

Writing Across the Curriculum – An Online Course in Computer Security

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Abstract

Writing fosters both critical thinking and student learning, serving as one of the most effective ways to understand a topic. Writing across the Curriculum (WAC) began in the late 1970's, as a pedagogical reform movement in response to a perceived deficiency in literacy among college students. Over the past two decades universities have worked to broaden the scope of student writing from composition classes to classes in the students' major. This paper chronicles the application of WAC into the discipline of Computer Science.

The purpose of this study is to develop an online Computer Security course (for sophomores and juniors in Computer Science), under the umbrella of WAC, to help improve the students' writing overall and focus on skills students require in upper level courses in the major. Developing this course as an online course (rather than a traditional face-to-face course) offers flexible configurability and scalability, features that are useful to prepare students for constantly changing real world security challenges. This paper includes all aspects of course design and insight into lessons learned. Results indicate that both the faculty and students benefit from such a writing intensive course. Reading and responding to the students' writing enables faculty to gain valuable insights into the students' thoughts, ideas, problems, and other issues. Students reported increased knowledge and comprehension of the subject material, deeper understanding of the conventions within Computer Science, improved analysis and reporting skills, ability to understand and present abstract concepts effectively, and skill in producing professional documents.

Introduction

Writing Intensive (WI) courses offered at many universities for several years are disciplinary courses aimed primarily to fulfill a student's general education requirements. A college-wide initiative at our university led to the implementation of several such WI courses (in different departments) under the realm of Writing Across the Curriculum (WAC). This paper documents the development of a new online course (Computer Security) in the Computer Science department that satisfies the WAC objectives. The motivation for such a course stems from the faculty's desire to develop a course to help to improve the students' writing overall, and focus on the skills students require in an upper level course in Computer Science. This course satisfies the general education requirements for our students, and would be a second course in writing after the Freshman Writing course offered by the English Department.

This paper is organized as follows. First, we present our **problem statement**;

We wanted to offer a course from the Computer Science department, which would not only enable our students to fulfill their general education requirements for a writing course, but also help them acquire skills they would need to succeed in the discipline.

Thus, we wanted to offer a course that addressed both the educational and professional needs of our students. The '**Background**' section provides the background information and the theoretical framework of WAC related to Writing in the Discipline (WID) and Writing to Learn (WTL). In this section, we also emphasize our motivations and objectives for developing a WAC course in our department. In the '**Computer Security Online Course Design**' section, we introduce our course design related to its basic principles, architecture, requirements, and applications. Further, we provide some details of our online course design and how we met our objectives. The '**Lessons Learned**' section discusses the important lessons we learnt from this process. The '**Conclusions, Discussion and Follow-on Research**' section is devoted to discussing the generalization of our course development effort and how other disciplines can adopt our results. Finally, we draw conclusions and offer some discussions related to future work.

Background

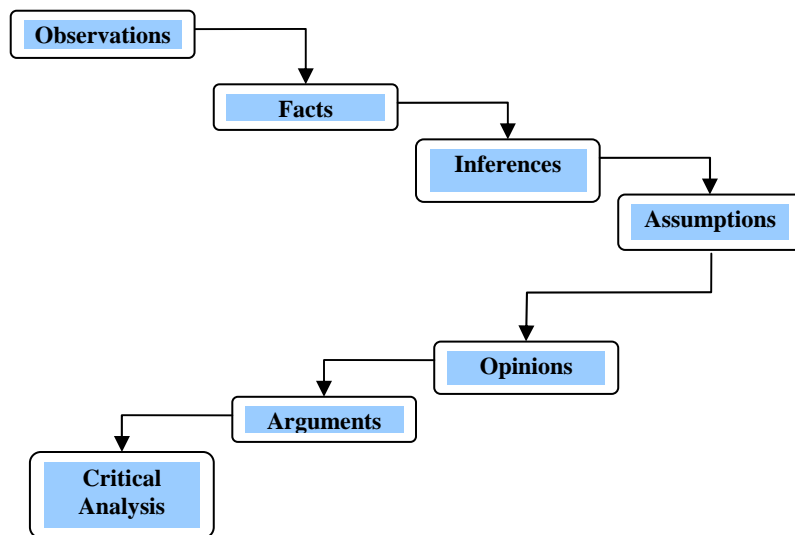
Writing Across the Curriculum (WAC)

The origins of WAC can be traced to the 1960's in Britain's "language across the curriculum movement" and to the 1970's in the US with a response "by some composition teachers to the media-induced perception of a new nation-wide literacy crisis" (Peritz, 1994). WAC was a phrase coined in the late 1970's and early 1980's to describe attempts by colleges and universities to broaden the scope of student writing beyond the confines of English department (Sully, 1995). This educational reform movement which began as a response to a perceived deficiency in literacy among college students has resulted in WAC instantiations in various different forms and programs at several universities. WAC has diverse meanings and many ideas fit under this broad phrase. A collection of essays (McLeod, 2000) explores the myriads of design of writing-across-the-curriculum programs and also contains an appendix listing the results of the first comprehensive survey of writing-across-the-curriculum programs in the United States, Puerto Rico, and Canada.

