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Effectiveness of an Online Writing System in Improving Students' Writing Skills in Engineering

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Abstract

Technology and Civilization is an advanced general education course (Area V: Culture, Civilization & Global Understanding) in the College of Engineering at San José State University (SJSU) that is designed to introduce students to the realm of history and usage of technology in society from an international perspective and to increase their awareness of both the uncertainties as well as the promises of the utilization of technology as a creative human enterprise.

This paper will present detailed data on student achievement of the course and General Education learning objectives. This course utilized the ETS Criterion Writing Evaluation System to allow the students to get enhanced feedback on their writing. In this paper, we will analyze the effects of Criterion on student learning outcomes. We will compare student performance from the Criterion pilot with existing assessment data from this course.

Introduction

In Fall 2011, SJSU received a U.S. Department of Education grant to improve the writing skills of Asian-American students at SJSU. This grant has several focus areas, one of which is the improvement of writing and writing instruction in General Education (GE) classes. An online writing program, the Educational Testing Service (ETS) Criterion Online Writing, was tested in a GE class, Tech 198, in the College of Engineering in Fall 2012.

SJSU is different from many in the United States. Instead of predetermining a specific series of courses as part of the General Education (GE) for each student, SJSU has five Core GE areas. In addition, every SJSU student must take SJSU Studies (formerly called Advanced GE) courses in four areas: Earth & Environment; Self, Society & Equality in the U.S.; Culture, Civilization & Global Understanding; and Written Communication. Any department may propose a course for any area of GE. Tech 198—Technology and Civilization, was approved as a SJSU Studies course in the Earth & Environment area until Spring 2000. In Fall 2000, after a revision to the university General Education program, the course was approved in another SJSU Studies Area (Area V--Culture, Civilization & Global Understanding) allowing for more breadth in content and added opportunities for students to cultivate academic skills.

Many universities offer courses for general education under the general theme of science, technology, and society. Frostburg State University[1] offers an interdisciplinary course titled Science Technology and Society as a freshmen level general education course for non-science and non-engineering majors. At the University of Denver[2], an interdisciplinary team including faculty from the Department of Engineering has offered a three-quarter long course called Technology 21 to approximately 100 students each year. This course is used by the non-engineering and non-science students to meet their university's science general education requirement. A general education course titled Technology and the Engineering Method at the University of Dayton[3] also fulfills a science education requirement and is taken by a diverse group of non-engineering students. At SJSU, since 2007, the College of Engineering has

increased its offering of GE courses from two to eight including Tech 198 and Engr 5, a course for non-engineering majors under the Physical Science GE area[4]. Other universities that have engineering courses as part of the General Education programs at their institutions include Miami University[5], Penn State University[6], Old Dominion University[7], North Carolina State University[8], and the University of Texas at Austin[9].

At SJSU, Tech 198 is required for several majors in the College of Engineering and the course provides assessment data for ABET and other accrediting bodies. Tech 198 is a required course for all BS Industrial Technology, BS Aviation, and BS Computer Engineering majors; in addition, it attracts students from other engineering majors and other majors at SJSU. This course is delivered in a novel way. It has a hybrid structure and is composed of three units that are delivered through self-paced multimedia CD (Units 1, 3, and 4), one unit that is delivered through WWW instruction (Unit 2), and three units that are delivered either through a traditional classroom model or using the Desire2Learn (D2L) course management system. This course is evaluated each semester under SJSU's GE program guidelines. The development and assessment of this course has been discussed previously[10].

Table 1. Content, Title and Instructional Delivery Method for Each Unit in Tech 198

Unit	**Title of Unit**	**Media Format**
1	Nature of Science and Technology	Multimedia CDs
2	History of Technology	Web-based
3	Technology and Work	Multimedia CDs
4	Technology and Gender Issues	Multimedia CDs
5	Technology Transfer and Cultural Issues	Lecture or D2L Online Module
6	Quality of Life	Lecture or D2L Online Module
7	Ethics	Lecture or D2L Online Module

For Tech 198, in addition to homework, each student must submit two research exercises. For each research exercise, the class is given a topic and article (or articles) related to the content of this class. Using library resources, each student must find additional articles, books, etc that relate to the article(s) given. Research Exercise 1 focuses on how a culture outside the US has changed in response to the internal and external pressures related to technology. Research Exercise 2 require the students to compare technological developments from at least two different countries. Each of the research exercises must be at least 5 pages double-spaced (1,250 words each).

