Collaborative Research in Computer Science Education: A Case Study

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ABSTRACT
This paper describes a process for establishing and maintaining a computer science education research group. Its purpose is to tell the story of one long-standing group, describe the benefits afforded by collaborative research groups and provide advice about how to form such a group. The intended audience is faculty members at teaching-intensive institutions who wish to establish or revive a research program in computer science education. We discuss establishing and maintaining a computer science education research agenda in a teaching-intensive environment.

Categories and Subject Descriptors
K.3.2 [Computer and Information Science Education]: Computer Science Education

General Terms
Human Factors.

Keywords
Collaborative research, computer science education research, case study, qualitative research

1. INTRODUCTION
For those of us who genuinely care about teaching and learning, teaching institutions are rewarding environments in which to work. Computer science education research is often valued at such institutions because of the teaching focus. However, due to high concomitant teaching loads and service expectations, it can be a challenge to maintain a scholarship program. We conquered this obstacle by forming a multi-institutional collaborative research group (the Debug Group). We have met weekly, via VoIP, since 2005. As a group, we’ve 1) studied debugging, mindsets, pair programming and qualitative research methods, 2) organized an ITiCSE working group and two NSF-sponsored workshops and 3) published nine papers. Our goal is to offer this as a possible model for other educators who, like us, might be unable to persist in their research without the support of such a group. We have found group collaboration to be both professionally and personally rewarding.

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2. METHODOLOGY
The case study is one of the primary qualitative research approaches. When using this approach, researchers observe and interview participants and examine documents and reports in order to “understand an issue or problem using the case as a specific illustration” [2, p. 73]. A few key themes which shed light on the case are identified. The researcher describes the case in detail and discusses the themes. At the end, he or she reflects on the lessons learned. Context is important [5].

Qualitative research projects commonly collect large amounts of data from a few participants. The participants are actively involved in the research and may be asked to verify the accuracy of the report before it is published [2]. The goals of qualitative research methods are to explore, to generate insight and to create theory rather than to prove hypotheses. Because we want to illustrate the value of collaborative research groups, describe how one such group succeeded and encourage others to collaborate, we chose to tell the story of our ongoing research collaboration as a case study.

In order to recreate the process of forming and maintaining our collaborative research group, we examined minutes from weekly meetings (October, 2005 through August, 2009) and semi-annual face-to-face meetings, traced email conversations and solicited responses to these questions from eleven group members.

- How did you come to join the Debug Research Group?
- Why did you seek out research partners and form or join this group?
- What benefits have you seen from being part of the group?
- Besides the "Debugging" series of papers, what papers or other scholarly achievements have resulted from your participation in this group?
- Have your research practices improved/disintegrated/stayed the same as a result of participating? How and why?
- If you are no longer ‘officially’ part of the group, why did you leave? What impact has being a member of the group had on you, since you left?

We use a case study research approach to relate our experiences. Using source documents including emails, meeting minutes and semi-structured interview questions, we reconstructed the history of our research group and tell its story here. We include our reflections on both the challenges and benefits of our collaboration. Section 2 describes our methodology and Section 3 outlines our history. Sections 4 and 5 describe the benefits and drawbacks of belonging to such a group and Section 6 provides practical advice for organizing a collaborative group and pursuing research in computer science education.
• What interesting thoughts do you have to share with others with regard to this group?
• What practical advice would you give to someone who is interested in forming a similar sort of research group?
• Is there anything else you would like to say?

One group member attended meetings only briefly and declined to answer the questions. Another member who attended for only a few months responded but did not directly answer the questions. In all, nine members responded in detail. Responses to the questions were analyzed by the three authors using thematic analysis. The authors identified themes and argued their analyses to consensus.

3. HISTORY
The Debug Group has been a very successful collaboration for its members. But this didn’t occur overnight. How did this group form, evolve and work together to achieve this success?

