MAA PREP REPORT: "SAGE: USING OPEN-SOURCE MATHEMATICS SOFTWARE WITH UNDERGRADUATES" (ONLINE WORKSHOP, SUMMER 2010)

ROB BEEZER, KARL-DIETER CRISMAN, JASON GROUT

1. Short Description of Program

The Sage PREP program was an online workshop organized and led by Rob Beezer, Karl-Dieter Crisman, and Jason Grout. The program was spread throughout the summer. The online group video conferences consisted of two 2-hour sessions on each of four days: 22 May, 8–9 June, and 9 August, 2010. Elluminate servers provided conferencing technology and a Sage server at the University of Washington in Seattle provided the mathematics software (including collaboration/sharing capabilities). For the most intensive component video conference (8–9 June), the organizers and several local participants convened at Gordon College in Wenham, MA, to coordinate and deliver content more effectively.

The core references for our workshop were the specially-created tutorials covering a variety of areas in Sage. See `http://wiki.sagemath.org/prep/2010/sessions` for the information page, and `http://prep.sagenb.org/pub/` for a listing of shared tutorials and participants' worksheets. Participants also referenced the standard documentation of Sage, including the official tutorial and reference (available at `http://www.sagemath.org`). We plan for our tutorials to eventually become part of the official Sage documentation.

The participants had a summer-long goal of learning enough about Sage to produce two worksheets for use in one of their fall courses. We believe that most participants were successful in this, and some did much, much more.

2. Attendance

We had 25 participants enrolled. All but two of these (Cahoon and Helfgott, who never showed) attended the majority of the sessions. The last session, in August, had lower attendance (around 60%), partly due to participants having unforeseen emergencies, but also perhaps due to the proximity to Mathfest and semester start dates. A fair number of those who did not attend had significant interaction with us during the creative period regarding their progress, so we know they did not just disappear. However, this did not account for everyone missing, and it seemed clear to us that the long creative period (and its reliance on participants' initiative and focus) had also taken a toll.

3. Preparatory Component

Before the initial introductory day of the workshop, participants were asked to open and work through two basic tutorials in Sage, one being absolutely introductory and one involving basics of functions and plotting. Participants were also encouraged to start working through a provided calculus tutorial. We also signed them up to the MAA listserv and requested they bring questions

to that forum. Participants were asked to test the video conferencing software (Elluminate) and to create accounts on the Sage server for the workshop.

The introductory day of the workshop (22 May) involved two video conference sessions in which we answered questions, reviewed the introductory worksheets and introduced participants to a variety of helpful resources in the Sage community. We also demonstrated some of the most valuable capabilities Sage offers educators.

After the introductory day, participants were asked to work through some more advanced subject-specific tutorials (e.g., calculus) to prepare for the intensive component of the workshop. We also hosted online office hours to address participant questions, in addition to the mailing list.

We believe this component of the program was very successful. The MAA list in particular provided a way for us and participants to quickly and publicly (within the workshop) answer questions and carry on discussions. Even though some participants had some apprehensions about the amount of time needed to review the preparatory materials on their own, the time commitment turned out to be reasonable, and the experience was very valuable in preparing them for the intensive component. As far as we could tell, we had 100% participation in these preparatory activities (other than as noted above). We feel that the timing of the preparatory component was particularly successful in this workshop since many participants had never used Sage before. Having the preparatory component (including an online session) over the several weeks before the intensive component allowed time for questions to be answered and time for the participants to become familiar with the basics of the software.

4. Intensive Component

The intensive component had three parts: a two-day online conference, then a two-month creative period where participants created new worksheets, and finally a wrap-up online conference day.

4.1. **Online Conference.**

The online conference (8-9 June) consisted of four 2-hour online sessions spread over two days. The first day (two sessions) focused on reviewing more advanced introductory material and illustrating a number of ways in which Sage was used in the classroom. Nearly all participants had something meaningful to contribute and questions to ask. They felt the pacing was right, and most of those with prior math software or programming experience were asking very insightful questions, indicating a high level of preparedness and investment. We feel that a similar format would be a good model for a one-day Sage workshop for educators.

The second day (two sessions) of the conference was designed to familiarize the participants with a range of subject-specific functionality, lead a discussion of pedagogical issues, and introduce some programming functionality. These goals were definitely achieved, especially for those who came to the workshop with specific curricular ideas. Even those who were just more generally curious or had somewhat less background in math software expressed a definite interest in having access to this information in the format we presented it (which was more concise and comprehensive than currently available elsewhere). However, especially for the latter group, it was difficult to assimilate the material so quickly and they felt overwhelmed by the end of the second day. No one wanted less information; instead, the consistent feedback we received was that more time to think through it would have been valuable. In future similar workshops, it might be wise to space the intensive component out over more time.

