
Developing Concepts and Practices of Research in Computing

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Abstract

Typically a graduate research methods course for a discipline has at least two goals: exposure to the relevant body of knowledge associated with the discipline and coverage of the accepted research styles associated with the discipline. One way to accomplish this is to prescribe to the class a pre-determined collection of published, refereed papers. These papers provide the opportunity for students to become familiar with accepted norms for the structure and style of published research papers in the discipline while simultaneously becoming familiar with discipline-specific knowledge and procedure threads. In this paper, we describe an alternative approach for a course that is shared by different computing disciplines. This approach focuses on the research process itself through a semester-long project that involves preparation of a document that conforms to an accepted format and style for the discipline. Rather than all students examining a predefined collection of papers, each student is responsible for identifying a topic of interest and for finding a faculty mentor to provide guidance for the literature associated with the topic.

Keywords: Research Methods, Research Ethics, Annotated Bibliographies, citations, graduate computing research, finding credible research papers

1. INTRODUCTION

Regional accreditation agencies require that students in a discipline be exposed to the research methods associated with that discipline. A standard approach is for research faculty in a discipline to agree upon a collection of research publications that are required reading in the course. Ward (2004) and Shaffer (2006) explored alternatives for preparing students of varying backgrounds for research. Their population consisted of students in the same discipline but of different academic ranks and different research experiences. Our students, however, have interests in information systems (IS), computer science (CS) and software engineering (SWE). Occasionally, advanced undergraduates in a five-year bachelor

and masters program enroll in the course. Moreover, our students are given three concentration options for completing the masters: thesis, project, or course-only. The challenge, therefore, is to satisfy regional accreditation requirements for research instruction for graduate and undergraduate students with different discipline interests and different concentrations.

As Gallupe (2007) has reviewed, a struggle within the IS discipline is significant as indicated by the title of his paper "The Tyranny of Methodologies..." We encounter an even larger set of issues when facing incorporating an approach acceptable to multiple computing disciplines. Holz, et al (2006) identified at least 54 specific computing research methods

including Design Research (Haynes, et al, 2009) and new thinking on interpretive research (De Villiers, 2006). Glass et al (2004) studied 682 research papers from the IS, CS, and SwE research literature. They classified the papers by topic, research approach, research method, reference discipline, and level of analysis. They clearly identified significant differences in the disciplines based on their findings. Although they expressed a desire for amalgamation, they recognized that "there is a tendency for each of the fields to disdain the work of the others" (Glass, et al, 2004), and even block promotion and tenure of faculty from other fields. Nonetheless, we find the Glass paper to be very instructive for our students and use the paper to provide a good introduction into the diversity of the computing discipline.

The writing skills of our student population are similar to those of Ward (2004) and Shaffer (2006). Our students come to us with little to no experience in research, indeed they are novices (Holz et al, 2006). Many of them are not very good writers, and for many English is a second language. The implication of research is that the targets must be at Bloom (1956) levels 4, 5, and 6. However, many of the tools of research involve learning skills of, in fact at levels 1 - 3. In addition, we feel that attitudes towards research require a detailed knowledge of responsible conduct. And, we believe that the process of writing a research proposal provides opportunity to practice techniques of the research process. We encourage, but do not require, students to seek out members of the faculty to help identify problems of significance, and also to review and mentor the students who desire their assistance. Faculty—student pairs who work well together may proceed to either a master's project or thesis work. In this case the writing activity may very well become the basis for the student's actual prospectus, or alternatively, a basis for a faculty-student collaborative effort to submit to a journal or conference.

The remainder of this paper consists of a description of each of the major components of the course and challenges that might be encountered during the delivery.

2. RESEARCH IN COMPUTING

Identify what constitutes research in computing: What establishes credibility?

Explain differences between refereed and non-refereed publications in computing.