In each semester prior to Fall 2012, students submitted their "final" research paper for grading. However, most of the grades on the research exercises were low (grades below a "C") and many students had their research papers returned for excessive grammatical errors. The instructor allowed the students to rewrite their research papers based upon her feedback. This equated to almost a doubling of the instructor's workload in grading these research exercises. For example, in Spring 2012, 37 of the 46 students in the instructor's section of Tech 198 submitted their research exercise 2 papers with revisions and these papers were regraded.

SJSU requires that students write throughout the curriculum. In order to achieve the broad objectives identified in the GE guidelines, writing is emphasized in all GE courses[11]. At the lower division level, at least 1,500 written words and some oral presentations are required in every course. The junior-level writing course, 100W, satisfies a GE requirement and requires a minimum of 8,000 written words. The three other Upper division SJSU Studies courses including Tech 198 requires that, in each course, students produce 3,000 written words and receive writing feedback throughout the semester.

SJSU has significant student populations of several Asian language speaking students including large groups of students from Chinese, Vietnamese, and Filipino backgrounds (see Table 2). Many of these students are high need Generation 1.5 students—U.S. educated English learners. These English learners enter SJSU with lower English skills than native English students. At SJSU, they struggle to complete their English and writing requirements. Often, these struggles impact their retention and graduation rates from SJSU. The challenges presented by this complicated skill set in Generation 1.5 students can be seen most clearly in English writing, a critical competency for academic success at SJSU which encompasses retention and graduation.

Table 2. Fall 2010 Undergraduate Asian students, by ethnicity

	F	M	**Total**
Cambodian	14	16	**30**
Chinese	361	486	**847**
Filipino	337	381	**718**
Guamanian	6	6	**12**
Hawaiian	11	6	**17**
Indian	105	128	**233**
Japanese	54	67	**121**
Korean	50	41	**91**
Laotian	4	5	**9**
Other Asian	85	125	**210**
Other Pacific Is	62	64	**4,957**
Other SE Asian	14	11	**126**
Samoan	0	4	**25**
Thai	9	7	**4**
Vietnamese	350	389	**16**
Decline to State	2,425	2,532	**739**
Total	**3,887**	**4,268**	**8,155**

Our institutional data clearly indicate that English writing ability is a significant problem among under-represented minority (URM) students including Generation 1.5 Asian Americans and Hispanic high needs students. In addition to the differences in English preparedness among students, there are significant differences that persist into upper division coursework. At SJSU, once students demonstrate English proficiency and satisfy lower-division composition requirements, they must pass a Writing Skills Test (WST) to progress to the required junior-level writing course. Here again, institutional data (see Table 3) show some disturbing disparities.

As part of its WASC self-study, SJSU conducted a comprehensive analysis to assess undergraduate students' writing skills based on the results of the WST over a four-year period which identified the importance of primary language status on WST success. While only 5% of native-English-speakers (ENL) fail the WST; 18% of EPL students (English Primary Language: English was not my native language, but English is now my primary language) fail; and 52% of OPL students (Other Primary Language: English was not my native language, and a language Other than English is still my primary language) fail on their first attempt. The WST failure rate is highest for Asian/Pacific Islander and Southeast Asian OPL students. In the November 2010 administration of the WST exam, the very highest WST failure rates were for students who identified as Asian/Pacific Islander OPL students (84%) or Southeast Asian students (96% for EPL and 82% for OPL) (see Table 3). These statistics, echoed throughout the system [12], demonstrate that pervasive weaknesses in writing still exist for both EPL and OPL high needs students. Most of the students in the College of Engineering are from URM groups

and the demographic make-up of the Tech 198 class generally follows the demographic make-up of the college. In Fall 2012, the three largest undergraduate ethnic groups in the college were: Asian (38.4%), Caucasian (21%), and Hispanic (20%).

