Maria Zamfir-Bleyberg

None

Jan Chomicki

Editor: Workshop on Deductive Databases
Reviewer:
      ACM Transactions of Database Systems
      Journal for Computing & Systems Sciences
      ACM Computing Reviews
      International Conference on Database Theory
Talks:
      University of North Carolina, Chapel Hill
      University of Pittsburgh
      Arizona State University
      Texas A & M
      University of New Mexico
      Ohio State University

Olivier Danvy

Referee:
      PLILP 1990
      RTA 1991
      MFPS 1991
      PEMP 1991
      ACM Transactions on Programming Languages and Systems, 1990
Talks:
      Stanford University
      Northeastern University
      MIT
      Harvard University
      Yale University
      Carnegie Mellon University

David Gustafson

Talks:
      Topeka chapter of DPMA

William Hankley

Reviewer:
      ACM Computing Reviews
      Hawaii Systems Conference
      IEEE Transactions on Software Engineering

Rod Howell

Referee:
>IEEE Transactions on Parallel & Distributed Systems
>11th International Conference on Distributed Computing Systems

Austin Melton

Referee:
>NSF
>IEE Software Engineering Journal

Program Committee for 7th Intl Conf on Mathematical Found of Prog Semantics
Program Committee for CSC 1992

Masaaki Mizuno

Conference Stream Chair, 1991 Symposium on Applied Computing

K. Ravindran

Referee:
>IEEE Computer Journal

Dave Schmidt

Reviewer:
>1991 Conf on Mathematical Foundations of Programming Semantics
>Conf on Partial Evaluation & Semantics Based Programming
>Louisiana Board of Regents
>Journal of Formal Aspects of Computing
>Journal of Automated Reasoning
>John Wiley Publishers
>Oxford University Press

Elizabeth Unger

Reviewer:
>Editorial Board, Journal of Information Management Systems ACM Computing Reviews Prentice Hall
>Addison Wesley Little Brown Benjamin Cummings Merrill

Reviewer of conferences:
>ACM CSC ACM/IEEE WAC 1990

Consultant to the Louisiana Board of Regents on Computer Education
Leadership and Organization:
>ACM Sigsmall Vice Chair (elected office by ~7000 members) ACM Sigapp Secretary (appointed office this
>year) ACM Sigsamll General Chair of the 1990 Conference WAC 1991 Co-program chair for annual meetings

Talks:
>University of Missouri--Kansas City

Virgil Wallentine

Program Co-Chair for 1992 National Computer Science Conference.
Reviewer:
>Harper Collins Publishers
>IEEE Software

1990 ACM Symposium on Applied Computing
Reviewed tenure decisions for two other CS departments
Program committee for 1990 ACM Symposium on Applied Computing
Program committee for 1990 ACM Symposium on Personal and Small Computers

A Beginner's Guide to PhD Research

Computing and Information Sciences Dept.
Kansas State University
Manhattan, Kansas

November, 1989

Preface

Several years ago, I chanced upon an internal report distributed by the Artificial Intelligence Department at Edinburgh University. The report, called *The Researcher's Bible**, was a helpful list of do's and don't's for the beginning PhD student. I have distilled from that report information useful to PhD students in the Computing Sciences Department at Kansas State University and added material specific to the requirements of our Department. The Computing Sciences Faculty have proofread the result and made several improvements (I hope!). I hope that you, the beginning PhD student, will find this report helpful to you in your PhD studies.

David Schmidt
November, 1989.

---

* By Alan Bundy, Ben Du Boulay, Jim Howe, and Gordon Plotkin. D.A.I. Occasional Paper 10, Artificial Intelligence Dept., Edinburgh University, Edinburgh, Scotland, Sept. 1978.

Introduction

If you are a PhD student, your objective is to obtain a Doctor's degree. Through the actions you take to get the degree, you learn to do research. What is research? A dictionary states that it is "scientific investigation or inquiry." Such a definition is of little help when you attempt research for the first time.