Ultimately what will establish the quality of research depends on the ability to know or find literature related to a problem of interest. Novice students have almost no comprehension of the difference between peer reviewed material and non-refereed work. Two common characteristics are provided as guidance for identifying peer reviewed works. First, the publication in which the work appears will have a policy statement that specifies a peer review process and criteria for acceptance. Secondly, the work in question will build upon the work of others, i.e., many of the referenced works will appear in publications that also require peer review. Additional guidance based on document format and components common to research oriented work is provided according to questions 3, 10, and 11 in Salkind (2011). Moreover, library search engines typically provide an ability to filter searches for peer reviewed publications. Other evidence of credibility can be found by using tools such as Google Scholar to find the extent to which a work has been cited, and by whom. The higher the number of citations, especially by those with expertise in the field, the higher the quality of the reference found. Likewise, lists of journals rated by experts in the discipline enhance the likelihood that a given paper in one of the better rated journals is of quality. Faculty mentors can provide guidance to beginning researchers by helping them review papers of known quality that illustrate desired methodologies and approaches that the mentor finds acceptable. Students will learn soon enough that not all mentors see things the same way. The initial interactions between faculty and student will establish the mutual desire of each to work with the other, as well as the approach to the research. That is, while faculty see approaches very differently among themselves, it will be important for the student to select one faculty member who seems compatible with topic interests as well as approaches. In addition to guidance for identifying research, a general discussion is given of scholarship as described by Ernest Boyer (Boyer, 1990). The descriptions of *scholarship of discovery* and *scholarship of application* provide meaningful insight to students who choose the thesis and project options in our programs.

List and describe research methods used in

computer and information sciences literature and specifically those research methods used for each of Computer Science (CS), Information Systems (IS), and Software Engineering (SwE). List several refereed journals which cover research in computing.

In order to become familiar with some of the issues that differentiate research processes, we require students to read the Glass, et al (2004) paper and discuss the issue with their mentors. The diversity of approaches becomes quickly evident. Also, it becomes evident that the student must choose one approach that is compatible with the mentor's interests as well as their own. It would be difficult to write a prospectus with multiple simultaneous models. We do not try to impose any specific methodology upon the faculty—student pair, and do refrain from making any judgment as to the validity of any specific approach.

Use library resources to access important databases to obtain refereed published papers and find a refereed paper for a topic of interest.

Our university makes a variety of on-line databases available to the community. We prefer to use the ACM guide to literature because of the wide diversity of material. Students are asked to choose a tentative topic and look up a paper in the ACM guide. We encourage them to look at many papers before choosing a specific paper. We ask them to look up the author in Google Scholar (or other citation service) to determine if others have referenced the paper. If quite a few have cited the author, it enhances the credibility of the paper.

Explain the relationships among the terms: citation, reference, and annotated bibliography. Prepare a reference according to a specified writing style guide. Prepare an Annotated Bibliography and explain the benefits of annotated bibliographies.

In the Appendix Figure 1 there is a depiction of components of an annotated bibliography. When a research paper is located in the search process, it is appropriate to document and abstract the paper. The annotated bibliography provides a method to accomplish these goals. Figure 2 identifies components of the annotated bibliography, and Figure 3 show a specific

example of an annotated bibliography. The components of the annotated bibliography represent the beginnings of the analysis phase of Bloom (1956) level 4. Part of the knitting that will occur at Bloom level 5 is dependent on successful completion of a sequence of related annotated bibliographies. The student's mentor serves as an important guide in this process.

3. RESPONSIBLE CONDUCT OF RESEARCH

We feel that there have been far too many breaches of responsible conduct of research. Famous examples have taken down institute heads and very distinguished investigators. Even the smallest of infractions can result in compromised outcomes. "Cheating" and other forms of dishonesty are simply not acceptable. We believe that our emphasis on this subject is as important as work on the skills of research. We have found a program we believe to be of great service to our students.

Complete the course on "Responsible Conduct of Research (RCR)" through the Collaborative Institutional Training Initiative (CITI) with a minimum score of 80.

"The CITI Program is a subscription service providing research ethics education to all members of the research community. To participate fully, learners must be affiliated with a CITI participating organization. The CITI course is a protected site. If you are a new learner at a participating organization you must register to create your own username and password and gain access to the site." (CITI, 2012) Our students are required to register for the online course, complete the eight modules for Physical Sciences, and submit a report of their final score. An RCR report score of 80 or better is required. They may repeat the sequence if necessary. Completion of the RCR assignment is also a requirement of all graduate research assistants. Students who complete the research methods course before receiving a research assistantship award, have already completed one requirement for the appointment. Students who receive a graduate research appointment before taking the course, have already completed the RCR course requirement and need only submit their score report. Win-Win!