State funding for the entire university, which includes SJSU, has been severely cut to help balance the state's budget and SJSU cannot serve as many students as it once did. Therefore, the SJSU Provost that each college in the university create at least one megaclass in Fall 2012 to serve an increased number of students. Normally, the maximum class size for each section of Tech 198 is 40 students. The class size for the Fall 2012 was increased to 134 students. To assist the professor in the class, a grader was provided by the university.

Table 3. WST failure rate for all SJSU students, by ethnicity, November 13 2010 WST Exam

	English is the students' first language				English is the students' second languag			
Ethnicity	**Number of students who pass**	**%**	**Number of students who fail**	**%**	**Number of students who pass**	**%**	**Number of students who fail**	**%**
Asian/Pacific Islander	168	63%	98	37%	34	16%	173	84%
Black/Africa-American	39	56%	31	44%	2	25%	6	75%
Filipino	78	80%	20	20%	2	33%	4	67%
Latino/Hispanic	107	65%	58	35%	24	36%	43	64%
White/Caucasian	267	91%	27	9%	8	57%	6	43%
Other	163	88%	23	12%	18	29%	45	71%
Southeast Asian	1	4%	23	96%	2	18%	9	82%
	823	75%	280	25%	90	24%	286	76%

Based on the history of low writing skills in the class and the university as discussed above, the Fall 2012 instructor in Tech 198 piloted ETS Criterion in the class for the two research papers. The hypothesis was that the use of ETS Criterion would improve students' writing in the class, therefore reducing the amount of time required to grade the students' research papers. Also, the instructor changed both research assignments in the class. Students were required to submit a complete draft paper for each research exercise and a final paper. All papers had to be submitted to Criterion and the students had to fix all the fixable errors. If there were too many fixable errors identified in Criterion, the instructor returned the essay to the student. Figure 1 shows the due dates for Research Exercise 1 for the Fall 2012 class of Tech 198.

Figure 1. Research Exercise 1 Due Dates for Fall 2012

Research Exercise 1 Due Dates

- **9/20/12, Research Exercise 1 Draft 1 DUE:** By 4:00 pm on 9/20/12, you must submit your rough draft to Criterion. You can submit your essay to Criterion multiple times. You must submit your draft to Criterion and email your first draft of your research exercise and your reference articles to Dr. XXX by 4:00 pm on 9/20/12.
- **9/27/12:** You will receive content feedback on your essay from Dr. XXX by 9/27/12.
- **10/11/12, Research Exercise 1 Final Paper DUE:** You should email your final draft of your research exercise (along with any additional reference articles) to Dr. XXX by 4:00 pm on 10/11/2012. Also, you should submit your research exercise to Criterion and fix any fixable errors. You should also submit a copy of your Research Exercise 1 Final Paper to the D2L dropbox by 4:00 pm.

Criterion Writing Software

Recently, universities have begun to explore using online technologies to increase instructor efficiency and serve more students. Many online software writing programs that are supposedly "studied" have data studies funded by the publishing companies that create such software. It is important to see valid and benchmarked data conducted on representative samples and with learning outcome measures and protocols with high reliability and validity scores. Student improvements in writing increase with more practice and opportunities to write, accompanied by specific, constructive feedback from faculty with opportunities for revisions. However, with class sizes increasing, how can engineering professors give suitable writing feedback to students?

Criterion operates on a web-based platform, is instructor driven, and can be used a tool for students to plan, write and revise their essays. By providing quick, diagnostic feedback and a holistic score students are able to review, revise and resubmit essays. This method has been proven to encourage students to write more extensively, be more critical of their work in the revision process, and increase time spent on writing. Also, by giving immediate feedback, students revise their essays more frequently. A study conducted by Covill[13] found that students actually desire and are looking for feedback to develop their work. Moreover, a research summary by Kluger and DeNisi[14]proposed “feedback that supports learning at the task level is likely to yield impressive gains in performance.”

