Tips for Guiding Undergraduate Research Projects

L.G. de Pillis

Associate Professor

Harvey Mudd College

depillis@hmc.edu

Research Interests:

Mathematical Biology, Numerical Linear Algebra,

Numerical Analysis, Computational Mathematics,

Fluid Dynamics, Partial Differential Equations

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Thanks to all who Contributed!

Contributors (alphabetically):

- **Asuman Aksoy**, Professor, Claremont McKenna College.
  Research Interests: Banach Space Theory; Measures of Non-compactness; Fixed Point Theory; Orlicz Spaces; s-Numbers.
- **Annette Hosoi**, Assistant Professor, Harvey Mudd College and MIT.
  Research Interests: Mathematical Physics; Fluid Dynamics; Partial Differential Equations; Computational Mathematics.
- **Michael Orrison**, Assistant Professor, Harvey Mudd College.
  Research Interests: Algebra; Combinatorics; Computational Representation Theory.

- **Shahriar Shariari**, Professor, Pomona College.
  Research Interests: Combinatorics of Finite Sets; Extremal Set Theory; Finite Group Theory; Matrix Theory; Representation Theory of Finite Groups; Surreal Numbers.
- **Francis Su**, Associate Professor, Harvey Mudd College.
  Research Interests: Random Walks on Groups; Combinatorial Topology; Mathematical Economics; Fair Division.
- **Lesley Ward**, Assistant Professor, Harvey Mudd College.
  Research Interests: Complex Analysis; Fuchsian Groups; Quasiconformal Maps; Harmonic Measure.

Overview

1. What is “success” in an undergraduate project? (for Student and Faculty Member)
2. Finding a Suitable Project.
3. Recruiting Research Students.
4. Possible Pitfalls.
5. Tips for Achieving Success.
6. Additional Resources.

What is Success?

Success and Rewards for the Student:

1. Taking ownership, excitement for research: A student is able to take ownership of the problem, and begins to take the initiative in the research.
2. Literature Searches: The student has learned how to search the research literature for related materials.
3. Understanding the nature of research: The student has been introduced to research related fields of mathematics that they would not have been exposed to in a typical course. The student understands that doing mathematics is very different from doing homework problems.
4. Ability to Communicate the Mathematics: The student is able to present her or his work to an interested third party. (Conference presentation, Journal Publication.)

What is Success?

Success and Rewards for the Faculty Advisor:

- The joy of mathematics: The excitement of seeing the research progress.
- The joy of mentoring: The excitement of seeing the student's mathematical sophistication and expertise develop.
- The joy of learning: If you have a good problem, and the student makes some progress, you will have learned something too!
- The joy of getting another publication: If the work is published in a peer-reviewed research journal, that can be considered an immense success and reward.

Finding a Suitable Project

1. Your Own Research as a Start Point: Examine something you have already done but in a different or special situation.

2. Your Own Interests as a Start Point: Get started on something you have not yet worked on but would like to.

3. Extending Known Results: Look for how to develop special cases of more general theorems, or analogies to known results. It is easier to modify a known result than to prove something entirely new.

4. Keeping a File: Keep a file of good problems. When you come across a good idea, put it in the folder.

5. Journals as Sources: The Mathematical Monthly and College Math Journal are full of research material undergraduates can handle. Other possibilities include UMAP Journal (Undergraduate Mathematics and its Applications) and even Mathematical Intelligencer can be accessible.

6. Computability: Look for a project that could start with a few computable examples - this gives an accessible way in. (If applicable can ask: How best to compute this? How can the computations be made more efficient? Can we benefit from using clever mathematics?)

7. Keeping it Modular: Can the topic be subdivided into smaller projects? (Example: reducing developing a mathematical model of tumor-immune system interactions to parameter fitting, phase-space analysis of an ODE system, computational experiments.)

8. Finding Experiments: Laboratory or computational.

9. Ideas from Workshops: Some ideas about open problems will arise in a workshop or conference.

Recruiting Research Students.

- Mention interesting research in class, and solicit responses from those who would like to know more.
- Post some open research questions that you are interested in outside your office door.
- Have a department info folder that outlines possible research projects of all faculty.
- Send out general e-mail with announcement.
- Interview all potential research students, and get a real feel for their capabilities. Do not accept a student who is under-qualified or under-motivated.

Possible Pitfalls

1. Major Question Ill-Defined: Even if the problem is open-ended, know what question you want to eventually answer. (Example: Why model tumor-immune interactions? Can we develop better treatment protocols?)
2. Problem Not Modular: If the problem does not have do-able intermediate steps, this can deprive the student of a sense of accomplishment for too long.
3. Lack of Milestones: Have a clear time-line of goals in mind, or the student may drift along without ever accomplishing anything.
4. The Project is Too Advanced: The student may feel overwhelmed.
5. Lack of Excitement for Student: If the student is not excited about the research, he or she will not be motivated to work on it.
6. Lack of Structure: If regular meetings for interaction and feedback are not set up, progress is likely to be slow. Both faculty and student must be aware that this will be a time investment.

7. Feedback Not Immediate: Give immediate feedback to students as to whether they are putting in enough time and moving in the right direction.
8. Level of Collaboration Unclear: Make it clear up front how much you are going to be involved. Be careful not to take over the problem, or the student will never take ownership. Be careful not to detach yourself too much, or the student may flounder.
9. Writing Delayed Too Long: Do not let the student put off writing until it is too late to do a thorough job.
10. The Student is Overcommitted: You must evaluate whether the student's course load and extracurricular activities will allow for a sufficient amount of time to be dedicated to the research project.
11. Continuing Another Student's Work: Sense of ownership may not develop.
12. Personality Factors: Personality conflicts between student and advisor can sabotage a projects and turn a student off to research.

Tips for Achieving Success

1. Writing Starts Immediately: Students underestimate how long it can take to write up research. Writing also forces the student to clarify her or his own thoughts, discoveries, and results.
2. The Project is Modular: The project has do-able intermediate steps. This will give the student a sense of accomplishment early on.
3. The Literature Search Starts Early: Requiring an annotated bibliography early on can work out well.
4. Both Advisor and Student are Interested: If you are bored, your student may be, too.
5. Advisor is Involved: Be ready to be involved in furthering the research project, do not abandon the student.
6. Balance of Numerical and Theoretical: If the student gets stuck on one aspect, they can work on another with a different feel.

7. Student Knows Research is not Homework: Either find a student who has already learned the difference between research and solving a homework problem, or be prepared to help the student learn about this difference.
8. Schedule Regular Meetings: Keep close contact with the student. Meet for at least one hour once a week to discuss progress and updated goals.
9. Keep a Weekly Goals List: At each meeting, come up with a mutually agreed upon list of goals to try to achieve before the next meeting. Follow up on that list from week to week.
10. Schedule Work Time for Student (Summer): For summer research, you can arrange a work place and regular work hours for the student. Expect to drop in and discuss issues regularly.

Additional Resources

- Senior Thesis Web Site at Harvey Mudd College: (http://www.math.hmc.edu/seniortheses/). Highly structured. Thesis Coordinators (past to present): Lesley Ward, Lisette de Pillis, Weiqing Gu, Andrew Bernoff.
- Mathematics Clinic Web Site at Harvey Mudd College: (http://www.math.hmc.edu/clinic/). Clinic Directors (past to present): Robert Borrelli, Michael Raugh.
- C*ODE*E Publication Web Site at Harvey Mudd College: (http://www.math.hmc.edu/codee/main.html). See online issues for papers by professors and students.