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Information for faculty
new to undergraduate research
Cayla McBee and Violeta Vasilevska



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(Communicated by Darren A. Narayan)

In this article we provide information for faculty interested in engaging in undergraduate research with their students. Most of the information discussed was gathered from the 2012 Trends for Undergraduate Research in Mathematical Sciences conference. The article includes information on finding appropriate research projects and students to work with. It also discusses various opportunities for faculty as well as some general advice for those new to mentoring undergraduate research.

1. Introduction

Student demand for undergraduate research is growing and the number of universities who value and support undergraduate research is expanding. Consequently many faculty members have become interested in getting involved in undergraduate research projects. Undergraduate research can take many forms: from research projects conducted during a class, to academic year projects or summer REU (research experiences for undergraduates) programs.

The Trends for Undergraduate Research in Mathematical Sciences (TURMS) conference was held October 26–28, 2012 in Chicago, Illinois. During the conference many ideas, suggestions and pieces of advice were given for faculty who are new to undergraduate research. In this article we will present some of that information.

2. Starting undergraduate research

While REU programs provide a beneficial undergraduate research experience, they are restricted to a small percentage of students. In order to reach a larger number of students many faculty are interested in undergraduate research activities they

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can implement at their home institutions. Fortunately there are a number of ways interested faculty can provide research experiences for their students.

One of the ideas suggested at TURMS is to engage students in academic year research projects. This can be done through independent study classes, undergraduate research courses or capstone courses. While independent study and research courses are usually done with a small group of select students, they can provide genuine research experiences. On the other hand, a required capstone course can be a great way for all math and math education majors to get involved in a research experience.

Another way to provide students exposure to mathematical research is to incorporate research projects into mathematics classes. Projects can be a rewarding experience for students and depending on the class and type of students involved, these research projects can lead to future undergraduate research experiences. Carefully chosen and structured in-class projects can be extended to larger projects later on. As mentioned in a later section of this paper, this can also be a good recruiting tool for finding students to work on undergraduate research projects.

An additional idea mentioned at the conference was that mathematics courses can be structured in such a way that students discover and prove course material with guidance from their instructors. This student-centered method of teaching is known as *inquiry based learning* (IBL) and has become more popular in recent years. IBL is regarded as a modified Moore method (legacyrlmoore.org/reference/FOCUS.html). IBL provides an opportunity for all students to get involved in discovery based learning and some instructors regard this as a valuable type of research experience. The Academy of Inquiry Based Learning (AIBL) website (inquirybasedlearning.org) provides useful information about this method and its variations. The website also gives information regarding mentoring programs, workshops, and grants offered to support new and experienced IBL instructors in their efforts to use or develop IBL course materials.

Finding project ideas. There are a number of places to find project ideas suitable for undergraduate research. Places to consider when looking for project ideas include your own research, articles accessible to undergraduates, problems from math competitions and problems from industry.

Considering problems from your own research can be a good place to start with undergraduates. In addition to being familiar with the material you can ensure you are making progress with your own research program while continuing to work with students. If your research involves mathematics that is not appropriate for undergraduate level research you may want to look for articles accessible to undergraduate students. By changing the hypothesis of the main result in an article students may be able to discover a new result. It is also interesting to

determine whether the main result of an article can be generalized or expanded in a new way.

Problems from math competitions such as the Putnam Competition or the COMAP Mathematics Modeling Contest are another good source of project ideas. Often problems from these competitions can be generalized or expanded to become suitable for an undergraduate research project. Information on the math competitions mentioned above can be found at their websites; see math.scu.edu/putnam for information on the Putnam Competition and comap.com/undergraduate/contests/ for information on the COMAP Mathematics Modeling Contest. Additionally, the Open Problem Garden is a collection of unsolved problems from a variety of areas in mathematics that can also be a good source of problems (openproblemgarden.org).

If students are interested in working on an applied problem from industry contact local companies to see about establishing collaborations or partnerships. In some situations companies have problems suitable for undergraduate research and they are happy to share these problems.

