, another workshop participant, has made major contributions in these areas.

Roughly half of the workshop participants were already familiar with the PreTeXt project. Among the remaining participants, there was definite enthusiasm for PreTeXt as a platform. Following Saturday morning's presentations, one of the working groups formed provided interested participants an opportunity to be guided by Rob through the process of installing and setting up the necessary software to begin using the PreTeXt system, to the point that participants were able to author and produce output for a "minimal working example" document.

Also at the workshop was David Farmer, of the American Institute of Mathematics. David provides a service in support of the PreTeXt project, in which he will automatically convert authors' LaTeX source into PreTeXt. His conversion does about 90% of the job, with some hand-editing required after the fact for the author to complete the process. By the conclusion of the workshop, David managed to perform PreTeXt conversions for three authors: Joy Morris, Remkes Kooistra, and Robert Petry. Conversions for several more texts by Remkes are planned for the near future.

3 Assessment

Technological solutions for assessment include both online homework systems and software to support evaluation of written work. WeBWorK [2] is a leading open source online homework system. It is mature, with a large bank of community-contributed problems, and supported by the Mathematical Association of America. As reported by Danny Glin (University of Calgary), a lot of the recent development in WeBWorK is related to making it more portable, so that WeBWorK problems can be embedded in other websites. This technology makes it possible, for example, to have interactive WeBWorK problems included in the HTML version of a PreTeXt book.

There is also a push within the WeBWorK project to improve documentation, with work underway for a new website. One of the working groups spent Saturday morning navigating the website, and giving suggestions for improvement.

While almost everyone at the workshop was familiar with WeBWorK, we also heard about two new developments that generated a lot of interest.

George Peschke and Chris Frei (University of Alberta) told us about their work creating question banks for calculus and linear algebra using the STACK plugin for Moodle [3]. For institutions using Moodle as their LMS, this provides an opportunity to provide online homework with computer-generated formative feedback, without the need for an external system like WeBWorK.

A modern take on traditional assessment was given by Andrew Rechnitzer (UBC). Andrew has created an open source alternative to online grading systems like Crowdmark and Gradescope, written entirely in Python. The PLOM system (PaperLess Online Marking) allows instructors to automatically generate many different versions of a test by mixing different versions of each question. While tests are written in class as usual, his software allows the work to be organized and processed so that markers can work online, and grade only one version of a problem at a time. The use of a rubric with predefined comments increases the quality and consistency of feedback to students, and the software saves time on tedious administrative work.

4 Jupyter

The Jupyter worksheet [4] has been an important research tool in data science and scientific computation for some time. From Michael Lamoureux (PIMS, University of Calgary), we heard about the PIMS Syzygy project [5], which provides online (browser-based) access to Jupyter using Jupyter hubs powered by Compute Canada. Although Syzygy was originally created as a research service, the fact that anyone with an institutional email address at a participating institution can sign in and access Jupyter's browser-based computing environment has made the service increasingly attractive as a teaching tool.

We heard from several participants who are either already including coding and software in their mathematics teaching, or are hoping to begin doing so.

Michael showed us some of the ways he uses Jupyter in the classroom. After his presentation (and coffee) a working group was formed, led by Patrick Walls (UBC) to get people started on Jupyter/Syzygy. In addition to basic details on accessing and using Jupyter, this group also looked at logistical details, such as distributing notebooks to students, and setting up grading tools that enable instructors to collect and evaluate student work in a Jupyter notebook.

5 Next steps

A major goal of the workshop was to promote awareness of OER projects, both within Alberta and beyond, and to begin to build a community of OER champions interested in sharing their work and supporting the work of others.

To that end, the workshop was a success. Friday evening provided an informal meeting in which all participants had a chance to share their interests and accomplishments. For those who wanted to share their work in more detail, we set aside time Sunday morning for a series of "lightning presentations" in which participants gave short (5-10 minute) talks about their work in OER.

A collection of resources shared during the lightning presentations can be found at

`https://sites.ualberta.ca/~jsylvest/birs_july_2019/`

To keep the conversation going, we created a Google group, where participants from the workshop, and the broader OER community, can share details on their projects, ask questions, and get support. The group can be found at

`https://groups.google.com/forum/#!forum/oer-math`

The question of how to support and sustain OER in mathematics is a difficult one, and not easily solved in a single weekend. We concluded the workshop with a group discussion on this topic, led by Claude Laflamme (University of Calgary, Lyryx Learning). Questions debated included:

- How do we organize and curate existing OER material?

  The experience of David Farmer with the Curated Courses initiative suggests that this is more difficult than one might expect. We heard from Rob Beezer that work is underway to produce an improved website documenting the many mature PreTeXt projects that currently exist.

No single website is likely to accomplish the task, which is why community organization and communication is essential, and an outcome of the workshop that will be continuously pursued.

- How do we convince faculty to adopt OER?

  This can be a challenge. Large departments often have textbooks set by committee. Everywhere, faculty have designed their courses around existing commercial textbooks. Champions of OER can have an impact; for example, at the University of Lethbridge, participants Joy Morris and Sean Fitzpatrick have made open textbooks available for at least 10 courses.

  Work underway in the PreTeXt project to integrate ancillary materials such as lecture slides, WeBWorK problems, videos, etc. will also support adoption.

- How do we fund OER development and deployment?

  A common misconception about open textbooks is that they are completely free. This, of course, is false. Aside from the time commitment needed from faculty members to create OER, there is the need to hire support staff (such as summer students), and maintain web servers needed to host content. Interactive content such as WeBWorK problems can be especially costly to maintain.

  We discussed the fact that while there is good support in the USA from the NSF, grant money in support of OER in Canada is limited, and not always available to academic institutions.

  Claude made the suggestion that we work towards establishing a not-for-profit corporate entity to support OER, modelled after the NumFocus Foundation [6], which supports a number of open source projects, including MathJax and Jupyter.

  This would certainly be a positive development in support of OER, but not one that we can expect to occur after a single weekend workshop.

References

[1] PreTeXt, `https://pretextbook.org`.

[2] WeBWorK, `http://webwork.maa.org/`.

[3] STACK plugin for Moodle, `https://moodle.org/plugins/qtype_stack`.

[4] The Jupyter Project, `https://jupyter.org/`.

[5] M. Lamoureux, Introduction To Syzygy. `https://intro.syzygy.ca`.

[6] NumFocus Organization, `https://numfocus.org/`