Two classic sources (Britton 1975, and Emig 1977) clearly illustrate how and why writing is essential to learning. Britton (1975) reports that in every kind of writing, defining the nature of the operation, devising ways of tackling it, and explaining its meaning and implication to oneself are essential stages that the mind engages. Emig (1977) argues that writing represents a unique mode of learning - not merely valuable, not merely special, but unique. Thus, WAC designated courses are based on theories that emphasize writing as a unique and valuable learning tool which helps students synthesize, analyze, and apply course content. Such courses enhance the understanding of the subject matter and encourage critical thinking, which is formally described [CRIT-THINK] as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. Leading theorists categorize activities which comprise critical thinking quite differently. For example, Figure 1 shows how the Dartmouth Writing Program [DART-EDU] categorizes the elements of critical thinking. We use this model as the first step in providing our students with a critical vocabulary for their own thinking processes. We want our students to understand that from a series of observations we establish facts, from which we make inferences.

After testing the validity of our inferences we can make assumptions and then form our opinions. From these opinions, using principles of logic, we develop arguments. In order to challenge arguments of others, we employ critical analysis (through which we challenge the observations, facts, inferences, assumptions, and opinions in the arguments that we are analyzing).

Figure 1: Elements of Critical Thinking



Next, we want our students to engage in a variety of critical thinking activities which we base on the critical thinking models from Bloom’s Taxonomy (Bloom, 1956) of higher thinking which categorizes thinking into the following six processes (students must master one level of thinking before they can move on to the next) :

Knowledge → Comprehension → Application → Analysis → Synthesis → Evaluation

The section ‘**Designing Writing Assignments**’ (p.10) describes various examples of assignments related to this hierarchy.

Over the last 30 years, the WAC movement has been implemented in many different and creative ways across several institutions. According to Bazerman (1994), WAC manifests in two ways: “learning to write” and “writing to learn” approaches. “Learning to write” implies learning to

write within a discipline, following the conventions specific to that discipline, and for a target audience. On the other hand, “writing to learn” uses writing to enhance a students’ understanding of the course material. Thus, WAC has two approaches:

1. **Writing in the Discipline (WID)** – based on the understanding that students must be taught the conventions for language, style and presentation unique to a discipline. Some examples of assignments may include article reviews, research papers, reports, etc. These courses are intended to enhance understanding of the subject matter and to encourage critical thinking. They also provide opportunities to practice various forms of writing in the discipline, such as lab reports, proposals, formal essays, research articles, press releases, etc. (Gentry, 2004).
2. **Writing to Learn (WTL)** – based on the fact that students comprehend and retain information better if they write it down in their own words. Some examples of assignments may include informal writing in the form of discussion forums, comments, writing in the first few (or last few) minutes of class, journals, logs, etc. These courses provide opportunities to use writing as a learning tool, in order to synthesize and apply knowledge. Other examples of WTL include keeping research or reading logs, writing responses to readings, free writing answers to questions raised in class (Gentry, 2004).

Motivations and Objectives for developing a WAC online course in Computer Science Department

Computer Science (CS) is a discipline that traditionally does not emphasize writing within the discipline. However, writing has been shown to enhance learning and being essential to learning (Britton, 1975, and Emig, 1977). Also, there is a general consensus among CS educators that both communication skills and writing proficiency are crucial in the workforce (as well as for graduate studies). This is evident from the fact that students joining the workforce are expected to possess problem formulation, problem solving, problem analysis, and problem synthesis skills. It has been known (McLeod and Soven, 2000) that:

1. Students’ writing skills diminish if not reinforced between freshman composition and graduation.

2. Students' writing improves most markedly if they write while they are engaged by their major subject.

These facts encouraged us to develop an online writing intensive course in Computer Security, in the CS department, for our second and third year students. This writing intensive course will not only reinforce writing skills of our students, but will also keep them interested in an important topic emerging around the globe. This course is very different from the other “programming” courses traditionally offered in the CS department, which are Laboratory-based courses. In this course, there is no hands-on component and students are not required to write any computer programs. Instead, students have to read, research, and report, as well as, analyze, synthesize, and evaluate information, throughout the course, including any new security threats discovered world-wide. These activities are in fact based on Bloom's critical thinking models (Section **Writing Across the Curriculum (WAC)**) and make this course very well-suited to a writing intensive course.