This report provides some guidelines for doing research and obtaining the PhD degree.

The general requirements for the PhD degree in computing science are:
1. Coursework: You must accumulate 24 credits of coursework work beyond the M.S. degree.
2. Initial research paper: During your first year of studies, you must write a paper on a topic of your choosing.
3. Preliminary exams: By the end of your second year of studies, you must pass 3 written exams and 1 oral exam.
4. Dissertation: You must research, write, and successfully defend a dissertation.

The exact requirements for 1. to 4. are given in the "Guidelines for the PhD Degree" booklet that is distributed by the Department, so we will not repeat them here. In the sections to follow, we will describe some strategies you can undertake to satisfy the requirements and obtain your degree.

I. Coursework

Coursework gives you background for doing dissertation research. The topics of PhD-level courses are not "cut and dried"; issues of current debate in the computing research community are often presented. When attending these courses, you should be a questioning, "skeptical" student: ask questions of the instructor, the course readings, and yourself. Do the topics of the course seem important to computing? Do the proposed solutions sound reasonable? Are any important issues overlooked? Is the instructor presenting the material in a way that makes it interesting and useful to you?

Such questions awaken your budding research skills. A person can do research only if there is an interest and a need to investigate a topic. You can encourage your research intuitions by striving to work beyond the requirements of your courses. Extra background reading, completion of optional homework exercises, and discussions with classmates outside of lectures can help. Discussions are particularly helpful, because new ideas are often created in conversations with others. Also, coursework and research are more fun when people perform it in common.

The University requires that you accumulate 24 coursework credits; this takes about three terms to satisfy. You should spend the first one or two terms "shopping around" for interesting topics and instructors. By the beginning of the third term, you should make a decision as to which areas of computing interest you the most. The third (and subsequent) terms should be spent taking

advanced seminars in those areas. If your chosen area of interest does not match the courses offered in your third term of study, you might contract with a faculty member to study a topic independently for course credit CIS798, CIS890, or CIS990. This is an excellent way to prepare for researching, as independent background reading is essential to any research work.

II. Academic Advisor

Your initial efforts in the PhD program are supervised by your academic advisor, who is assigned to you on your entry into the program. The academic advisor's responsibilities are to help you schedule your coursework, monitor the writing of your initial research paper, encourage you to select a Supervisor, and guarantee that you will be prepared to take your preliminary exams on schedule. (See Sections III.-V. below.)

The research interests of your academic advisor might not match your initial interests, and you should not assume that your academic advisor will become your research supervisor. Your academic advisor acts as a "temporary supervisor" until you find a permanent one.

III. Initial Research Paper

By the end of your first year, you are required to write a paper, called the *initial research paper*, on a topic of your choosing. Writing the paper gives you a first experience at reading background literature, collecting ideas, and presenting the ideas in a unified way. The Department uses the term paper to verify that you have elementary reading and writing skills. (It is better to discover such shortcomings the first year than to deal with them in the midst of writing a dissertation!)

You are encouraged to write your paper in combination with a course that you take in the first year of studies. Don't worry about whether or not the topic of the paper matches your "real" interests— the purpose of the paper is to test your writing skills, *not* to start you on the first draft of the dissertation! Obtain your academic advisor's permission before you start the paper. If you have no topic in mind for the paper, your academic advisor will suggest one.

The paper should be 10 to 20 pages in length, with a bibliography of 6 to 10 references.

IV. Supervisor

The most important step you take at the end of your first year of PhD coursework is the selection of a major professor (hereafter called your *supervisor*). Your supervisor's primary duty is to manage your dissertation research, but your supervisor also helps you form a supervisory committe, schedule exams, and handle other administrative matters.

Select a supervisor that is *capable*, *concerned*, and *compatible*. First, your supervisor must be capable of understanding and managing your research work; this normally requires that the supervisor has researched and published in the area you plan to study. Second, your supervisor must be concerned enough about the topic you select that the supervisor will take a personal interest in your work. Finally, you and your supervisor must have compatible personalities, because the two of you will be working together for several years.