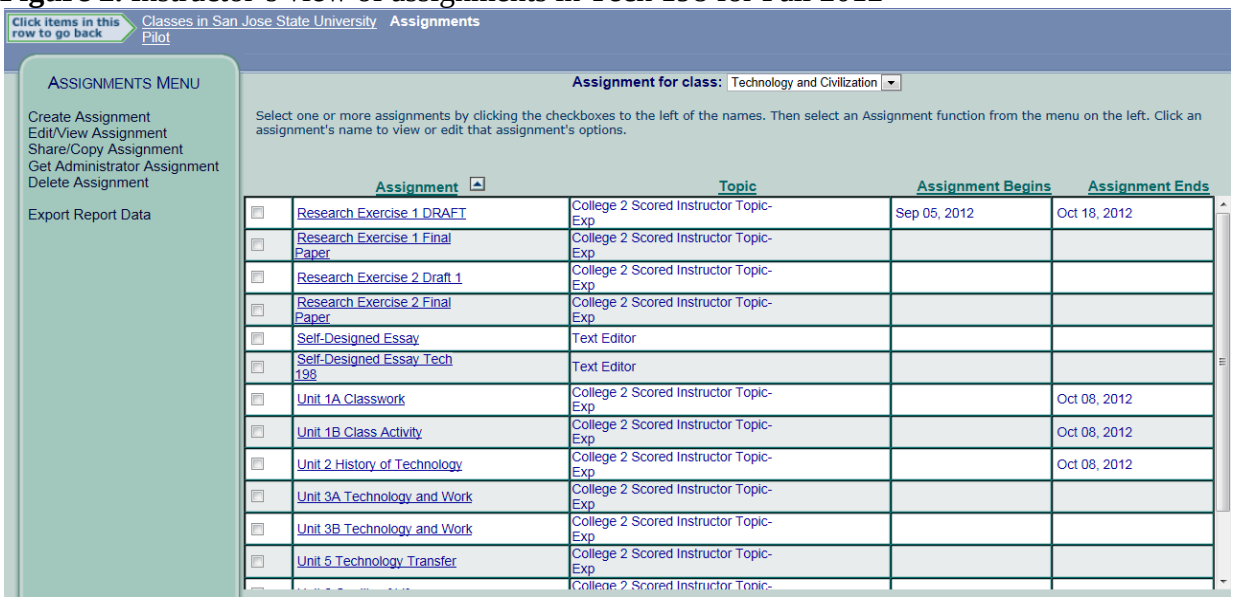
The Criterion Online Writing Evaluation has several unique features that attracted the professors at SJSU, including advisories, diagnostic feedback, and several writer’s handbooks. The Criterion system can be applied in a variety of instructional settings and for a variety of uses to support the writing and revision process. An advisory is given to the student when there is a dispute about the reliability of the score. When students submit their essays, feedback on their writing is generated in less than 20 seconds. The Criterion Performance Summary report includes scores from 1-6 points, along with descriptive messages in the areas of Grammar, Usage, Mechanics, Style, and Organization & Development. Feedback messages to the students also include an explanation for each error and provide a direct link to the correlating section in the online Writer’s Handbook for further instructional information.

Criterion aids instructors to quickly evaluate their students writing skills by scoring submitted essays and providing annotated diagnostic feedback that addresses their use of mechanics, style, grammar, usage, and organization and development. With the increase of their writing and revising activities, teachers and students have more time to interact on a more substantial level, thus allowing students to make more improvements in writing skills and overall writing quality (e.g., Bardine, Bardine, & Deegan[15]; Butterfield, Hacker, & Plumb[16]; Goldberg et al.[17]; Lehr[18]; Tiene & Luft[19]). Currently, more than half a million elementary, middle, high school and college students use the Criterion service in the United States. The development and assessment of the Criterion program has been discussed elsewhere[20]. In this paper, the author will describe how this program was used in the Fall 2012 Tech 198 class.