Computer security is an important topic in today's world, as computers (and computer networks) are ubiquitous. Introduction of new technologies and new applications around the globe, bring new threats. In order to counter these threats we need a rapidly evolving protection mechanism. Thus, we have to prepare our students (all over the world) to face security challenges in the real world, given the fact that these are changing rapidly over time. Developing this course as an online course rather than a traditional face-to-face course offers flexible configurability and scalability. For instance, we may change the course anytime (maybe, even in the middle of the semester) in relation to the current technological developments in Computer Security. Also, we may apply the latest globally available research results to discuss various aspects of the course. Thus, this course is very well-suited for students around the world (global students) and the best way to deliver such a course is to offer it online.

Following a faculty development workshop (Gentry, 2004), we came up with the following objectives for this course. This WAC course should:

- Have content (computer security) as its primary focus but should also reinforce writing skills by using writing in a substantial way to enhance learning.
- Add writing to content as a way of improving students' understanding of the content.
- Use writing to enhance learning so that students comprehend concepts better and retain that knowledge longer than students who did not use writing to learn.
- Teach students the specific conventions of writing in the discipline as outlined by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society [IEEE-CS], as well as how to conduct research and write research papers in computer science.
- Provide opportunities for revision after feedback from peers or faculty.
- Fulfill the Research Writing Requirement, whereby the students are expected to learn how to:
 - a. use the library as a research resource
 - b. locate and evaluate sources (including Internet sources)
 - c. develop and sustain a thesis
 - d. summarize, paraphrase, and use quotations
 - e. address and integrate ideas from outside sources
 - f. use the basic methods of documentation in an approved style
 - g. avoid plagiarism

We would like to stress that writing is a step-by-step process and it is important that every formal student paper receive peer and/or instructor feedback. Additionally, all major assignments should have a revision component so that the student can understand that writing is an ongoing process and not a one-shot approach.

Computer Security Online Course Design

Syllabus Building

This is usually the first step in any course design. For a WAC course extra effort needs to be made in building a syllabus which reflects the writing intensive nature of the course. In addition to the general guidelines we use in designing any course syllabus, the following needs to be included in a WAC course syllabus:

1. A statement indicating the writing intensive nature of this course.
2. Assignments (not necessarily detailed descriptions) that meet the formal writing requirement.
3. Assignments that constitute the Informal Writing component.
4. Assessment criteria or tools to indicate how student writing will be graded.
5. Research methods instruction.
6. Academic Integrity Policy.
7. Writing to learn activities.
8. Draft/feedback/revision process for formal papers.
9. A writing sample is collected from the student in the 1st week (which is analyzed to determine if students are placed appropriately and if any referrals need to be made to the Academic Support Center for additional support and help with the writing in the course).

In addition to the above we also include a statement on Course Goals, an example of which is quoted below:

*“By the end of this course you will be able to understand and appreciate the different computer security techniques. By working on the writing assignments you will be able to understand at least one technique in Steganography and one in Digital Watermarking. Also writing different papers throughout this course will prepare you for writing technical papers in any topic in Computer Science. You are encouraged to submit a paper/poster to the **Undergraduate Research Program** as well as to the **Science Scholars Presentation** (more details will be given throughout the course) at the end of the course”.*

The Writing Process

A general misconception on the part of students, faculty and administrative staff has been that course content is important but not the process. By adopting the WAC into specific disciplines, we encourage our students to understand that both content and process are equally important and that writing is not a “one-time” event but rather it is a process which should be nurtured all

along. We have identified many problems with the writing process and some of the typical ones are:

- procrastination
- low motivation and interest levels of the students
- no clear indication of what is expected of them in college
- poor language skills
- trouble with problem analysis
- lack of organizational skills
- lack of understanding of conventions within the discipline
- writing only a first draft
- attributing source material as a last step
- using one source for each section
- no prewriting
- revision includes only editing

To mitigate some of these problems we adopted the following process strategies:

1. Arranging for prewriting or organizing activities including maps, outlines, charts, free writing, questioning, online discussion forums, etc.
2. Providing revision tools such as audience awareness, explaining the purpose, providing opposing point of view, outlining, thesis & paragraph identification, thesis & topic sentence unity, integration of source material, etc.
3. Providing research strategies such as what to search, how to search, what is a reliable source, how to integrate source material into student writing, etc.
4. Providing editing and proof reading capabilities such as letting the paper rest, reading the paper out loud, looking for one problem at a time, sentence focus, etc.

The above points are important considerations when we design assignments for the course as discussed in the next section.

Designing Writing Assignments

As mentioned above, we want our students to utilize higher level thinking and not just recall and report what they know (which are considered less sophisticated in Bloom's taxonomy). We want our students to translate information into novel forms, apply it to new contexts, analyze, synthesize, and evaluate it.