In a small department like ours, it is sometimes impossible for you to obtain your first choice of supervisor. Some professors have a "full load" of advisees, and they are unable to work with any additional students. If this happens to you, don't get discouraged. Consider other professors and remember that, at this early stage of your studies, there are many research areas that will prove interesting to you once you learn a bit more about them.

With the cooperation of your supervisor, you will formulate a *program of study*, which lists your coursework, supervisory committee, and chosen area of research. Your coursework and committee must complement your chosen area of research: coursework should include specialty courses in the research area, and the committee should include people who research in your chosen area. The department head has final approval of the program of study.

V. Preliminary Exams

By the end of your second year, you take the three written preliminary exams. By passing the exams, you verify that you have fundamental knowledge in three main areas of computing. You should select the three exam areas based on topics you like and topics you might eventually research, since preparing for the exams becomes more pleasant when you know that your studying is preparing you for the first stage of your dissertation work. The exams are based on the material in the fundamental graduate courses, so you should take the fundamental courses in the three areas you select for the exams. A list of courses and topics is given in the "Guidelines for the PhD degree" booklet.

Reading lists for the written exams are available approximately 3 months prior to the exams. Contact the chairman of the graduate studies committee to obtain the reading lists. You should start studying as soon as you receive the reading lists. Some students wait too late to begin studying and thereby place unneeded pressure on themselves. You may find it helpful to form a study group with other students who are taking common exams. But beware— do not trust other students to research an exam topic and then give their notes to you! Their notes may be incomplete and inaccurate, so read for yourself all the items on the reading lists. Earlier versions of the exams are usually available. Ask the chairman of the graduate studies committee for copies.

The usual format for each exam is a closed-book, four hour, pencil-and-paper test, but you should check with the chairman of the graduate studies committee for verification. An exam will contain factual questions, questions that require analysis of standard results, and questions that require synthesis or construction of new results. The exams are meant to be a bit difficult, so don't be too distressed if you fail one or more of them the first time. You are given a second chance to pass the exams, and you will certainly learn more about an area if you take its exam twice!

Meet with your supervisor as soon as you pass the written exams to schedule the oral exam. Your supervisor will contact your supervisory committee members and set the format of the exam.

Your supervisory committee will review your academic progress at the oral exam. The committee may choose to test your knowledge of computing, although they are more likely to focus on your intended research directions. Be prepared to describe your research interests and possible dissertation topics; in turn, your committee will contribute ideas towards your research proposal. Based on your performance, the supervisory committee votes to pass or fail you. If the committee votes to pass, they will sign your preliminary exam ballot and return it to the Graduate School.

VI. Dissertation

The bulk of your time in the PhD program will be spent on research. The research leads to the writing of a dissertation, which is the evidence you submit to the Department and University that you can perform original research of high quality.

What is a dissertation? The *Graduate Faculty Handbook*, which is the University's standard reference for such matters, merely states:

> Regardless of the form used, a thesis or dissertation shall be sufficiently complete so as to allow an independent investigator or scholar to repeat and/or verify all of the work leading to the author's results and conclusions. In certain cases, where a manuscript prepared for publication is to be used, the terseness or page restrictions required by a professional journal may prevant an author from meeting this condition with the publishable manuscript alone. In such instances the thesis or dissertation must include additional materials which will insure independent reproducibility.

This information isn't very helpful! The reason the description is so vague is that the format for research and the dissertation vary from discipline to discipline. Computing, currently being a half-science, half-engineering discipline, has no set tradition for its research and dissertations.