Originally, the Tech 198 instructor created prompts (folders) in Criterion simply for the Research Exercise draft and final papers. However, after a few weeks, the students requested additional

prompts for the homework in the class so that they could use Criterion to improve their writing. To allow the students to use this program in other classes, the instructor created two additional "Self-Designed Essay" prompts. Criterion also includes over one hundred topics in the ETS Topics Library that can be used or adapted by instructors. Figure 2 displays the list of assignments created in Criterion for the Fall 2012 Tech 198 class.

Figure 2. Instructor's view of assignments in Tech 198 for Fall 2012



Embedded in the Criterion software is a Writer's Handbook. Nine versions of the Writer's Handbook are available for student users. For Tech 198, the instructor used the High School/College Writer's Handbook. The topics in the handbook include those which would be of interest to students trying to improve their writing. In addition, when students receive their diagnostic feedback in Criterion, they get a link which opens the specific section related to the marked error. The five scoring categories under Trait Feedback Analysis are:

- Grammar score – based on errors such as those in subject-verb agreement among others
- Mechanics score – derived from errors in spelling and other like errors
- Usage score – based on such errors as article errors and confused words (an example would be an instance in which the essay writer uses a word that although phonetically similar has a different meaning from the intended word; using "to" where it would have been proper to use "too")
- Style score – based on instances of overly repeated words and the number of very long or very short sentences as well as other such features
- *Organization/development score* – based on the identification of sentences that correspond to the background, thesis, main idea, supporting idea, and conclusion