Finding students to work on undergraduate research. To become involved in undergraduate research one has to recruit students. One idea suggested during TURMS is to offer financial support to students participating in undergraduate research. Many universities have special funds for undergraduate research; however, if your university does not have such a fund available, two possible sources of funding are donations from alumni and donations from faculty. At Coastal Carolina University an alumnus made a donation that was to be used to support an undergraduate research project for one faculty member and three to four students. In addition to the alumni donation, some faculty members also donate to the department discretionary fund to support and encourage undergraduates in their projects.

Another recruiting technique is emailing students doing well in appropriate math classes to see if they would be interested in engaging in an undergraduate research project. Patrick Rault at SUNY College of Geneseo has had success in finding problems critical to his research that will not take much more time for students to complete than for himself. He then emails several promising students in early to mid summer, inviting them to work on the undergraduate research project. Typically one to two students will make significant headway on the problem before the end of the summer and those students can then be enrolled in an independent study course. He requires students to finish the project by the end of the spring semester, present at a regional conference, and possibly submit for publication. In instances where funding is unavailable for students, offering course credit can be a good motivator.

A third recruiting technique is to offer students the opportunity to continue a project they began in class. Although choosing a project that can be extended may be challenging, it can provide a great way to excite and motivate students.

Developing a culture of undergraduate research. In addition to recruiting students it is important to support a culture of undergraduate research at your institution. One way to do this is to invite speakers focused on undergraduate research to your campus to give talks targeting undergraduates. You may also want to organize gatherings after the talk and give the speaker the opportunity to speak informally with the students. Attending undergraduate poster and paper sessions can be a great way to find possible names and contact information for speakers. Make a note of the topics and advisors of the posters that stand out to you. In the future it may be useful to contact these advisors to invite them as speakers to your college or university.

In order to expose students to undergraduate research you may want to bring them to local conferences such as Regional Mathematics Undergraduate Conferences (maa.org/rumc/supported.html) and sectional MAA meetings. Additionally, any conferences that offer undergraduate paper or poster sessions are great venues for students to attend. For example the Joint Mathematics Meetings, MathFest, the Nebraska Conference for Undergraduate Research in Mathematics, and the UnKnot Conference can be a great experience for students.

Another idea is to partner with local colleges in organizing seminars for students. At these seminars students can present topics that interest them. The seminars can also be used to motivate students to continue with work on their projects.

3. Opportunities for faculty

There are a number of different programs undergraduate faculty can apply to if they are interested in learning more about engaging undergraduate students in research. We will discuss a few here, each of which has its own objectives and goals that will help interested faculty become better equipped to mentor and work with undergraduate students.

For individuals early in their career who are interested in learning more about undergraduate research, Project NExT and the various section NExT groups can be very helpful. Project NExT (New Experiences in Teaching) is a professional development program sponsored by the Mathematical Association of America for new or recent PhDs in the mathematical sciences. Although it addresses all aspects of an academic career, Project NExT fellows are able to attend special talks and workshops on undergraduate research and are made aware of opportunities for those interested in undergraduate research. Individuals who have completed their PhD and who will be in their first or second year of full-time teaching at the college level are eligible to apply to become a Project NExT Fellow. In addition to Project NExT, many MAA sections have section-level programs that resemble the national Project NExT. More information regarding Project NExT

and the various section NExT groups can be found at the Project NExT website (archives.math.utk.edu/projnext/index.html).

A resource available to individuals at any point in their academic career is the mini-course “Getting students involved in undergraduate research”, offered by Joseph Gallian and Aparna Higgins at the Joint Mathematics Meetings each year. This two-part MAA mini-course covers many aspects of facilitating research by undergraduates. It is designed for faculty who are new to directing undergraduate research and is a great resource for those beginning to work with undergraduates.

For those who would like to apply to a more comprehensive program for faculty interested in directing undergraduate research groups, The Center for Undergraduate Research in Mathematics (CURM) may be a good option. CURM is funded by the National Science Foundation (NSF) and Brigham Young University (BYU) and is directed by Michael Dorff. CURM trains professors as mentors, provides funding to establish undergraduate research groups, advises professors on how to organize undergraduate research groups, and prepares undergraduate students to succeed in graduate studies. CURM achieves these goals by offering mini-grants providing financial support to research groups. These research groups are composed of one faculty member and two to five undergraduate students. Professors accepted into the program receive funding to attend a faculty summer workshop at BYU and students and their faculty mentors receive funding to attend a spring research conference there. More information regarding CURM can be found at the CURM website (curm.byu.edu).