The following quote from the article *Computing as a Discipline** sheds some light on what should be expected of a computing science dissertation:

> The three major paradigms, or cultural styles, by which we approach our work provide a context for our definition of the discipline of computing. The first paradigm, *theory*, is rooted in mathematics and consists of four steps followed in the development of a coherent, valid theory:
>
> (1) characterize objects of study (definition);
> (2) hypothesize possible relationships among them (theorem)
> (3) determine whether the relationships are true (proof);
> (4) interpret results.
>
> The second paradigm, *abstraction* (modelling), is rooted in the experimental scientific method and consists of four stages that are followed in the investigation of a phenomenon:
>
> (1) form a hypothesis;
> (2) construct a model and make a prediction;
> (3) design an experiment and collect data;
> (4) analyze results.
>
> The third paradigm, *design*, is rooted in engineering and consists of four steps followed in the construction of a system (or device) to solve a given problem:
>
> (1) state requirements;
> (2) state specifications;
> (3) design and implement the system;
> (4) test the system.
>
> Computing sits at the crossroads among the central processes of applied mathematics, science, and engineering. The three processes are of equal— and fundamental— importance in the discipline, which is a unique blend of interaction among theory, abstraction, and design.

---

* By Peter Denning, et. al, *Comm. ACM* 32-1 (1989) 9-23

Your PhD research should encompass at least one of the three paradigms just described. The dissertation is a documentation of the steps you took to fulfill the paradigm. A dissertation in computing might span more than one paradigm (e.g., a dissertation based on the design paradigm might also contains proofs of correctness of parts of the implementation, or a dissertation based on the theory paradigm might also contain implementation of some of the concepts studied), but the dissertation's main characteristic is that *an idea is developed and then validated by means of a rigorous proof, a simulation, or an implementation.* The validation must clearly demonstrate that the research idea is a sound contribution to computing knowledge.

How much work goes into the dissertation research? People have suggested various "rules of thumb"; we suggest that the results in a dissertation should equal or exceed the results found in one quality journal paper. This does not mean that you must publish a journal paper before you receive the degree, but some minimum quality and quantity of results must be met before the supervisory committee deems the research completed.

VII. Research Topic

Your supervisor will recommend background readings in your area of interest. You should also visit to the Departmental and University libraries and explore the reports, books, and journals related to your area. Write a note card for each paper or book that you study (or would like to study, if you can't find enough time!). This helps remind you what you've learned and what you've liked.

Your supervisor will soon ask you to try your own hand at problem solving. You may be asked to duplicate experiments, implementations, or proofs similar to the ones found in your readings. Problems uncovered in others' research will present themselves, and these often provide starting points for your own work. Or, your supervisor might present a family of problems in your area and ask you to try solving some of them. Soon, you and your supervisor decide upon the problem area you will research.

In *The Researcher's Bible**, Bundy, et. al., state these criteria that a problem should satisfy:

1. You and your supervisor must be enthusiastic about solving it.
2. The solution of the problem must be worthy of a PhD degree, that is, the results you create must satisfy the "one journal paper" rule.
3. It must be within sight of the state of the art, that is, it must be solvable within three years of research work.

The importance of criteria 1. cannot be overstated! Dissertation research is hard work, and you will need all the enthusiasm you can muster. Your supervisor's enthusiasm is also important, because you must count on your supervisor's help when you are lost or stuck. In addition, not only will you be working on your research problem for several years to obtain your degree, but when you continue work after your schooling, you will likely be building on your results.

When you choose a problem, avoid the following traps:

1. Solving the world: Don't pick a research goal that's too ambitious. Read the literature and talk to fellow workers to find out what the state of the art is. One good source of ideas is

---

* All of the numbered lists given here onwards are adapted from *The Researcher's Bible.*

the "further work" section of research publications. Read the literature carefully. Another starting point is redoing others' bad work, but properly.

2. Manna from heaven: Don't choose a topic with no obvious starting point. It does no good to sit in your room with a blank piece of paper and a pencil, waiting for insights to come down from above.

3. Hacking: Don't just write code. You can spend years at a terminal, modifying and extending code. You get a sense of achievement when an error is exposed or a nice output is printed. This "progress" is illusionary. Your program must be explainable at a higher level than code for it to make a real contribution to computing. Recall the design paradigm: a system should be implemented only after requirements and specifications are set.