Table 1: Bloom's Taxonomy of Thinking Skills

| Knowledge | Comprehension | Application | Analysis | Synthesis | Evaluation |
|-----------|---------------|-------------|-------------|-------------|------------|
| List | Summarize | Solve | Analyze | Design | Evaluate |
| Name | Explain | Illustrate | Organize | Hypothesize | Choose |
| Identify | Interpret | Calculate | Deduce | Support | Estimate |
| Show | Describe | Use | Contrast | Schematize | Judge |
| Define | Compare | Interpret | Compare | Write | Defend |
| Recognize | Paraphrase | Relate | Distinguish | Report | Criticize |
| Recall | Differentiate | Manipulate | Discuss | Justify | |
| State | Demonstrate | Apply | Plan | | |
| Visualize | Classify | Modify | Devise | | |

This is seen as moving (from left to right) in Table 1 which shows Bloom's levels of cognitive activities (Bloom, 1956). This table also lists a number of verbs describing the activities for each mode of thinking. We use this table to design our writing assignments for varying the levels of sophistication in our students writing.

Effective writing needs to be in context and we need to design assignments by clearly spelling out the writing situation. Figure 2 represents the Communication Triangle (Kinneavy, 1971) which offers a useful scheme for understanding the writing situation. Various elements of discourse (the writer, the audience, the subject matter and the writing itself) are represented in this triangle. By emphasizing one or more of the various elements of discourse represented in this triangle, the writer chooses different modes of discourse.

- **Expressive writing** focuses on the writer's experience and motives.
- **Exploratory writing** asks questions of the writer.
- **Informative writing** answers questions from an audience.

- **Scientific writing** provides proof for its assertions for an audience.
- **Literary writing** invites attention to the message itself for an audience.
- **Persuasive writing** attempts to change the views or behavior of the reader

Figure 2: The Communication Triangle



The communication-centered approach offers alternatives to the topic-centered research paper, in which the writer is expected only to report on research findings, rather than to apply, analyze, synthesize, or evaluate resources. Using the four elements of the communications triangle as a frame, we generate writing assignments that have real context. A writing assignment should specify the role of the writer (the purpose of the writing), the rationale for the assignment, the expected form of the writing, the intended audience, the length, the style, deadlines as well as grade considerations.

Following the above two notions, we put forth the principles we employ for designing assignments (Gentry, 2004) in our course:

- Tie writing in the course directly to course objectives – we specify both the formal (research reports, literature survey, etc.) and informal (chat sessions, discussion boards, etc.) writing assignments.
- Engage students in patterns of thinking characteristic of discipline: ask them to explain, define, apply, classify, compare and contrast, problem-solve, show cause and effect,

illustrate, analyze, persuade. For instance, in one of the assignments, students are expected to compare and contrast several different steganography techniques.

- Invite analysis and synthesis to force students beyond retention and recall. In one assignment, we ask the student to report on the security control measure they use on their computer and then we ask them to justify the attacks they are trying to protect against.
- State a purpose and identify a specific audience. This is important since the student knows exactly why an assignment has to be done in a particular way, for whom it is intended, what is the level of detail required, etc.
- Use open questions that permit a variety of legitimate responses. In one assignment we invite the students to defend or criticize a premise, such as the following: Attempting to break into a computer system without authorization – should this be legal? Why? Or, Why Not?
- Segment assignments into manageable steps, allowing opportunities for intervention throughout. We often request a first draft from the student for peer review from another student or a group.
- Scaffold tasks within the assignment or writing assignments over the semester from simple to complex, building on previous steps. We start with simple assignments and build up to complex ones based on previous assignment results. For example, an assignment to compare and contrast the different steganography techniques is followed by an assignment for a detailed technical research report on one of the techniques chosen from this list.
- Include evaluative criteria in the assignment. We always provide a grading rubric along with the assignment thus the student is aware of the evaluation criteria.

As noted in the ‘**Syllabus Building**’ section, our course syllabus is an assignment-based syllabus in which we include information about assignments. Tables 2 through 4 list several assignments from the course ranging from the first writing sample to detailed technical reports. The assignment sequence mimics the hierarchy in Bloom’s Taxonomy introduced previously.

Table 2: Example of Writing Assignment #1

| Assignment 1: First Writing Sample | |
|---|---|
| Description | You are required to write a page introducing yourself, then explain and provide the reasons for your participation in this writing intensive course in Computer Security. |
| Purpose | To determine if you are placed appropriately and if any referrals need to be made to the Academic Support Center for more support and help with writing in this course. |
| Audience: | Course Instructor, Academic Support Center, Department Faculty Members |
| Mode of writing | Expressive – focus on your personal motives and experiences |
| Length | One page (Max) |
| Grading Criteria | None. This assignment is not graded. |
| Deadline | In Class Writing Assignment – Due today by end of class. |

