Mentoring Undergraduate Students for Research/Development Posters and Papers

Many 4-year, undergraduate computing curricula include a student software development project, capstone activity, research experience, or thesis. Students may work in a team or individually with guidance from a faculty mentor. For example, many computing departments develop software for campus groups, non-profit community organizations, or local businesses. Also, many schools encourage student-faculty research projects, such as the Research Experiences for Undergraduates (REU) program of the United States National Science Foundation (NSF) or various international grant programs. Topics for such activities

may arise from student proposals, an on-going long-term faculty-research effort, a community-based client, local businesses, or other collaborations.

As these projects move toward completion, students have expended considerable time and effort, and their work often has yielded worthwhile results. In this context, natural questions are, how might a computing program celebrate and publicize successes, how might students receive appropriate recognition, to what extent can these achievements help the recruitment and retention of current and future students, and how might others learn from this effort?

As outlined in the Figure 1, this column suggests that posters and papers may address such questions, recognizing the students involved, providing feedback and insights for future projects, and generating publicity. Separately, the Web contains many sources that discuss in detail the development of papers or posters; for example, articles by Michael Ernst [2,3] seem especially valuable. Other sources discuss advantages of fostering a sense of community within a project group (e.g., see [4]).

With such technical guidance widely available, this column discusses ways faculty might mentor students as they

Figure 1: Poster/paper development within a student project

embark on developing posters or papers. Areas covered include planning early, identifying relevant content and the potential audience, deciding between a poster and paper, determining a timeline, reviewing matters of writing and presentation, considering details for these two formats, structuring the writing and development process, and considering the submission process. Although much of this column may be well-known to experienced faculty, this integrated review is intended specifically for students and new faculty.

Early Planning

In my experience, initial work with students on a project typically focuses on many logistics, such as a tentative, week-by-week plan, meeting times, project expectations, etc. However, early discussions also should consider potential visions for the end of the project.

- Assuming the work goes well, how might the effort be celebrated and publicized on campus (e.g., to students, the campus community, potential computing majors)?
 - Are there opportunities for a presentation to the campus community?
 - Could a poster be presented at a Prospective Students event or a Family weekend?
 - Could a product be posted in the computing building (e.g., hallway or common area)?
- If the project is designed as one step within a longer effort, how will the results of this work be communicated to those who come later?
- If the conclusions seem noteworthy, at what conference(s) might they be presented?
 - What venue(s) might be appropriate for a poster presentation?
 - Might the work be the basis for a paper at a conference? Student track or regular track?

On some campuses (e.g., Grinnell College), every student proposal for an independent project must include consideration of where the result of a successful project might be published or presented. Of course, not all efforts will achieve

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substantial results, but thinking about such possibilities can establish a worthwhile goal and provide motivation.

Content and Target Audience

Shifting to the latter stage of the project, reflection on the work is appropriate, as well as a consideration of how the work might come to a positive, productive conclusion. For graduate-level thesis, scheduling may set aside time for such reflection and completion of final products. At the undergraduate level, however, time often is compressed. Ideally, end-of-project discussions might start three to four weeks before its scheduled end, so students have time to think about what they have accomplished, and how it might be celebrated and publicized. Pragmatically, however, in the last few weeks, students mostly focus on achieving the project's goals. In practice, this period of reflection, celebration, and publicity often starts at the very end of the formal project, and some wrap-up activities may continue informally into the next semester to complete a public activity (e.g., campus presentation, poster, paper).

Whenever it starts, this concluding activity might begin with both student reflection and student-faculty discussions.

- How would the students describe the main outcome of this work?
 - Was this activity successful, and if so, how was success determined?
 - Might some negative results be useful for others working on similar projects?

- What about the work might be new or different?
 - What was the motivation for this work? Why did this seem worth pursuing?
 - What is new or different: a result, a product, a process, an approach, etc.?
- What would be an appropriate target audience? Who might care about this work: a research community, a client for this work, students and/or faculty elsewhere?
 - Why might this work be of interest to that target audience? Assuming this was a worthwhile for the students involved, what might others learn from this experience?
 - What background can be expected for this target audience: what can be assumed, what context should be described, how much detail will this audience appreciate?

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Poster or Paper?