Discuss issues related to Responsible Conduct of Research. List and discuss

issues related to plagiarism, to ethics and integrity in research, and to research misconduct.

After the student has completed the RCR course, we ask them to reflect on a number of issues: research misconduct, conflict of interest, review boards and protection of human subjects, plagiarism and tools for its detection, ownership of work, writing and data, the concept and clarification of intellectual property, and the idea of ethics and integrity in research. In addition, students must become familiar with university standards for reporting and processing of allegations of misconduct.

4. WRITING PROJECTS

Most of our students will elect NOT to be in thesis or project research. These two achievements require taking on a substantial amount of work and require a mentor and faculty committee to assure the quality of research. Students wishing to pursue thesis and project options will be able to use this course to develop essentially a thesis prospectus or project proposal. For the remainder of the students, the opportunity to gain experience in studying ideas and synthesis of a new approach is valuable. The ability to find and use new information is valuable to all students. The writing project of the course enables all to benefit from this experience.

Identify and discuss the basic components of a research paper.

Gordon Davis (1997) wrote a guide for development of a thesis. We find the book relevant for our students. In addition to explaining clearly the components of a thesis, the book also makes very clear the relevance of project management to the thesis writing process. The concept that a thesis has a lifecycle is important. The concept that it can be managed represents an opportunity to finish the progress successfully.

Select or create a word template for all sections of the research paper. Apply project management in planning the conduct of the SWP.

The concept of CMMI is that there should be a written methodology for completion of a thesis or project process. Reaching level 3 of the CMMI requires that there is a written

methodology for completion of work at each stage of the process. We use a template to identify the writing requirements for each sections of the writing project. We ask that the project be developed in MS Word with track changes so the mentor may make comments as well as the course instructor. One of the sections of the project requires documentation of the project plan. The work product takes place in sections, one at a time. Each new submission has to fix the issues from a previous submission plus the new work.

List and describe the Semester Writing Project (SWP) options for this course; describe the committee composition requirements for thesis and project options in the Masters of Science in Computing; identify and work with a faculty mentor for each stage of the research process. Identify with your mentor relevant research approach and research methods suitable for this project.

Most students attempt to find a problem worthy of study on their own. Minimally we assume the role of "editor". We strongly urge students to contact potential faculty mentors to optimize their options of pursuing a thesis or project. Those who develop relationship will at the very least get some domain guidance. Those who choose to work on their own are urged to complete an expository document. The graduate school produces a document describing the requirements for completing either a project or a thesis. We require that all students are familiar with this document.

It is the mentor's job to help the student determine a research approach and method for solving the problem of interest of the student. Usually the mentor will have a strong influence on the approach and even the topic of interest to the student. Also, as the student approaches the topic, the mentor can steer the student into consideration of alternatives, and to specific papers.

Develop introduction and background with references and annotated bibliographies for each reference demonstrating the appropriate use of citations and references; then determine research objectives and support of the objectives, and finally apply appropriate techniques for experimental design, testing, measurement and evaluation, result analysis, result

presentation.

It is the obligation of the student to proceed through the templated structure a chapter at a time. Hopefully, the student will take advantage of expert assistance from a faculty mentor. Otherwise, the course instructor must provide commentary to help the student make progress.

Most initial student work is substantially flawed. With commentary, the work-product quality usually improves. Each "next-submission" usually improves provides there is adequate time to generate feedback for the student. As the class size increases this becomes very difficult. Also with multiple resubmissions of work, the grading and feedback problem increases.

Prepare a written and graphic presentation for a research publication. Submit the final publication for plagiarism review.

During the course, the student is asked to complete what would be the basis for a research publication. Since the annotated bibliography is included in the document to confirm due diligence, each student is required to remove it so that their final document can be submitted to "TurnItIn.com" to establish that the work represents the work of the student. Throughout the course, the importance of citing the efforts of others is emphasized. The use of the plagiarism software at this phase of the project is in the spirit of a spelling grammar checker..."did I make minor errors in my paper that might be misinterpreted as plagiarism". A different perspective is explored in final examination—use of the software to obscure plagiarism. We allow up to 3 submissions to the review process, with the final version, revised according to the feedback obtained from the plagiarism report, submitted as the final product.

We also expect the student to summarize the work in two PowerPoint presentation products suitable for presentation at a meeting to communicate the essence of the research study.

