Developing Graduate Research Skills using Guided Reading Assignments

Theodore W. Manikas, Gerald R. Kane
Department of Electrical Engineering
The University of Tulsa
Tulsa, OK 74104-3189
tmanikas, grk@ohm.ee.utulsa.edu

Abstract
An important skill for graduate engineering students is the ability to perform research and communicate their findings. Many graduate courses address this need by requiring students to write a research paper. Unfortunately, many graduate students lack sufficient experience in compiling information from a variety of technical sources and presenting these results. We have addressed this problem by adding guided reading assignments to assist students in the research process. The instructor specifies the initial articles, with the students eventually branching out into their own specific research areas. For each assignment, the student writes a short report that addresses certain aspects of each article. Using these reports, the instructor provides feedback to guide the student's research. We have found that these assignments aid the students in the literature review process and result in more focused research papers. In this paper, we discuss the specific procedure for creating and evaluating these assignments.

Introduction
Students who undertake graduate study in engineering will need to learn how to perform research and communicate their findings. The primary application is the development and defense of a thesis; however, these skills will also be useful throughout the student's graduate and post-graduate career. A common approach for developing research and communication skills is the assignment of research papers as part of graduate coursework. Typically, the assignment will require each student to select a topic that is related to the course material, and write a paper based on specific format requirements. The instructor may offer additional information such as a list of suggested topics. However, it is the responsibility of the student to find the necessary background material and compile this information into an acceptable paper.

An important part of formal reports is the literature review [1]. This means that students need to be familiar with the current related research in their selected areas, and must be able to reflect their knowledge of this work in their research papers. Unfortunately, many graduate students lack sufficient experience in compiling information from a variety of technical sources and presenting these results. There are a variety of useful handbooks that describe the mechanics of writing, such as the texts by Davis [2] and Day [3]. However, instructor guidance is necessary to aid students in both the selection of an appropriate research topic and the selection of related research articles [4]. This paper describes a specific procedure for implementing this process.

Guided Reading Assignments

In order to develop graduate student research and communication skills, many graduate courses require students to complete a research paper. The traditional approach is to assign the research paper, and assume that the students will be able to complete this paper by the due date. Each student is responsible for determining how to select an appropriate topic, find related articles, and compile this information into an acceptable research paper. Initially, we tried this approach in our graduate courses; however, we discovered that there was a wide variety of quality in the research papers. While some students were able to produce good results, the typical research paper from most students tended to be unfocused. In particular, these papers often contained a random collection of items from various sources, with no cohesion or unifying theme. Based on our discussions with several students, we found that most students were uncertain about how to perform a proper literature search or develop a proper literature review. Therefore, in addition to assigning research papers, we also decided to develop a set of intermediate assignments to guide students in the research process.

First, students need a good starting point. Before the formal assignment of the actual research paper, but after we have covered sufficient background material in the course, we start the students on introductory related reading assignments. We select a survey article that provides an introduction to the general area that we want students to cover for their research paper. The first assignment is to read this article and answer a set of specific questions on key points in the article. For example, in our VLSI Design course, we wanted students to focus on physical design automation for integrated circuits. Thus, all students were required to read Breuer's general review article [5], which provide a good introduction to the physical design problem (Figure 1). They were given a set of short essay questions on key points in the article. This assignment allows students to gain general background information about the assigned research area.

For the next assignment, we have students select a citation from the survey article. They must find this article via library search and write a short summary of the article. This assignment helps students get started on basic library research. In the VLSI Design course, students selected a citation from the Breuer paper (Figure 2). In order to assist students with the library search process, we provide a handout that provides tips about finding articles. For example, we tell them about the common journals, conference proceedings, and books that relate to the assigned area and that are readily available either in our library or on-line (Figure 3). We also identify potential problems with using the web for literature search. Most students use search engines such as Google or Yahoo to find items on the web. However, these search engines often fail to uncover relevant scholarly material [6]. Also, many items that are found by the search engine are not peer-reviewed. Thus, we advise them to use our library databases that contain citations to journal and conference publications from professional societies such as ACM and IEEE.

After these initial assignments, we give the formal research paper assignment. The first part of the assignment asks students to select a starting point related to their previous assignments. We ask each student select a recent article as a seed paper and submit it to the instructor for approval. Figure 4 shows an example of the research paper assignment for VLSI Design. We also provide

guidance on writing the research paper by having them follow a set of format specifications that are similar to simple journal paper or conference paper guidelines (Figure 5). Papers are typically due at the end of the semester, and are graded using the holistic approach of Pappas [7].

Observations and Outcomes
As mentioned earlier, we decided to develop the guided reading assignments to focus the students' research efforts. This is a relatively recent approach that has been applied to two graduate courses, Computer Engineering and VLSI Design, in the past year. However, we have noticed definite improvements in the quality of research papers. The literature reviews are more focused, and the papers are more cohesive with respect to their main topics. These courses are typically taken by first-year masters students, so we will need to determine if the skills developed by writing the research paper help students with their thesis research.

References
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THEODORE W. MANIKAS
Theodore W. Manikas is an Assistant Professor of Electrical Engineering at the University of Tulsa. He is a member of the ASEE, ACM, and IEEE. He received the B.S. in electrical engineering from Michigan State University, M.S. from Washington University (St. Louis), and the Ph.D. from the University of Pittsburgh. He is a registered Professional Engineer.