VIII. Research Proposal

Before you begin your dissertation research, you must have the approval of your supervisory committee. The approval is given at the research proposal meeting. The purpose of the meeting is to demonstrate to your committee that you have conducted adequate background reading, you have chosen a problem to investigate, and you have selected a paradigm and specific techniques to solve the problem.

You must write a proposal paper. It should contain:
1. A statement of the problem.
2. A survey of the area in which the problem arises and earlier efforts at solving the problem.
3. A description of the proposed research, stating the paradigm to be used to solve the problem, how the problem will be solved, and what are the expected results.
4. An account of any work you have done on the problem to date.
5. An approximate timetable.
6. A bibliography.

Expect your supervisory committee to ask critical questions. They must verify that you have chosen a problem worthy of a PhD degree and that you have the preparation and potential to complete the degree. Expect your committee to suggest revisions to the problem, the solution method, and the timetable. And if your proposal meets with skepticism, expect your committee to require a second proposal paper and meeting.

A change of supervisor or research topic necessitates another research proposal meeting.

IX. Research

Doing research is difficult, full-time work, and you should treat it no differently than any other full-time job: you must work regular, significant hours, and you must expect that progress will be uneven. You must also accept the following "facts of life":
1. Academic life is competitive and lonely: One fears one's own failure and the success of others. Often one's research interests are not shared by coworkers.
2. Getting down to work is hard: There are always pressures which make it easy to avoid research work, e.g., teaching or coursework. Starting in the morning is almost always hard, as is "changing state" from teaching to attending lectures to researching.

3. Solving problems is hard: One tends to avoid them and hope that they will go away or one tries to solve them all at once.

4. Reading is difficult: The difficulty seems to depend on the stage of academic development. Initially it is hard to know what to read. Later, reading becomes seductive and is used as an excuse to avoid research. Finally, one lacks the time and patience to keep up with reading (and one fears to find evidence that one's own work is second-rate or one is slipping behind).

5. The dissertation seems all-or-nothing: Once one has embarked on doing a dissertation, there is no "safety net," e.g., an "almost-PhD" diploma.

This list is a bit depressing, but it's important for you to know that everyone who does research faces the very same hurdles that you do. So, don't get discouraged if you encounter one of the above "facts" in your own work!

You can make best progress at research if you develop good work habits. Here are some tips that you might find helpful:

1. Getting started: Make a regular working schedule, and stick to it. It doesn't have to be 9am to 5pm, but there should be a definite time of day when you start work. Otherwise, you will find yourself postponing research with endless, routine, domestic chores. When you do start your work each day, begin with something easy. A good strategy is to finish a section or small problem that you left unfinished from the night before. Or, find an easy task associated with the work that you can do, e.g., a diagram or some typing. Combat the "blank sheet of paper" syndrome by getting a binder labelled "Dissertation" into which you can put bits of the research as you develop them.

2. Combatting isolation: Find a friend to whom you can talk when you need feedback. Write or send E-mail to others who work in your field. See your supervisor on a regular basis— at least once a week— and give your supervisor notes that describe what you have been doing. This creates a basis for discussion.

3. Imposing structure on your ideas: When faced with a problem, divide it into smaller subproblems. Tackle the subproblems one at a time. If a problem seems too hard to solve in its current form, and it is not clear how to subdivide it any further, try to solve a simpler version of the problem and then generalize your simpler solution to a solution for the more general case. (Example: Rather than proving all programs in a computer language have "Property X," begin by proving that some subset, say, the "structured programs," have Property X. If you can't prove it, try restricting the set of programs further or weakening the property to a "Property Y" such that Property X implies Property Y. Once you complete a proof, analyze it and try to generalize it to a larger class of programs or a stronger property.)