After considering the significance, content, and target audience for a student report or

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presentation, a natural question is whether a poster or a paper might be most appropriate. At a basic level, posters and papers represent two levels of achievement.

- A poster generally reports intermediate work toward a larger goal. The recent work has moved a project forward, but the work does not seem finished. Being at an intermediate stage, researchers and developers likely have ideas regarding current accomplishments and next steps and getting additional perspectives in a poster session can help confirm or reassess an overall, long-term plan.
- A paper generally reports work that has been completed. Sometimes a long-term goal has been achieved, and other times work has reached a substantial, interesting, and worthwhile result. Of course, a paper often concludes with a section reporting “next steps,” but the main body of a paper should have sufficient substance to largely stand on its own.

Overall, if a report mostly would contain a brief beginning and many future directions, then perhaps the results should be given in a poster. On the other hand, if the main body of a report will contain an extensive description of what was done and what conclusions result, then perhaps a paper might be considered.

Although this distinction between a poster and a paper may seem clear, three issues commonly arise which may require experience beyond what students typically possess.

- Within a research or software-development context, how significant is this work?
- If the department controls bulletin board space and/or if the school holds events highlighting student work for prospective students (admission sessions), parents and siblings (family weekends), alumni (homecoming), student-research days (e.g., near the end of a semester), or award opportunities (e.g., for student products), then students may be encouraged to create a poster and/or paper that fits with those local opportunities.
- If a final report is to be presented at a conference, are the results sufficiently

substantial for consideration at a national or international event, or would a report or presentation fit better within a local or regional conference?

For many students involved in a research or development project, the work is new, exciting, and substantial. Students have done something worthwhile that is

fore which a week or two might be needed for determining the outline and writing assignments.

Overall, allowing at least a couple months with dedicated students has worked well for me over the years—assuming the students and I meet weekly to check in and determine progress. Clearly different students react to deadlines and

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new to them, but some students, particularly undergraduates, may overvalue or underestimate their mastery and the quality of their work. Overall, students often cannot determine the extent to which their work is significant and innovative within the broad computing community. Thus, faculty advisors may need to be reasonably directive in determining whether results will be reported as a poster or a paper and in identifying an appropriate venue for presenting this material.

Timeline

As the students and faculty mentor decide upon a poster or paper, they also should develop a plausible timeline. As a start, each conference has its own submission deadline, and I suggest that my students plan a submission about a week before the conference. A slippage of a day or two may be acceptable, but deadlines for conferences generally are firm.

From the target submission date, students can work backward. I suggest allowing a month or more for refinements (e.g., after a first draft), as that will allow at least two to three revision iterations. Working backward further, creating the first draft might take a couple weeks, be-

a schedule in various ways, but I find that student involvement in setting deadlines is particularly important so they will have buy-in.

Writing (General)

Whenever I work with students about a poster, a paper, or even an assignment (e.g., a lab write-up, software documentation), I observe that (almost?) any written piece must have at least two vital qualities to be successful and worthwhile.

- *The author must have something substantive to say, and*
- *The author needs to present that content well.*

In my experience, student writing often lacks one (sometimes both) of these. For example, in a first-year tutorial, in which students write short papers on a technical subject, I regularly receive papers, in which the author has a few brief items to report, and the multiple-paged paper simply repeats those few pieces many times. Sometimes in reviewing conference submissions, I find similar troubles. To (over-) generalize, if a paper has little content to offer, then the paper likely should not be written in the first place.

Similarly, if an author has worthwhile ideas, then those insights should be conveyed effectively. Certainly, from time to time, both for assignments from students and for submissions to conferences, a presentation may be unorganized, overwhelmed with syntactic problems, or otherwise muddled. In an interesting discussion concerning submissions to conferences on the SIGCSE-MEMBERS listserv in the first part of October 2019, questions surfaced regarding the extent to which reviewer should make extensive comments on the writing within the submissions. Some discussants worried about being unfair to authors for whom English¹ is a second language. Some noted that weak exposition was common to native English speakers as well. Others indicated that any writing should be clear, well organized, and stated precisely. Overall, some reviewers may be more sympathetic than others regarding careful writing. In any case, confused writing may obscure what an author hopes to convey, and, at some point, a submission may be downrated. Further, whenever submissions are graded or reviewed, a submission displaying confused or unorganized writing has a strong chance of being downrated or rejected. In short, writing matters, as readers seek to understand content.