5.0 CONCLUSIONS

We have created a design for exposing graduate students to the research process in a world where there is a tremendous difference in acceptability of approaches and methods within the computing community. Personally, we are

not committed to a specific methodology as we teach this course. We are committed to exploring Bloom 4 and 5 to enable our graduates to be more effective in seeking alternatives in their future professional activities. Through the years, we have experimented with other approaches and assignments.

- Focusing on citation styles, (Ward, 2004) was abandoned when a colleague pointed us to Zotero (The Zotero name is a registered trademark of George Mason University. <http://zotero.org/>).
- Many assignments have either been abandoned in favor of allocating more class time to the writing process. These include:
 - Peer review exercises, Plasberg et al (2002);
 - Coverage of basic statistics, Quantitative, qualitative approaches, Shaffer (2006)
- Delivery of some topics has been replaced with the RCR online course. Many are revisited on the final examination.
 - Research Misconduct
 - Human Subjects in Research
 - Misuse of Data
 - Plagiarism
 - Conflict of Interest
 - Recognition of Prior Work
 - Confidentiality in Peer Review
- Critical analysis and review of research papers, Fekete (1996), Budgen et al (2006), Glass et al (2004), are embedded into the annotated bibliography template for the course.
- Oral presentations, Ward (2004), were replaced by two styles of presentation, text and visual. In the past, oral presentation were only required of thesis and project concentration students in order to provide a "defense" experience in front of a friendly audience. This requirement was eliminated because it was duplicative of thesis/project committee processes.

The relationship of the Computing Research Methods framework from Holz et al (2006) to both the annotated bibliography and the Semester Writing Project is being introduced for the first time this semester. Although similar to Polya's (1957) problem solving model, we find the descriptors for applying the framework to be much clearer and more relevant than Polya's generic ones for these assignments. For those who choose to be involved in thesis or project

research, we provide a climate celebrating the student—mentor relationship in a direction suitable to those involved. For the balance of the students, we feel they have been exposed to the research process, and to the ethical issues surrounding the process.

Our students are given three options for a concentration: thesis, project, or course-only. A challenge that is made to each student throughout the course is, "How can the work this semester be leveraged to "customize" a portion of their program of study. Since 1996, every student who was interested in a thesis or a project used this course as the basis for their thesis perspective or project proposal. The few who have changed their topic or project objective, reported that they replicated the process presented in the course (the whole point of the course!) to prepare their new thesis perspective or project proposal. Although the majority of the course-only students are satisfied with successfully completing the course, many have elected to continue working with their faculty mentor, through a directed study, to extend the effort on the course document for submission to a conference or journal.

The final exam consists of new outside readings that provide opportunities to explore additional responsible conduct of research perspectives, and to reflect on the relevance of their semester writing project to their professional objectives and their program of study.

We believe that our curriculum *embedded* approach to teach CRM allows students who are not mentored during the course by a faculty member to achieve at least *advanced beginner* level and those who are mentored, at least *competence* level, Holt et al (2006). After completion of the research methods course, the *master/apprentice* approach is used with thesis or project students to achieve at least the level of *proficient*, Holt et al (2006).

Our students express satisfaction with the course. It has been conducted face-to-face, blended, and fully online. Our preference is the blended approach. In the fully online it is difficult to solve what are "little" issues that can become game-stoppers. We suspect that our approach could be used for undergraduates in computing, or could be adapted for other disciplines.

6.0 REFERENCES

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Using a Citation in the Text

Here is the text of your paper. In a scientific paper it is necessary to reference your work. If it is desired to reference a specific paper [Glass, 2004] then a citation is used. Think of this citation as a pointer to both a reference at the end of the paper, and to the annotated bibliography.

Citation and Reference

References:

[Glass, 2004] Glass, Robert, V. Ramesh and I. Vessey, "An Analysis ..."

Annotated Bibliography

Annotated Bibliography 2.

Complete reference with citation link:

[Glass, 2004] Glass, Robert, V. Ramesh and I. Vessey. "An Analysis of Research in Computing Disciplines." *Communications of the ACM* (2004): 89-94. Print.

Research Objective: The research objective of this paper is ...

Research Approach: The approach that author developed is a ...

Research Method(s): The research method that the developed is ...