Another workshop and program individuals interested in undergraduate research may want to explore is the Research Experiences for Undergraduate Faculty (REUF) workshop. The American Institute of Mathematics (AIM) has sponsored one-week REUF workshops in 2008, 2009, 2011, 2012 and will be again sponsoring a workshop in 2013. These workshops bring together established research mathematicians with faculty at undergraduate institutions who are interested in involving undergraduate students in research. Research groups are formed during the workshop and the majority of the time is spent working in these groups on problems and formulating plans for future work. In addition to the workshop itself, there are also opportunities for continuing activities and collaborations. More information on upcoming REUF workshops can be found on the AIM website (aimath.org/research/upcoming.html).

An additional program undergraduate faculty members may be interested in exploring is the Undergraduate Faculty Program at the Park City Math Institute (PCMI). As stated on their website, the program’s objectives are to help undergraduate faculty “renew excitement about mathematics, talk with peers about new teaching approaches, address some challenging research questions, and interact with the broader mathematical community”. In the recent years some of the undergraduate

faculty programs have been structured so that participants have the opportunity to both generate a list of research problems on a particular topic suitable for undergraduate exploration and form lasting collaborations that continue after the summer program. The 23rd Annual PCMI Summer Session will be held during the summer of 2013. Additional information can be found at the PCMI website (pcmi.ias.edu) by following links to the Undergraduate Faculty Program.

Finally, the Department of Mathematics at Fresno State is accepting applications for Faculty and Undergraduate Research Teams (FURST). This program provides support to research teams composed of one faculty member and two students at primarily undergraduate and minority-serving institutions. The program gives financial support to the teams and provides a one-month immersion program at Fresno State and support for travel both to Fresno State and the Joint Mathematics Meetings. The expectations for the teams are that they will recruit new members for the following year and that faculty will pursue internal funding to support the research group in the year following the FURST award. More information can be found at fresnostate.edu/csm/math/furst.

4. General advice

In this section we will discuss some of the advice given at the 2012 TURMS conference, as well as present some useful references for individuals beginning their work with undergraduate students.

The importance of networking with those involved in directing undergraduate research was mentioned several times during the conference. It was suggested that the best thing to do in starting an undergraduate research project is to attend conferences that focus on undergraduate research and talk to people to find out what has and has not worked for them. Examples of such conferences include TURMS and any of the workshops and programs mentioned earlier in this paper. Many faculty members have a lot of experience mentoring and working with students. These experienced individuals are often happy to share their knowledge with others.

Another piece of advice given is to document everything. By documenting successes and failures it will be easier to report on your progress and keep track of what worked well and what did not. Ideas that worked well can be used and adapted in future projects.

The final piece of advice, suggested for individuals interested in becoming involved with undergraduate research projects, is to look at and read the many websites and articles available that are relevant to undergraduate research. Although it is not possible to list all of these references here, we mention a selection of resources we hope the reader will find helpful:

- Two useful articles published in the Notices of the American Mathematical Society are [Leonard 2008] and [Gallian 2012].
- The website cur.org for the Council for Undergraduate Research (CUR) contains many useful links for those interested in undergraduate research including a link to the CUR Quarterly, a publication described by CUR as “the official public voice of CUR”. The publication provides information about student-faculty collaborations from various types of institutions; see cur.org/publications/curquarterly.
- The Mathematical Association of America’s website has useful resources for undergraduate research, including short articles on topics ranging from how to get started to finding students; see maa.org/columns/Resources/resources.html. The MAA main page also contains links to an index of programs for undergraduate students (see maa.org/funding/undergraduate.html).
- The National Science Foundation website contains information regarding REU site proposal funding (see nsf.gov/funding/pgm_summ.jsp?pims_id=5517).

5. Conclusion

Undergraduate research can be time consuming, but also a very rewarding experience for both faculty and students. We hope that the information provided in this article will be a good starting point for any faculty interested in establishing an undergraduate research group.

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