We scheduled the discussion of pedagogical issues in using software (Sage in particular) at the end of the two-day conference to give participants time to more fully develop their ideas of how they would like to use the technology. However, pedagogical issues (particular of a more mundane variety,

like grading) came up fairly frequently in a somewhat disjoint fashion earlier. In this discussion of pedagogical issues, we were impressed with the variety of ideas and experience participants brought to the table. In the future, an earlier dedicated discussion of participants' pedagogical experience and ideas concerning software in the classroom would be valuable.

By the end of the two days, quite a few participants already had very concrete ideas about what sort of worksheets they wanted to design, and were already sharing some with the rest of the workshop on the server. We were impressed with the energy and participants' initiative in creating worksheets covering a wide range of disciplines, including basic calculus, algebra, dynamical systems, and statistics.

4.2. **Creative Period.** In the two months between the intensive 2-day video conference and the final wrap-up video conference, the goal was to support participants in creating a variety of worksheets for their classes. We hosted online office hours at least once each week (more in the final weeks). Roughly one-third to one-half of the participants continued actively creating and sharing worksheets during this time. The MAA list had bursts of activity, many of our office hours were attended, and the organizers had further in-depth discussions on technical and general pedagogical details of many good worksheets, from the central limit theorem to vector fields. We consider all of this a success.

This period also had disappointments, though. It became clear that the office hours model was not ideal for everyone, mostly because (as in a real course) the ones who came were the 'students' who either needed the most help but wanted to succeed, or the ones who already were strong and wanted to become even more effective. For many others, two months proved to be a long time to stay focused, especially if they weren't sure what they wanted to do. Although the extra time was very useful for allowing flexibility for some participants, for others it apparently was too long between sessions to maintain focus. Few of these types of participants responded to our requests and encouragement to ask for help and suggestions in their worksheets, even after making it highly personalized and sending individual reminders to participants who hadn't yet taken advantage of office hours. As noted above, we think that this lack of focus led to a drop in attendance at the last online sessions in August.

4.3. **Wrap-up.** The last video conference (9 August) was designated as a wrap-up day, in which we again had two 2-hour sessions. During these sessions, we spent a significant amount of time having participants share and explain their worksheets with the group. We also had a discussion on creating worksheets and using Sage in the classroom, a guest presentation on the history and future of Sage by William Stein (the founder of Sage), and an introduction to how Sage can be used from within LaTeX to help write notes, books, tests, quizzes, and other materials. By popular demand, we also had a short discussion on setting up campus and personal Sage servers.

The participants who attended this session were mostly highly engaged, and we had a another great pedagogical discussion. Although there was some initial hesitation, quite a few participants ended up sharing their work with the whole workshop; we certainly have plenty of ideas of whom to nominate for presenting at the Joint Meetings. It was clear that these active participants had not just learned a lot, but also were fired up–as one participant put it, "I should be getting ready for classes, but I just want to play with Sage!"

5. Follow-up Component

There are several follow-up activities that we have incorporated. Most importantly, at the beginning of the workshop, the participants were supposed to commit to using Sage in a particular course immediately after the workshop in the fall. We will initiate follow-up discussions during

the semester (perhaps starting in early October) to gauge progress and satisfaction and offer encouragement and help. We especially hope that the MAA list will serve as a resource for participants.

We also plan to organize an informal meeting between participants that are attending the Joint Meetings in January 2011 to discuss their experiences in the classroom this fall.

6. Successes and Improvements

In addition to the specific improvements and successes noted above, we feel that Elluminate, the MAA Sympa mailing list, and the Sage server all ended up being very useful and reliable. By popular demand, we shifted some of our funds to support a group Sage server through the fall semester for several faculty to use; we would probably budget for this if we did a similar workshop again. We also feel that the tutorials we created were successful in introducing participants to Sage functionality.

In a future workshop, we believe that a different schedule (perhaps one involving one day a week for four weeks) would be one of the most valuable improvements. An ideal schedule would stretch out the intensive conference sessions over more time, but shorten the long somewhat-independent creative period. Another valuable improvement would be finding some way to effectively encourage participants to take more advantage of the organizers' stated availability for help (having group meetings more often might help with this). We also found that a substantial minority of the participants were highly motivated and had lots of experience in using software in teaching. Utilizing this enthusiasm and experience more in group discussions would be beneficial.

We tried to help participants also participate in the more permanent Sage educational community. Several participants posted to the regular Sage mailing lists and asked questions or offered their worksheets and other help. One participant even learned how to contribute code to Sage! We feel these things were important successes, as they built the foundation for sustained activity and development.

7. Conclusion

We feel the workshop was a great success. If given the opportunity to do a similar workshop again, we have specific improvements we'd make to increase the effectiveness for participants.