Conclusion of Research: The conclusion that was drawn is

Limitation of Research: The limitations of the research papers are ...

Related to Paper: This paper is of great importance to my paper because

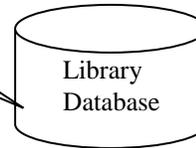
A complete paper contains text and reference section

Figure 1. Using an Annotated Bibliography in Scientific Writing

An annotated bibliography is a structured way of taking notes about a research paper.
One annotated bibliography is written for each paper you review during the writing your own paper.
An annotated bibliography has sections (see example below) that you must complete exactly as shown:

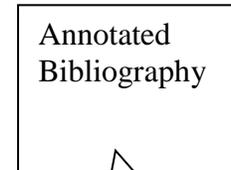
- Citation Link and Reference
- Research Objective
- Research Approach
- Research Methods
- Conclusion of Research
- Limitations of Research
- Relationship to YOUR paper

**Find and Read
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Use of Annotated Bibliography

Scan the academic literature looking for papers that are potentially interesting and related to the topic of your choosing.
Write one annotated bibliography for each paper you feel is important.
Consult the guidelines for structuring either your paper.
During development of your paper, the back part of the paper will consist of your collection of annotated bibliographies.



**Write one annotated
bibliography for each
paper of value to you**

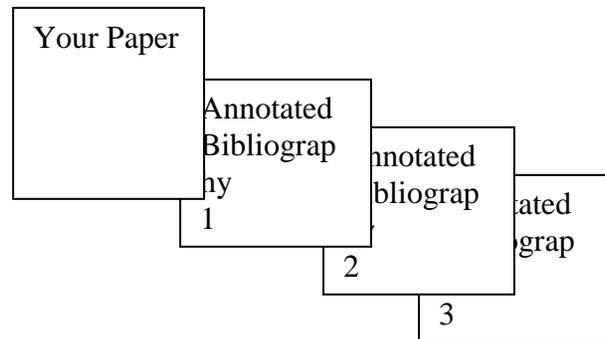


Figure 2. Discussion of Annotated Bibliography

Complete reference with citation link:

[Hart, 2008] Hart, Mike. "Do online buying behavior and attitudes to web personalization vary by age group?." *ACM* (2008): 86-93. Web. 2 Feb 2011. <<http://portal.acm.org/citation.cfm?id=1456659.1456670&coll=DL&dl=GUIDE&CFID=859417&CFTOKEN=43856965>>.

Here is the reference . It is written in the

This is a "citation link"

Research Objective: The research objective of this paper is to "examine the association of students' age groups with their online experiences to date, their intentions for future online purchasing, and their perceptions of web personalization and privacy issues".

Research Approach: The approach that author developed is a conceptual analysis by collecting the large sample of South African web users purchasing behavior, their perceptions of web personalization, their concerns pertaining to privacy, and attitudes relating to the online submission of personal information targeted for survey via registering for an national FM web portal.

Each section of the annotated bibliography is shown here as an example

Research Method(s): The research method that the author developed is by conducting the survey on two samples by using questionnaire forms, tested by staff by using pilot testing. The survey data was exported to Excel and Statistica, where data was statistically analyzed. Chi-squared tests were conducted on the statistical data for comparison of significant differences in percentages. Means scores were compared using non-parametric Mann-Whitney tests, and tested for an overall trend in age using Spearman rank correlation. By using all these methods the survey results were compared to find out the intentions, attitudes and the behavior of different age groups towards online purchasing and their interests in web personalization.

Conclusion of Research: The conclusion that was drawn from the research is that although privacy and spam are major concerns for all, the perceived benefits of online purchasing outweigh the concerns. All groups are interested in personalization and feel it could benefit them, but are much more ready to provide personal information explicitly than implicitly. Due to lack of earning or less internet access by the youngest age group (18-24) the rate of buying when compared with middle age group (25-34).

As you read the paper by Glass, et al you will find examples of research methods

Limitation of Research: The limitations of the research papers are the samples were collected from most of the younger people where national FM radio skewed up on them. This research is conducted on one particular demographical region which may not suit for the countries where the internet usage, culture, age and taste are different.

Related to Paper: The information that I learned from the study of this paper is the concept of web personalization, privacy, intentions, attitudes and the behavior of different age groups towards online purchasing

Figure 3. A Sample Annotated Bibliography