Table 3: Example of Writing Assignment #2

| Assignment 2: Steganography Techniques | |
|---|--|
| Description | You are required to compare and contrast various Steganography Techniques introduced in Lecture Notes for Topic 2. |
| Purpose | To understand and become aware of the different Steganography Techniques. |
| Audience | Course Instructor, Fellow Students in the class. |
| Mode of writing | Informative – report on similarities and differences of various techniques |
| Length | At least 3 pages. |
| Grading Criteria | Grading rubric is attached. |
| Deadline | Due – 9/15/2005 |

Table 4: Example of Writing Assignment #3

| Assignment 3: Steganography Research | |
|---|---|
| Description | You are required to research and write a detailed technical report on one of the Steganography Techniques from your Assignment #2 following the Numbered Reference Style introduced in Topic 2. You will present (on the due date at 2:00PM EST) your report using Microsoft Powerpoint (3 minutes to present, 2 minutes for questions) using the Blackboard Chat Tool explained in the introductory lecture. |
| Purpose | To understand the Numbered Reference Style and formation of a research paper in Computer Science. You are expected to apply, analyze, synthesize and evaluate resources along with reporting the research findings as explained at the end of Topic 2. To learn and improve skills for short presentations. |
| Audience | Course Instructor, Fellow Students in the class. |
| Mode of writing | Informative – first draft of the report Scientific – provide proof for any assertions Persuasive – convince the reader about your chosen technique |
| Length | Numbered Reference Style. Include Abstract, Introduction, Results, Conclusions, and Future Research Sections. |
| Grading Criteria | At least 5 pages. |
| Deadline | Grading rubric is attached. |
| Description | First Draft Due – 9/29/2005 for peer review and instructor review. Final Report and Presentation Due – 10/13/2005 for instructor review. |

Assessment Strategies

Any course development activity involves assessment strategies to evaluate their students. Assessment is important for the students, the instructors, and also for the society at large. From a student's point of view an assessment strategy that is fair, meaningful, and, well understood can significantly increase his or her motivation level towards the course. From an instructor's perspective, assessment is one of the most effective communication tools for individualized interaction with the student and helps in steering the student towards what works and away from what doesn't. Finally, fairly or unfairly, cumulative assessments, typically in the form of a grade, play a significant societal role in terms of how a student is judged professionally by others, particularly during the early phase of his/her professional life.

For a WAC course, maintaining electronic portfolios should very much be a part of the assessment strategy. In today's world the culture is just right for keeping electronic portfolios and blogs (or weblogs – publication of personal thoughts with links) are very common nowadays. A more formal definition of blog from Wikipedia [WEBLOG] is: “A **weblog** (*usually shortened to **blog**, but occasionally spelled **web log***) is a web application presented as a webpage consisting of periodic posts, normally in reverse chronological order”. In our course, student writers can maintain individual blogs or maintain a collaborative approach with everybody's thoughts and ideas, the format varying between simple bullet lists of hyperlinks, to article summaries with comments and ratings provided by the students.

Thus, there is much more to assessment than simply tests. This is where the term rubric comes in. Simply put, a rubric shows *how learners will be assessed and/or graded* (Ronkowitz, 2005). There are several advantages of using a rubric (Gentry, 2004):

- They give students specific guidelines regarding objectives and expectations.
- They allow students to work on specific writing skills.
- They aid tutors who help students develop their writing skills.
- They can increase the quality of instruction by providing focus and attention to important objectives.
- They are consistent tools for evaluation.

There are different types of rubrics (Ronkowitz, 2005) ranging from:

- Holistic – provides a single score based on overall achievement, for example, a presentation rubric or a course grading rubric.
- Analytic – provides specific feedback along several dimensions, for example, a Lab report rubric.
- General – contains criteria which are general across tasks, for example, a position paper or course grading rubric.
- Task-specific – unique to a task or assignment, for example, a research paper rubric or a portfolio rubric.

As such, creating a rubric (and many different ones for a given class) is not a simple task and involves several distinct steps as detailed in (Ronkowitz, 2005):

1. Identify the type and purpose of the Rubric - what you want to assess/evaluate and why.
Before we even begin the assessment process we should decide what will be the outcome and then working backwards we design the assessment even before we design the course!
2. Identify distinct criteria to be evaluated - Reference the existing description of the assignment/activity and pull your criteria directly from your objectives/expectations.
Make sure that the distinctions between the assessment criteria are clear. For example the criteria can be:
 - **Organization:** shows careful development of related ideas in coherent, sequential paragraphs.
 - **Revision:** shows that revision focused on clarifying supporting ideas and unifying paragraphs.
 - **Clarity:** shows editing that focused on developing powerful sentences that are clear and logical.
 - **Mechanics:** shows proofreading related to spelling and grammar issues. This criteria changes from assignment to assignment and from task to task.

