Course-based Undergraduate Research Experiences: Two Examples

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Mathematics at Illinois State University (ISU)

- Located in Normal, IL (2 hours south of Chicago)
- First public university in the state of Illinois (founded in 1857)
- Enrollment: 21,000 students. Largest freshman class in 33 years!
- 16 Ph.D. students: Mathematics Education
- Integrated Masters Program
- Visit our homepage
Undergraduate Research in Mathematics

- Designed to give math majors an opportunity to do research.
- Journey: find patterns, make conjectures, examples, prove/disprove your conjectures, revise conjectures, generalize results.
- Be prepared to be stuck at every stage; that is our steady state!
- read the literature: papers published in journals!
- An exciting opportunity for students.
- Builds vertical integration in a department
Course structure

- MAT 268 - Introduction to Undergraduate Research in Mathematics
- 3-credit hour course
- Meets twice a week (75 minutes each)
- Prerequisite: MATH 146 (Calculus II)
- Can be used as a mathematics elective for math and education majors
- My course webpage, Spring 2011
History of MAT 268

- We have been offering this since 2007
- My colleague Saad El-Zanati started this course
- We offer it only in the Spring semester.
- Try to alternate between people in algebra and discrete mathematics groups who teach this course.
- I taught this twice (Spring 2011 and Spring 2018)
Every year in the Fall semester (before registration) we advertise this course to our juniors.

The instructor teaching this course will make a flyer which is distributed.

Undergraduate director, academic advisors and math instructors encourage our strong students to sign up for this class. (Our local Putnam toppers often end up taking this course)

Registration is closed: Interested students talk to professor who will be teaching the course. Instructor will determine eligibility.

Average enrollment: 12 students.
Organization of the class

• First few weeks (out of 16 weeks) are spent in bringing students up to speed: learning some background material.

• Instructor assigns problems to students that are designed for students in this class.

• Students work in small groups; typically about 3 groups of size 4 each.

• These students are urged to attend seminars in the department: algebra seminar, discrete mathematics seminar and undergraduate mathematics colloquium.
Sample research problems

1. Find all values of $n$ for which 1’s in the multiplication table of $\mathbb{Z}_n$ occur only on the diagonal.

2. Ask the same question for any ring: What about $\mathbb{Z}_n[x]$? or $\mathbb{Z}_n[x_1, \cdots x_n]$? (joint with Michael Myers in Math Magazine)

3. What about the group ring $\mathbb{F}_p C_p$? where $p$ is a prime.

4. When is a subgroup of the additive group of a ring $(R, +)$ also an ideal $(R, +, \times)$? (joint with Christina Henry in Involve)

5. Characterize all ordered pair $(m, n)$ of integers for which there is a lattice polygon $P$ with $m$ points in its interior and $n$ points on its boundary.
Resources for students

- Algebra: M. Artin, Dummit and Foote
- Roots to Research: A vertical development of Mathematical Problems (Judith D. Sally and Paul J. Sally, Jr.)
- LaTeX: all students in this class are expected to learn and use LaTeX for writing their final paper
- SageMath software for computations (some use Maple or Mathematica)
- Math ArXiv and Mathscinet
- Encyclopedia of integer sequences
Evaluation

This is up to the instructor. Final grade is based on

- Participation in class
- A final paper: each student will focus on his/her own contribution in their paper.
- Final presentation (This is announced in the department and interested people are welcome to attend)
- Presentation in the University undergraduate research symposium.

No exams! and hence no grading 😊
Final words

- This is a fun course for both students and teachers.
- Strongly recommend this course for your program if you don’t have one already.
- Summer REU programs ([ISU’s REU Page](#))
- Graduate schools
- I would like to maintain an archive of undergraduate research problems. (There may be some already?)
Undergraduate Research Symposium

Spring 2017
Undergraduate Research Symposium, Spring 2011
Thank you!

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