As a separate consideration, readers today are likely bombarded with papers, emails, news reports, etc. In short, potential readers of a paper or observers at a poster exhibition will likely encounter far more material than they can synthesize in a limited time. Thus, pragmatically, a presentation needs to organize and present ideas that will connect easily to a potential audience. If a potential reader has to struggle to understand the first few parts of a paper or poster, the reader may well skip to something that can be synthesized relatively quickly.

Although these key elements (content and presentation) are vital for both posters and papers, the consideration of these elements differs considerably for the two formats.

Posters

For many students, a poster represents a new type of presentation format, and a discussion of guiding principles might start by considering context. At typical sessions, observers circulate through a display area to view several posters. Some attendees may progress methodically from one poster to the next, but many will stop only when something catches their attention.

With this in mind, a vital component of any poster is to attract attention—displaying images, tables, or figures that can serve as take-off points for discussion. Then, when a passerby stops to look, the author can use a section of a poster to begin a short (e.g., 1-minute) introduction to initiate a conversation. Overall, then, a poster might not be considered as an end in itself, but rather as a prompt to invite and promote discussion.

With this in mind, long blocks of text or detailed, complex presentations, or the extensive use of jargon and/or acronyms likely will be counterproductive. Observers at a poster session may quickly lose interest or move to another with less extensive descriptions and dense writing.

Similar motivations and goals can apply if a poster will be displayed on campus within a department or building. In this context, posters can help create an atmosphere that suggests that interesting and worthwhile activities take place in the computing program, and students are actively engaged in exciting work. In this regard, posters not only publicize past successes but also can help recruit both prospective and current students into the program.

Overall, a poster can act as a springboard for engagement and discussion. Reference [3] provides many detailed suggestions and examples for preparation of a poster.

Papers

Papers provide a wonderful way to integrate results and experiences from a research and/or development project, communicate and celebrate outcomes, celebrate successes, and help students build a foundation for their eventual careers. Students often demonstrate excitement in seeing their names in a conference

program, proceedings, or published article. For example, when my students present a conference paper, I give each student a copy of the proceedings, and even quiet or shy students often express their satisfaction and enthusiasm.

As already noted, a paper should have something worthwhile to say, and then present that material well. This section addresses both content and writing by considering organization, conference or journal parameters, development of a first draft, and iterative refinement of drafts.

PAPER ORGANIZATION

Students likely have experience writing papers for courses in humanities and/or social studies, and many issues of writing (e.g., logical organization, division of a long narrative into cohesive sections, focus within paragraphs, grammatical and syntactic considerations) carry over to technical documents. In addition, technical papers often follow a reasonably traditional format.

- An abstract highlights the main point of the work—identifying the thrust of the full paper and also suggesting why a reader might find this work interesting and worthwhile.
- An introduction provides an overall framework for the work and also indicates the structure of what follows.
- An early section often describes past work on the subject and how the current efforts fit in.
- The main body presents the research and/or development project itself.
- An acknowledgments section identifies those who have contributed or influenced the work.
- A conclusion summarizes what has been done, the possible limitations, and likely next steps or new directions.

After describing this common organization, I sometimes suggest that students read (or reread) several published papers. Although students likely prepared for their research or development project by reading past work, in this pass, students might focus on program organization and wording. They might also read selected articles from past conferences or journal issues to compare a traditional paper format with what their intended conference

¹ Since conferences sponsored by ACM SIGCSE require papers written in English, submissions to these conferences require some level of proficiency for English. For international conferences utilizing one or more different primary languages, similar issues may arise for authors not proficient in language(s) of the conference.

or journal has published. To what extent do these accepted or published articles follow a traditional format? How does the nature of the work in these papers compare with the work done by the students?

WORKING TOWARD A FIRST DRAFT

After students have examples of the structure of technical papers, I usually facilitate brainstorming sessions with students on their first draft to construct a section-by-section outline. What are the main points to be made, how might they be organized, what are tentative headings for each section and subsection, etc.? Once students agree upon an organization into sections, they volunteer to write each section. Assignment of writing tasks continues until all students are actively engaged and someone has agreed to write each section.