3.1 Group Formation
The Debug Group first met in October, 2005, but our story began earlier. All of the original members of the group previously participated in the Bootstrapping [1] or Scaffolding [6] projects. In 2002, Sally Fincher, Marian Petre and Josh Tenenberg set out to create a “community of practice of researchers in computer science education” by organizing the Bootstrapping Research in Computer Science Education project [4]. Fincher, Petre and Tenenberg led two intensive workshops on the design, conduct and management of computer science education research. In the year between the workshops, participants collected data for a joint multi-institutional study. The Bootstrapping project was designed to “foster a community of discourse, in which ideas can be generated, tested, examined and extended” [1]. They repeated the experiment in 2003 and 2004, calling it Scaffolding Research in Computer Science Education [6]. Both the Bootstrapping and Scaffolding projects were highly successful; they spawned a community of scholars eager to engage in computer science education research.

During the SIGCSE 2005 conference, members of the Bootstrapping and Scaffolding groups met to share research ideas. Attendees were encouraged to find others with like interests. One participant expressed interest in novice debugging but noted that extensive research literature existed. She recommended a study of the literature before engaging in debugging research. Later, at an informal working day before ICER 2005, a discussion agenda was developed and the Debug Research Group subsequently began to meet via teleconference. Originally 10-15 people expressed interest in the group. Of those, eight formed a core group who met regularly.

Our initial goals were to:
• review literature on debugging, focused primarily on novice debugging; secondarily comparing novices with experts; not including debugging environments per se but including any qualitative or quantitative assessments of debugging environments;
• publish our findings as a literature review;
• look for a feasible study to replicate.

We were initially motivated to join the group for a variety of reasons, including both an intrinsic interest in the topic as well as an interest in working with this particular group of people:

I was interested in the topic of debugging and this seemed like an enjoyable way to work in this area.

My research interest is novice programmers, and debugging is a very important skill that many novices do poorly. So the interest area of the research group was of interest to me.

I knew about the group because I knew one of the members very well, and when I was invited to join [in late 2007] I jumped at the chance.

Some participants felt isolated at their home institutions:

I wanted to work with [another participant] since our [earlier] collaboration … was fun. To be honest I wasn’t as interested in Debugging as I am in many things. I am isolated in my job and working with other people gives me the chance to talk about issues, do research etc.

I did this for two reasons: 1) to keep me making progress, 2) to have some people to work with, which I enjoy. There was no one at my institution who I wanted to work with.

Other motives for participating were mentioned as well:

The larger group gave us a wider range of students, larger numbers for finding subjects, and more people with whom the work could be shared.

I recall that we did decide to start with reading and literature review and I thought that was a great excuse to force myself to read background papers BEFORE doing a project, rather than after.

3.2 Group Process
Our group used web-based teleconferencing software for one-hour weekly meetings. The teleconferencing facility permitted voice and video transmissions and included a shared white board for note taking and diagramming. We disabled video transmissions for performance reasons.

We designated one participant as meeting organizer and discussion leader. During the meetings, reading homework was assigned to each participant. Each week participants presented summaries of their assigned papers. These summaries evolved into an annotated bibliography which later served as the basis of our published literature review on novice debugging. The summaries and weekly minutes were initially posted to a website. In 2008, an interactive wiki which could be edited by any group member replaced the website.

3.3 Evolution of the Group
Our initial group of eight members met weekly as a reading group for over a year. Two additional participants attended meetings briefly. One did not find the group to be a good fit; the other was unable to attend at the inconvenient local time. Another group member stopped attending after one year, “because of other commitments. It wasn't that the group was low on my priorities, but that I felt that I wasn't consistently pulling my weight.”

Three other group members left in 2008, for a variety of reasons:

I did not have time to be as functional a member of the group as I felt necessary to stay in the group. Also, the topic of the group was starting to drift from debugging and, while also interesting, it gave me an excuse to pull back.
As the only European member I sometimes felt a bit out of the loop, and my other research group had several Europeans, so it was easier for me to meet with in person and I thought it would be more likely to lead to things European, grants, colleagues, kudos at work etc. … We were at a place where it seemed like I could bow out easily, so I did.