3. Determine your levels of assessment - Identify your range and scoring scales. Are they linked to simple numeric base scores? Percentages? Grades or GPAs?
4. Describe each level for each of the criteria, clearly differentiating between them - For each criterion; differentiate clearly between the levels of expectation. Whether holistically or specifically, there should be no question as to where a product/performance would fall along the continuum of levels. (Hint: Start at the bottom (unacceptable) and top (mastery) levels and work your way “in”).
5. Involve learners in development and effective use of the Rubric - Whether it is the first time you are using a particular rubric or the 100th time, learner engagement in the initial design or on-going development of the assessment rubric helps to increase their knowledge of expectations and make them explicitly aware of what and how they are learning and their responsibility in the learning process.
6. Pre-test and retest your rubric - A valid and reliable rubric is generally developed over time. Each use with a new group of students or a colleague provides an opportunity to tweak and enhance it.

For each type of assignment (research paper, compare and contrast paper, survey paper, presentation, group presentation, etc.) we will use a different rubric based on the purpose of the assignment. We also have an overall grade rubric. A reliable rubric takes time to develop and needs to be evaluated from time to time, thus a need for a rubric for rubrics! In the first week of classes we share the various rubrics (for different assignments and overall grade) with our students, inviting them to offer suggestions for making the rubric better (learner engagement, as outlined in step 5 above). Based on the input from our students we edit our existing rubric and come up with a new one which we will use in that semester. It is anticipated that these rubrics will change from semester to semester along with the assignments and contents in the course. Following the above listed steps we came up with the rubric shown in Table 5 for evaluating student writing for one of the assignments. There are several websites for generating a rubric. We used the Rubistar [RUBI] site to generate the rubric for many assignments in this course. An example of one such rubric is shown in Table 5 overleaf.

Table 5: A Sample Rubric for the First Assignment (Research Report: CSCI 3157: Computer Security, Assignment 3: Steganography Research).

| CATEGORY | SCORE | | | |
|-------------------------------|--|--|---|---|
| | 4 | 3 | 2 | 1 |
| Organization | Information is very organized with well-constructed paragraphs and subheadings. | Information is organized with well-constructed paragraphs. | Information is organized, but paragraphs are not well-constructed. | The information appears to be disorganized. |
| Amount of Information | All topics are addressed and all questions answered with at least 2 sentences about each. | All topics are addressed and most questions answered with at least 2 sentences about each. | All topics are addressed, and most questions answered with 1 sentence about each. | One or more topics were not addressed. |
| Quality of Information | Information clearly relates to the main topic. It includes several supporting details and/or examples. | Information clearly relates to the main topic. It provides 1-2 supporting details and/or examples. | Information clearly relates to the main topic. No details and/or examples are given. | Information has little or nothing to do with the main topic. |
| First Draft | Detailed draft is neatly presented and includes all required information. | Draft includes all required information and is legible. | Draft includes most required information and is legible. | Draft is missing required information and is difficult to read. |
| Mechanics | No grammatical, spelling or punctuation errors. | Almost no grammatical, spelling or punctuation errors | A few grammatical, spelling, or punctuation errors. | Many grammatical, spelling, or punctuation errors. |
| Sources | All sources (information and graphics) are accurately documented in the desired format. | All sources (information and graphics) are accurately documented, but a few are not in the desired format. | All sources (information and graphics) are accurately documented, but many are not in the desired format. | Some sources are not accurately documented. |

Online Design

As mentioned previously, Computer Security is rapidly changing based on new threats daily and in order to offer configurability and scalability to this evolving course, we offered this course as an online course. Internet-based distance learning (DL) provides an easy mechanism to impart this rapidly evolving knowledge in Computer Security to our students. In particular, we used the

Web-campus based Blackboard provided by Blackboard.com®¹ [BLACK] (www.blackboard.com) – a comprehensive and flexible e-learning software platform that delivers a course management system. This system offers students a robust set of tools, functions, and features for learning. This tool also comes with interactive discussion forums, which provide a great opportunity for students to exchange knowledge and help each other advance their understanding of the subject material.

Also, we integrate the following goals of the DL initiative put forth by our university in this course. These goals are:

- Enhance students’ global knowledge and perspective,
- Develop students’ facility with the Internet as a learning, research, communications and collaboration tool,
- Promote students’ ability for self-directed learning and responsibility-taking in the educational process.

Again, the premises for offering this course as an Internet-based DL course is that the evolutionary nature of this course makes it perfectly suitable to be offered via this mode, since it is very easy to impart rapidly changing knowledge in the short term of a semester.

Discussion Board is a communication tool provided in Blackboard, which enhances our course by providing a feature similar to the virtual chat, but designed for asynchronous use and the students do not have to be available at the same time in order for a conversation to take place. Such interactive discussion forums provide a great opportunity for students to exchange knowledge and help each other advance their understanding. Thus, in this course we promote interactive discussion in two ways - by using the Discussion Board, and, by encouraging the use of the Electric Blackboard which allows us to save notes and discussion items for our course within the Blackboard environment.