4. Writing: Write notes and papers to yourself. The notes serve as a "diary," documenting what approaches did and did not work. They also serve as a sourcebook for inspiration and strategies that might be useful in the future. Once you have made concrete progress on the research, draft a working paper that your friends and supervisor can read. Ultimately, these working papers will form a first draft of your dissertation.

5. Imposing a structure on your working life: Set short term deadlines for yourself. Scan the journals and newsletters for announcements of conferences in your area, and write papers by the submission deadlines for the conferences. If your paper has concrete results that seem of quality equal to those in published papers, submit the paper for possible publication.

6. Avoiding research roadblocks: Sooner or later, you will encounter a problem that you just can't solve. Rather than falling into the trap of the "blank sheet of paper," admit (temporary) defeat and back up. Go to the library and read the literature related to the problem you are trying to solve. It is amazing how much better one understands a research paper when one has been trying to solve a problem similar to the one described in the paper! Talk to your supervisor and friends. Often, new insights arise when you describe your difficulties to others. Finally, don't be afraid to back away from a problem for a month or two. Give your mind a rest and work on some other topic related to your research. It is not unusual for a researcher to spend a year trying to solve a small, well-defined problem, so don't get discouraged if you work several weeks and can't find a solution.

Your research will take one or more years, and it is possible that you will adjust your original research problem and solution strategy based on the work you do over that time. Any significant change of problem or solution method (e.g., changing from the theory paradigm to the design paradigm) must be reported to your supervisory committee.

Finally, you might wonder when you have accumulated enough results for your dissertation. Remember the "journal paper rule": the results should be of quality and quantity equal to that found in one quality journal paper. Your supervisor can help you decide whether your work has reached this point.

X. Dissertation Document

When is it time to write the dissertation? Some people begin writing once the bulk of the research is completed, and clear cut results have been achieved. Others will write while the research is being conducted. (Background chapters can be written almost any time.) If you have been fortunate and published research papers in conferences or journals, use the papers as a basis of a first draft of the dissertation.

The dissertation presents the results of your research and satisfies the promise of your proposal paper. It should include:

1. A statement of the problem.
2. A survey of the area in which the problem arises and earlier efforts at solving the problem.
3. A description of your research work, stating the paradigm used to solve the problem, the specific methods used, and the problem's solution.
4. Conclusions and future work.
5. Bibliography.

Your supervisory committee's job is to verify that your dissertation achieves the standards set by the University and Department for a degree. Don't surprise your committee by solving a different problem than the one you presented at your proposal meeting. In turn, they may surprise you! It is a good idea to meet with each of the members of your committee a month or two before your final examination so that any potential wrinkles are ironed over. Your supervisor can be of great help in ensuring a smoothly run final examination.

XI. Publications

The Department requires that you write at least one research paper based on the results in your dissertation. The paper should reflect the very best aspects of your work. It is the evidence to the world that you have made a useful contribution to computing. You are writing the paper not only to satisfy a Departmental requirement but to help your fellow researchers.

There exist a wide range of journals, conferences, and workshops that print papers on computing. Journal publications describe completed research projects, conference papers present results of work in progress, and workshop papers state preliminary results or proposals. Standards of refereeing vary from excellent to haphazard to nonexistant, but as a general rule, journals have better quality refereeing than do conferences than do workshops. Many academic departments count only journal papers as "publications" due to the lack of uniform quality refereeing in conferences and workshops.

Your goal should be the publication of your paper in the best journal in your research area.

Try to write clearly and simply. The most important results are useless if they can not be explained clearly to others. Model your paper after those papers you read that you found useful and enjoyable. Keep the paper brief and to the point.

There is no time restriction on when the paper is written: you may choose to write a research paper before, during, or after the writing of the dissertation. Your supervisor can help you decide.

Conclusion

Virtually no one is a "born researcher." The skills needed for research are best developed through study of others' results and one's own practice and persistence. The techniques listed in this booklet have been used successfully by many researchers in computing. Give them a try.