I left due to overload of research projects and reduced enjoyment in weekly meetings. … Also, at the time, the group was in a “re-start” phase, where exactly what we wanted to do next was unclear.

A new group member joined in 2008. At present there are five active group members.

3.4 Publications and Other Activities
Collectively, we’ve been quite productive.

As mentioned, we began by studying the novice debugging literature to learn about previous research and to pinpoint what we wanted to investigate further. We identified papers of interest and kept a list of them. When we presented paper summaries in the weekly meetings, we rated some as “must read” for everyone. Many papers led to the identification of other readings, which were added to our list. After many months of reading, we organized our summaries into a literature review, which was published in the journal *Computer Science Education*.

As we read, we identified studies we thought were suitable for replication while simultaneously generating and recording our own ideas. Concurrent with the writing of our literature review, we began to design and implement a research study of novice debugging1. We planned for one semester, collected data the next semester and then met, face-to-face, for four days to analyze our data and organize a report on our findings. We spent the next two semesters working remotely, followed by another multi-day face-to-face meeting to further analyze the data and write-up our findings. The results of this study were published in two journals (*Computer Science Education* and *IEEE Transactions on Education*) and in two conferences (SIGCSE and ITiCSE). We also organized an ITiCSE working group in 2007 that was related to debugging.

Our study of novice debugging led to many discussions about how novices learn to program and about retention in computing. One of our members encountered Carol Dweck’s work on mindsets [3] and the effect that student mindset has on persistence in a course or major. Additionally, as we discussed attitudes toward programming and how they affect persistence and success, our reading broadened. The discovery of the mindset research led a subset of the group to teach students about mindsets and to conduct a simple survey to see if student mindsets had changed as a result. We learned that the simple intervention did not produce the change we had hoped for, but it did lead to useful information which was published as an ICER conference paper. This study led several of us to change the way we speak to students about how they expect to learn challenging, new material.

Thinking more about novices and specifically about those who survived their introductory programming course, we asked the survivors to provide advice to future novice programmers. This advice was presented at the SIGCSE conference.

We also published research on student attitudes toward programming in which we were able to compare attitudes of students learning to program in different languages or under different teaching models (traditional, media computation, etc.).

As we dug deeper into our investigations of novices, we found it necessary to learn more about how to conduct good educational research. Our backgrounds as computer scientists, we discovered, did not always prepare us for the research we wanted to conduct. With external support we organized two workshops: a statistics bootcamp and a workshop on qualitative research methods, both held in conjunction with ICER conferences. These workshops brought in many like-minded researchers in addition to our group.

4. BENEFITS
Group members identified many benefits of participation. Perhaps the most commonly cited benefit was that participation in the group made it easier to get things done and to make progress on research projects:

Being in the group helps me keep my research moving forward, because the weekly meetings provide ‘mini-deadlines’ that help motivate me to accomplish something.

The regular meetings force me to do something research-related every week. Without this group, or something similar, I would focus almost exclusively on teaching.

Related to this was the notion of sharing the workload, especially when outside commitments interfered with research time:

Having different people be able to take ‘the lead’ in time critical things (editing a paper, etc.) when personal teaching deadlines keep me from doing something.

It also turns out to be easier to hit deadlines because there are others around to pick up the ball when you cannot.

Group members also discussed how being in the group has improved their research:

You develop better research studies because more people critique them.

My research practices have improved. I have learned what makes for good/bad data and good/bad questions. What makes a study low or high cost is clearer to me.

I’ve learned a lot about educational theories that I would not know otherwise, and I’ve used research techniques, particularly qualitative ones, that I would probably not otherwise [have] used.

Some members noted that participation in the group made them more productive.

Another common benefit cited by the participants was the sense of community that developed, and how being in the group helped members avoid isolation:

The group provides a set of people to talk to about CS Ed research. As I am in a small department in a college that is geographically isolated, this is extremely important to me.