GERALD R. KANE
Gerald R. Kane is a Professor and the Chair of Electrical Engineering at the University of Tulsa. He is a member of the ASEE, ACM, and IEEE. He received the B.S.E.E. from Washington University (St. Louis) and the M.S. and Ph.D. from Rice University. He is a registered Professional Engineer.

1) Read the article by Breuer (IEEE TCAD, Dec. 2000, pp. 1449 -1475) – this is a good background paper on the fundamentals of design automation methods for VLSI circuits. Concentrate on Section III (Fundamental Algorithms in Physical Design) and answer the following questions:
   a) What is the purpose of partitioning? Identify at least two partitioning algorithms.
   b) What is the purpose of floorplanning? What optimization method is commonly used to solve this problem?
   c) What is the purpose of placement? Describe the major classes of placement algorithms.
   d) What is the purpose of routing? Describe the stages of the routing process.

Figure 1. Example of initial reading assignment.

1) Select a paper that is cited in Section III of the Breuer paper that you read for the last assignment (Physical Design).   Read this paper and write a summary that describes:
   a) The basic problem that the author is trying to solve
   b) A brief overview of the author's solution method
   c) A summary of the author's results
   There should be **one** paragraph for each part. **Submit a copy of the paper so that I can verify your summary.**

Figure 2. Example of second reading assignment.

There are books, journals, and conference proceedings in the design automation field. For your use, the available materials include the following:

Conference Proceedings:
1) Proceedings of the ACM IEEE Design Automation Conference (DAC)
     A significant conference in the design automation field since the 1960's
     Available in hard copy in McFarlin Library
     Also available on-line in the ACM Digital Library (McFarlin Database)
2) International Symposium on Physical Design (ISPD)
     A newer conference with emphasis on physical design automation
     Available in the ACM Digital Library

Journals:
1) IEEE Transactions on Computer-Aided Design of Integrated Circuits (IEEE TCAD)
     Available in hard copy in McFarlin Library
     Recent issues (1998 – present) are available on-line in IEEE Xplore (McFarlin Database)
2) ACM Transactions on Design Automation of Electronic Systems (ACM TODAES)
     Available in hard copy in McFarlin Library
     Also available on-line in the ACM Digital Library (McFarlin Database)

Books:
1) Sherwani, **Algorithms for VLSI Physical Design Automation** (1999).
     On 2-hour reserve in McFarlin Library.

Figure 3. Example of information about relevant literature.

Your previous reading assignments gave you an overview of methods used in physical design automation. Now, you will concentrate on a specific topic in this area. A common topic of recent interest is floorplanning, so this is the recommended starting point for your research.

1. Each student must select a floorplanning-related article from a recent (2002 - 2004) professional society publication. The article must be from an *edited* publication - web-based articles are not allowed. This article will be your *seed paper*, and will be used as the starting point for your research. Examples of relevant publications are listed in your handout: "VLSI Design Automation Resources".

2. When you have selected your seed paper, submit a copy of this paper to me for topic approval – put your **name** and **e-mail address** at the top of the front page of the copy. **Note: I will keep this copy, so make another copy for yourself.**

3. *You must have an approved seed paper on file with me in order to receive credit for the research paper.*

4. *Seed papers must be submitted by <u>Mar. 30th</u>.*

It is expected that graduate students will do a *complete* literature search of all articles relevant to their research topics. This includes complete citations of references in your paper. *Lack of citations in your paper, or copying other authors' work without giving proper credit, constitutes* **plagiarism** *and will result in a paper grade of* **F**.

Figure 4. Example of research paper assignment.

The final draft of the research paper must meet *all* of the following format requirements.
1. The final draft should be double-spaced throughout on one side of 8.5 x 11-inch (21.3 x 27.5-cm) white paper.
2. Font size should be no smaller than 10 pt for all text.
3. Number all pages consecutively with numbers appearing at the bottom center of the page.
4. There is **page limit** of 20 pages – your paper, including title page, figures, tables, and references, should not be more than 20 pages long.
5. **Title page** (page 1) should contain the paper title, author's name, course name and number (EE 6443), term (Spring 2004), and abstract. The abstract must be a single paragraph that summarizes the main findings of the paper in less than 100 words.
6. The body of the paper should start on page 2.
7. Number **tables** consecutively with Arabic numerals in order of appearance in the text. Type each table double-spaced with a short descriptive title directly **above** the table.
8. Number **figures** with Arabic numerals in order of appearance in the text. Each figure should have a short descriptive title directly **below** the figure.
9. Table and figure pages should be separate from the text pages. You may combine tables and/or figures on the same page, if necessary.
10. All **equations** should be typewritten and the numbers for displayed equations should be placed in parentheses at the right margin. References to equations should use the form "Eq. (3)" or simply "(3)."
11. Cite **references** in the text by an Arabic number between square brackets, as [1], [1, 2], [1, Theorem 5.4], etc. It is suggested that the text references be given in the form "As Jones [31] showed. . . ," rather than "As [31] showed...."
12. If a table or figure has been copied from a paper, give proper credit to the original source by including a citation in the caption.
13. The **list of references** should appear as the last part of the paper. Reference should be listed in *alphabetical order* by primary author's last name. Type the references double-spaced throughout. Reference citations should include author name, paper title, date, and where published. The use of non-refereed sources (e.g., web sites) should be minimal - most references should be from edited, published sources such as journals, conference proceedings, and books.
14. Your paper should be checked for spelling and grammar (using U.S. English).

Figure 5. Example of research paper format requirements.