With assignments made, students write a first draft for each of their sections. At this stage, I ask my students to be as complete as possible—what should be conveyed to the target audience with nothing omitted in this first draft? Editing, condensing, and refinement can come later—but for many, getting the content down is a major accomplishment.

As writing begins, students and I also agree upon deadlines. Since students often are quite busy and overcommitted, I have found distant deadlines rarely work. Even well-intentioned students often focus on immediate demands and leave other activities until later. Thus, I recommend setting several relatively short deadlines (e.g., a week) for individual sections or subsections rather than a long timeframe for finishing multiple pieces.

CONFERENCE/JOURNAL PARAMETERS

At some point in writing, authors need to review the instructions and formats required for a specific venue. For example, *ACM Inroads* specifies a page format, citation style, etc. for works that appear in that publication; [1] contains links to several relevant templates and policies. Unfortunately, formatting conventions may vary for each computing conference and publication. Further, each venue likely has a specified maximum length, and longer submissions may be downrated significantly or automatically rejected.

For an initial draft, I want students to focus on extended content, and format is secondary. However, at some stage, students must carefully review the requirements for the venue where the paper will be submitted. When this is done early, students will not have to reformat an article repeatedly, but different faculty may focus on other priorities at various times. In my own experience, writing a full polished paper (e.g., in Google docs or similar) and then converting to a conference-specified format can take considerable time, so relatively early use of a conference template may save time in the end.

STEPS TOWARD REFINEMENT/POLISHING

In my experience, after students include all relevant material in a first draft, the result (usually compiled from several student authors) tends to be long, repetitive, and rambling. For example, with each of the last several papers my students have developed for conferences, the first draft was several pages longer than page limits set by the conference or journal. Overall, the first draft may be far from a final work, but it is an important start.

As a next step, I ask all involved to review the document to address three basic questions.

- Has any content been omitted?
- What material seems repeated and where?
- To what extent does this draft connect with the target audience regarding expected background, level of sophistication, jargon, etc.?

When students have reviewed the complete draft, a group meeting can identify what is missing and where it might be put. Also, if sections seem repeated, the group can decide where the material be based, and what can be dropped. Further, if likely readers will find some areas either too elementary or too rushed, those sections can be identified for revision.

Finally, for this stage, students should look again at the abstract. Many conferences separate an abstract from the rest of the paper (e.g., in a conference program), so an author should not assume that a reader will see the abstract and body of the paper together. Thus, the revision the entire draft should check whether these two parts are self-contained and independent.

Feedback and Iterative Development

What follows next over several weeks is an iterative process that may be generally similar for polishing either posters or papers.

Discussion after a first draft of a poster or paper likely identifies large-scale adjustments, moving pieces from one section to another, identifying repeated descriptions that can be cut or combined, correcting misleading or confusing passages, etc. For posters, the overall layout can be reviewed for visual interest and overall appeal. For papers, modest restructuring of sections sometimes may improve the clarity and efficiency of the overall presentation.

With this in mind, a second draft can address general structural matters and basic editing. When authorship involves several students, I suggest a new round of assignments, so each section is reviewed and edited by a different person from the original author. Often, an initial writer becomes invested in particular phrasing or explanation, making reworking of sections and paragraphs difficult. Instead, a new writer can build upon an initial draft, but make changes as needed. As with the first draft, the group should set a realistic deadline for this second draft—long enough to get the job done, but not so long as to invite procrastination.

With a second draft of either a poster or paper, a general framework likely has started to emerge, and a refinement process can start. Often, a poster will seem too busy or a paper will be too long by a few pages. To address such matters, I encourage students to review each component of the work from at least two perspectives.