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1 This study was supported, in part, by an NSF grant that covered data transcription costs and travel costs for two face-to-face meetings.
I have no research colleagues in education at my own institution, so the weekly meetings were great in terms of giving me a community to belong to and that 'spoke the same language'.

Several members felt that participation in the group allowed them to work on larger projects:

The larger group gave us a wider range of students, larger numbers for finding subjects, and more people with whom the work could be shared.

...gathering much larger data sets than I would be able to alone, and multi-institutional ones.

I teach at a small institution, so one of the great benefits is being able to collaborate on larger multi-institutional studies.

The research led to changes in teaching:

I think this has helped broaden my perspective and also led to improvements in my teaching.

I would take suggestions and ideas from our discussions and immediately incorporate them into my everyday teaching.

Finally, participating in a group is fun!

Our weekly meeting is often the highlight of my week.

I enjoy the meetings - it has added to my social life!

Paper writing by committee can be fun and easy.

5. CHALLENGES

There have been a few challenges along the way. As time passed, we’ve struggled a bit to stay focused. Progress slowed at times as we discussed what to investigate next.

As the group evolved, so did our interests. Some of the group members were very busy with other commitments and several were engaged in research projects with other partners. I think the group was just tired of reading about debugging so we started exploring several different ideas. We became more fragmented and less focused on debugging specifically. At that point, several group members left. Those remaining were a bit fatigued and it’s taken us a while to refocus.

Technological support is key to meeting productively across long distances. Our experiences with teleconferencing software have been stressful at times as we attempt to communicate from a variety of platforms, operating systems, browsers and locations. It is not uncommon for one or more participants to have problems hearing or speaking during meetings. Despite the technical challenges, we regret that our current software product has been discontinued. We expect to invest both time and effort in finding and learning its replacement.

Finding a commonly acceptable meeting time is our largest ongoing challenge. As discussed earlier, having a weekly meeting is important to maintain progress and to provide a sense of community. However, finding a common time is problematic. We reschedule the weekly meeting at the beginning of every academic term in order to find a time that works for everyone. Often, someone has to leave a few minutes early to prepare for class, or has the meeting occur during their lunch hour.

Originally, the group included members from outside of North America. However, the wide range of time zones led to very inconvenient meeting times for some members:

Right now I don’t remember if that meant that the meetings would be at 23:00 - 24:00 or 24:00 - 01:00 my time but the end result was that before I was able to go to sleep the clock would be 01:00 or 02:00 (wind-down time) ... which meant that I would get 4 or 5 hours sleep those days.

6. ADVICE

Having persevered as a group since 2005, we offer the following guidance to colleagues who may be interested in traveling a similar path. This guidance is as much about being successful in education-based research as it is in being successful as a group.

6.1 Distributed collaboration

Our productivity is due, in great part, to our effectiveness as a group. We believe that the following advice will allow others to form similarly effective research groups.

Be active in searching out others with interests similar to your own. Research partners provide motivation and keep us on task. When we have spoken at meetings such as the CRA-W Mentoring workshop about our experiences, several participants expressed an interest in forming similar groups, so the question is, how do you find collaborators? Potential collaborators attend SIGCSE symposia and often participate in BOFs, ITiCSE conferences and working groups, CCSC conferences and NSF-sponsored workshops. They also read the SIGCSE list. Intensive workshops are good places to make lasting connections.

Establish a regular meeting time. How can a group keep going, despite the daily pressures of teaching that swamp us all? Our group meets for one hour each week. Our weekly meeting motivates us to set personal deadlines and make progress. Meeting times may change from semester to semester, as teaching schedules change. We recommend weekly or bi-weekly meetings.

Determine a meeting interaction-strategy. Our meetings are democratic, but we do depend on a leader to establish the meeting agenda, keep and post minutes and assign action items. Because teleconferencing requires a higher than normal degree of respectful listening, we find it useful for our leader to moderate our discussion, bringing us back on-topic when needed. Other groups manage successfully without a specified leader. Be flexible, the appropriate interaction-strategy may have to be determined over time.