¹ Blackboard is registered trademark of [Blackboard Inc.](http://www.blackboard.com)

Virtual Classroom, another important tool in Blackboard, allows the instructor and students to participate in real time lessons and discussions and also view archives of previous classroom sessions. The virtual classroom, also called the chat room, is used to hold "live" classroom discussions, TA (Teacher Assistant) sessions, and office hour type question/answer forums. We invite guest speakers and subject matter experts to talk with the class in the Virtual Classroom. This is important as Computer Security is a rapidly evolving field and every day new research is being presented in the technical community. This research can very easily be communicated to our students by our invited guest speakers who are experts in Computer Security.

Discouraging Dishonesty

Every course design should incorporate tools to promote honest student learning and we use the multilayered approach presented in (Christe, 2003) to focus on student honesty. Following the experiences in (Christe, 2003) we encourage student honesty throughout our course in different areas such as:

- Syllabus design – by clearly defining our expectations to the students so that they will be able to meet them and identifying and referring them to institutional policies (for example the University Academic Integrity Policy) for dishonest behavior.
- Content Presentation – using technology we emphasize the important points using good course design, offer supplemental resources (library research links etc.), and present course information in a sound learning environment.
- Student Rapport – promoting an excellent student-instructor relationship can diminish dishonest student behavior and thus we include activities that promote this communication between the students as well between the student and the instructor.
- Assessment – using outside services which help prevent plagiarism on student papers. Our university recently entered into a licensing agreement with Turnitin.com² [TURNITIN] which provides a system of powerful tools to help detect student plagiarism.

² Turnitin is the educational division of iParadigms, LLC

Feedback and Discussions

In order to enhance and improve the learning experience of our students, any course design (online or otherwise) should incorporate adequate tools for appropriate criticism in a timely manner. This provision for obtaining feedback can be made in many different ways and Brown (2005) documents some of these methods which include reflective responses to prescribed questions, semi-automated responses by the system to student actions and work, shared comments in online forums and blogs, and personal responses via email, telephone, and post. We used a variety of surveys (start-semester, mid-semester, and, end-semester) as well as blogs to obtain students feedback about our course. Using Blogger.com [BLOGGER] (or any available free service), we create blogs for a particular feedback topic and invite students to add to the interactive discussion. We can allow for anonymous posts from students in order to receive honest feedback. Any student can respond to the teacher's response or comment as well to other student responses or comments. Another use of the blog facility is publishing student writing for peer review or for demonstrating ideas from a particular paper. From time to time, we invite global experts in the Computer Security field to participate in our class discussions and offer insight into research findings reported by students. In this case again we use blogs which can be accessed world wide. In addition, we use the Discussion Board and Virtual Classroom tools as noted previously. Another option is to use a wiki (similar to the blog), which is a web-page that is editable by anybody, and is usually used as a repository for information. Our university has started investigating offering faculty the capability to create wiki pages with great educational functions. It should be noted that a wiki entry evolves over time due to its rapidly-changing nature and sometimes may be the fastest way to exchange information.

Lessons Learned

Major Hurdles: Offering WAC courses is not an easy task even though there is a general consensus that writing is everyone's responsibility. During the course development process we identified some of the major hurdles facing WAC course developers. Some of these are:

- Faculty resistance – this shows up in various forms – faculty not having enough time and motivation for putting in extra effort for developing WAC courses. Of course, this can be

mitigated by offering release time with reduced course load for developing WAC courses, offering monetary incentives, offering adequate training and help to faculty, etc.

- Inadequate Support – lack of support within a peer group will not help in getting a WAC course off the ground. Acceptance of such course offerings has to come from within the department after consulting all faculty members.
- Communication Barriers between faculty and administration – Administrators need to approach the faculty and not impose a “top-down” view of WAC courses. Instead the faculty should be allowed to work from the bottom-up in developing WAC courses along with support from administration.
- Focus on course content and not process – faculty should be educated to focus not only on the course content but also the process. Both the content and process are important and this should be taken into account when developing WAC courses.
- Insufficient WAC Program Evaluation and Assessment – Faculty should be provided sufficient program evaluation and assessment, what works, what does not etc. so that they can strengthen their course offerings.

Student Involvement and Reactions: Another potential problem was convincing and making the computer science students aware about the writing intensive nature of this course, and at the same time not intimidating them about writing research papers. This was overcome by offering several seminars aimed at the prospective students and getting their feedback and input in the course design process. This collaboration proved fruitful since the course design successfully incorporated student ideas and alleviated their fears about the intensity of this writing course. At these seminars, we also invited outside speakers from local companies to speak about the importance of writing in their organization and how prospective applicants can improve their chances of employment with such skills. A representative from our Career Management Services also participated in these seminars to enlighten our students about the rewards of such skills in the workplace.