- *Focus*: Does each part of the poster or each sentence or paragraph of a paper relate directly to the main points being made? After working on a project for a few months, researchers and/or developers may report extensive experiences that might be interesting, but not directly related to the theme and goal of this poster or report.
- *Verbs*: In both student writing and narratives by professionals, I often observe constructs that are long and inefficient, with numerous small words that add little actual substance. Years ago, an editor of mine observed that such passages frequently can be condensed

and made more effective by addressing verbs. A simple example follows:

- Wordy sentence relying upon a linking verb (e.g., is, was) and additional distractions: *It is true that hitting the ball was done with the bat and the ball went a long way.* (18 words)
- Passive verb (e.g., was hit): *The ball was hit a long way by the bat.* (10 words)
- Active verb (e.g., hit): *The bat hit the ball far.* (6 words)

Each of these sentences is grammatically correct. However, the wordy sentence with a linking verb contains many small words, each of which adds little to the result. For example, the phrase, “It is true that” adds no content whatsoever. The second sentence is better, but the verb, “was hit”, brings the reader back to the subject, “The ball”, slowing the reader down and reducing efficiency. The third sentence, with the active verb “hit” is efficient, each word contributes directly to the idea being conveyed, and the reader is propelled from subject (bat) to verb (hit) to direct object (ball).

Over the years, as I have worked with student writing, I have found that recasting sentences to utilize active voice often allows a passage to be reduced by 35%-40%, while adding interest and highlighting ideas.

With each subsequent draft, students can review progress made. For posters, it can be helpful to ask another student for feedback—what goes well, what is confusing, how could this poster be improved? For papers, finding a separate reader or reviewer can present a challenge, but obtaining an objective perspective can be helpful. My colleague, Fahmida Hamid, also recommends asking a non-author to complete a review form (perhaps obtained from the conference), so students become attuned to expectations as they are refining their work.

Submission Process

Since few students have experience attending conferences or submitting posters and/or papers, a faculty mentor may need to take the lead in anticipating deadlines, submission logistics, and funding for conference attendance.

As posters and papers are being developed, a parallel activity should involve logistics specific to an identified conference or journal. Each venue can be different, and all information will need to be ready at the time of submission. For example,

works to on-campus or off-campus venues. Thus, students may need guidance to help them learn about opportunities and encouragement to create worthwhile products as a conclusion of their projects.

Faculty, acting as mentors, can serve

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many ACM conferences require indexing information and a list of keywords, so such information likely should be discussed in advance. All students also might be asked to complete copyright permission forms, for use when needed—often months after a submission is actually made.

Looking ahead further, presentation of posters and/or papers at conferences often incurs costs for registration, travel, and perhaps meals and lodging. In this regard, schools and programs have a wide range of funding sources, but also may have deadlines, processes, and constraints. In some cases, funding may require considerable advanced notice (e.g., months), so preliminary discussions with administrators may be necessary before actual work on a poster or paper starts formally.

Although I am not aware of many cases in which posters and/or papers are accepted, but then have to be withdrawn due to lack of funding or logistical details, such situations do arise. Awareness of local policies and practices can make a substantial difference!

Conclusion

When students perform substantial work on a research or development project, student posters and papers can make a substantial difference in encouraging students, celebrating successes, enhancing program visibility, and attracting prospective students. However, these students rarely have had solid experience in developing and submitting these

an important role in helping students mark their successes with posters and papers—providing experience with common forms of professional communication that students may well draw upon in their subsequent careers. ❖

Acknowledgments

Ideas for this column developed during conversations with my colleague, Fahmida Hamid, and her students in Summer 2019, as they were completing student-faculty research projects. Much in this column reports my reflections on the perspectives raised during those discussions. Further, I appreciate Michael Ernst's writings on poster and paper development [2,3], as his detailed observations have allowed me to skip many such matters here.

References

1. ACM Inroads, Instructions and Forms—link at the upper-right of the *Inroads* Submission Web site; <https://mc.manuscriptcentral.com/inroads>. Accessed 2019 October 23.
2. Ernst, Michael, How to write a technical paper; <https://homes.cs.washington.edu/~mernst/advice/write-technical-paper.html>, updated October 20, 2019 Accessed 2019 October 23.
3. Ernst, Michael, Making a technical poster; <https://homes.cs.washington.edu/~mernst/advice/poster.html>, updated October 18, 2016. Accessed 2016 October 21.
4. Kobulnicky, Henry A; Dale, Daniel A., A Community Mentoring Model for STEM Undergraduate Research Experiences, *Journal of College Science Teaching—National Science Teachers Association*, 45, 6 (2016),17-23.

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DOI: 10.1145/3381880

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