Set goals. At the start of each term, we agree on goals and set deadlines for various activities.

Be flexible. As busy, engaged teachers and researchers, we juggle multiple demands. The demands vary over time and from person to person. As a group, we’ve come to realize that each individual’s contribution will vary from project to project. Members engage most fully with those projects which match their interests and availability. We keep multiple projects going in parallel so projects are often at different stages of evolution. The leadership role changes from project to project.

Use collaboration tools. The Internet and collaborative technology have made it possible for us to work together effectively. As noted above, we use a VoIP teleconferencing program for our weekly meetings. Other technologies that we find useful include Google
does for maintaining shared documents and spreadsheets, CiteULike (www.citeulike.org) for managing citations and web sites and wikis for organizing our experimental resources. These tools facilitate sharing and help ensure that we are all using the same version of documents or data.

Meet face-to-face at least once a year. We meet annually during the SIGCSE symposium and other conferences if several of us attend. These face-to-face meetings revitalize the group and add an enjoyable social element. We were fortunate enough to receive external funding for two intensive four-day face-to-face meetings in 2007 and 2008, where we were analyzed data, wrote-up results and made plans for the future. These intensive meetings were highly productive.

Enjoy your research collaboration. Our group members continue to enjoy each other although some group members have moved on to other topics or groups.

6.2 Education-based research

When we discuss education research, we mean empirical research related to learning, teaching methods, tools and learning environments, rather than experiential reports on pedagogy or classroom practice. In particular, computer science education research investigates educational practice within the context of teaching computer science. Our experiences suggest useful advice on doing computer science education research well, in addition to the practicalities for forming and running a group.

Learn about qualitative research methods. Over the past thirty years or so, educational research has evolved to include qualitative as well as quantitative explorations. Quantitative research, such as experiments with control and treatment groups, is useful for determining whether a pedagogical technique or tool works. However, it does not offer insight into why or how things works; this is where qualitative research comes into play. Qualitative methods are more focused on the participant’s view of a situation, rather than placing them into artificial or contrived experimental situations [2].

Trained as computer scientists, we were familiar with quantitative methods but had little exposure to qualitative ones. To fill this gap, we read about and discussed these techniques as a group. One group member took an education research course at her university. We also organized a workshop so that we and others could learn from an expert.

Find a local statistician. For quantitative research projects, having a contact or a group member who is comfortable with statistical techniques is very helpful. We found it especially helpful to have access to such a person when critically analyzing published literature as well as our own findings.

Pick a topic of interest and start reading. Problem identification happens naturally in an educational setting. We found our research questions when we observed problems among our students, struggled with techniques for teaching a concept, or realized we were dissatisfied with results at the end of a course. We picked topics we truly cared about and did not limit ourselves to reading only computer science journals. The other sciences have well-established education research journals and conferences from which we learned.

Keep an annotated bibliography. The natural place to start, in attempting to solve a problem, is to review the literature and look for previously identified solutions to it. Our practice is to write a brief summary of everything we read – it helps us keep the information organized (and not forgotten) and in more than one instance has formed the basis of the background research for a paper or grant proposal. Through review of the literature, we have found studies that we wanted to replicate or refute.

Do not assume that everything published is good. We critically assess the research that we read. Not all published research is of high quality or worthy of replication. Building on existing work is necessary, but it is important that the research that we build upon be valid. We constantly question procedures and conclusions that are not convincing.

7. CONCLUSION

Participation in the Debug Group has been incredibly rewarding. We have learned a lot about students’ struggles, motivations, and attitudes, we’ve become better researchers and we have published extensively. By focusing our research on issues in computer science education, we believe that we have also become better teachers.

We hope that our experiences might serve as a model for other computer scientists who would like to conduct education-based research, but find it difficult to do in teaching-oriented institutions.

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9. REFERENCES