In these seminars, students are also informed about the various assessment services we use throughout the course – for example the Turnitin.com service for detecting plagiarism. It is interesting to note that at first students were very apprehensive about such services, but soon

started understanding the concepts of using and citing other works in their papers. Also, one of the syllabus topics for the Computer Security course was Digital Rights Management and Copyright Protection with extensive discussion on fair usage of digital works (including documents, images, video, music, etc.). These discussions enlightened the students about current legislation in the digital world and prepared them to accept such assessment services.

Principles of Good Design

We also learned that classical ideas for evaluating teaching in traditional, face-to-face courses, based on the popular Chickering and Gamson (1987) framework can be easily extended to online courses. We applied the seven principles of good practice (Chickering and Gamson, 1987) to improve our course design as outlined below. Good practice in undergraduate education:

1. Encourages contact between students and faculty – very important factor in student motivation and involvement and becomes very critical in an online class.
2. Develops reciprocity and cooperation among students – collaborative work offers rewards of good learning and increased thinking and understanding. Discussion boards, blogs
3. Encourages active learning – students do not learn a lot by just sitting and listening to lectures, instead they learn much more when they apply this knowledge by writing about it, by discussing it with fellow students as well as faculty and relating it with other experiences.
4. Gives prompt feedback – students need to understand their performance in the class as well as need suggestions to assess themselves and improve upon that assessment.
5. Emphasizes time on task – it is important for students to learn effective time management and understand time allocation and requirements for various tasks.
6. Communicates high expectations – all students (ranging from the poorly motivated to the bright) benefit from this since they know the faculty members expectations.
7. Respects diverse talents and ways of learning – every student has a different way of learning and offering this course in an online mode automatically respects the various individual learning styles of students.

Conclusions, Discussion and Follow-on Research

This course attempts to fulfill the WAC objectives for a course in Computer Science department, which is traditionally not a writing oriented department. The purpose of a WAC course is to increase students' communication and analytical skills, which is not an easy task as evidenced by the various problems outlined in '**Lessons Learned**' section. Any WAC course implies change, and, both instructors and administrators must be committed to make the program work. Also, there must be a university-wide awareness that writing is not a "one-time" event, but, rather an ongoing process and more courses in many more disciplines should encompass writing and critical thinking. The overall goal should be to change this perception (among students and faculty) that writing is a generalized skill which needs to be mechanically learned once. Instead, writing which requires persistent reinforcement should be practiced, often in different settings, over the entire course of one's education. The pedagogical movement which started more than two decades ago still offers many opportunities and it is not impossible to visualize different WAC programs at a university merge into broadly conceived interdisciplinary ventures (Thaiss, 2000).

The main advantage of offering this WAC Computer Security course online is that we can easily capture the fleeting and rapidly evolving nature of the course from a global perspective. Security threats and means to protect against them can emerge anywhere in the world, thus, this course is aimed at a global audience, hence very suitable for online delivery. Also, increasing the students' ability for self-directed learning and responsibility-taking in the educational process and developing the students' facility of using the Internet as a learning, research, communications and collaboration tool are added benefits. Clearly, there are some limitations to this method of imparting knowledge, and we have many challenges to negotiate. Some of these are in the fields of student assessment, learning outcome assessment, student attitude, etc. Numerous applications of this Internet-based course offering include 24/7 learning, open education, global reach of material which is rapidly evolving.

We would also like to conduct follow up studies with our graduating seniors as to the importance of such writing intensive courses within their chosen careers and how they benefited from these.

Of course, these actions will need to be pursued for some time and will involve lot of support from the Alumni Association and the Career Management Services at our university.

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Links

- [CRIT-THINK] The Critical Thinking Community at <http://www.criticalthinking.org/aboutCT/definingCT.shtml>.
- [BLACK] Blackboard at <http://www.blackboard.com>.
- [BLOGGER] Blogger: Dashboard @ <http://blogger.com>
- [DART-EDU] Materials for faculty: Pedagogies: Teaching critical thinking at <http://www.dartmouth.edu/~writing/materials/faculty/pedagogies/thinking.shtml#elements>
- [IEEE-CS] IEEE Computer Society Press Proceedings Author Guidelines at http://www.computer.org/portal/site/ieeecs/menuitem.c5efb9b8ade9096b8a9ca0108bcd45f3/index.jsp?&pName=ieeecs_level1&path=ieeecs/publications/author/style&file=index.xml&xsl=generic.xsl&
- [RUBI] Rubistar: Create rubrics for your Project-Based-Learning-Activities at <http://rubistar.4teachers.org/index.php>.
- [TURNITIN] Turnitin at <http://www.turnitin.com>.
- [WEBLOG] Weblog – Wikipedia, The Free encyclopedia at <http://en.wikipedia.org/wiki/Blog>.