Figure 3. Criterion sample feedback for Grammar

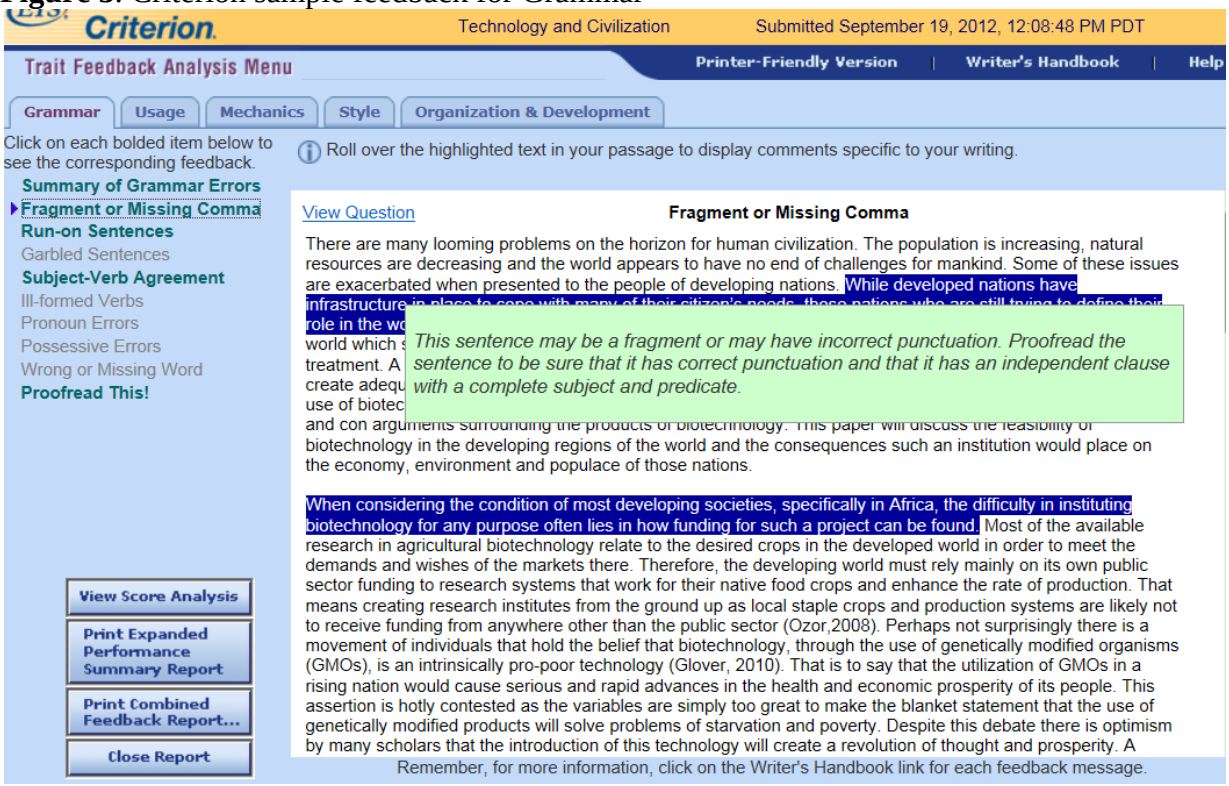


Figure 4. Sample of Usage Error

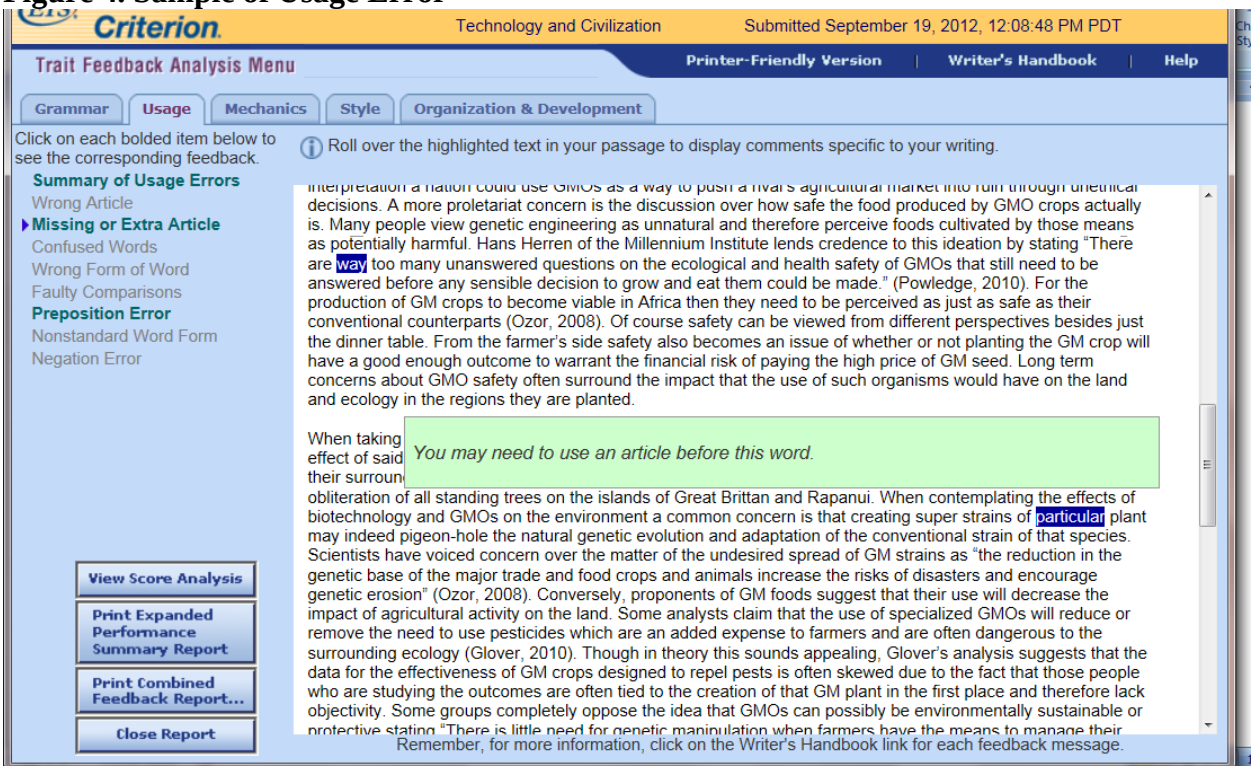
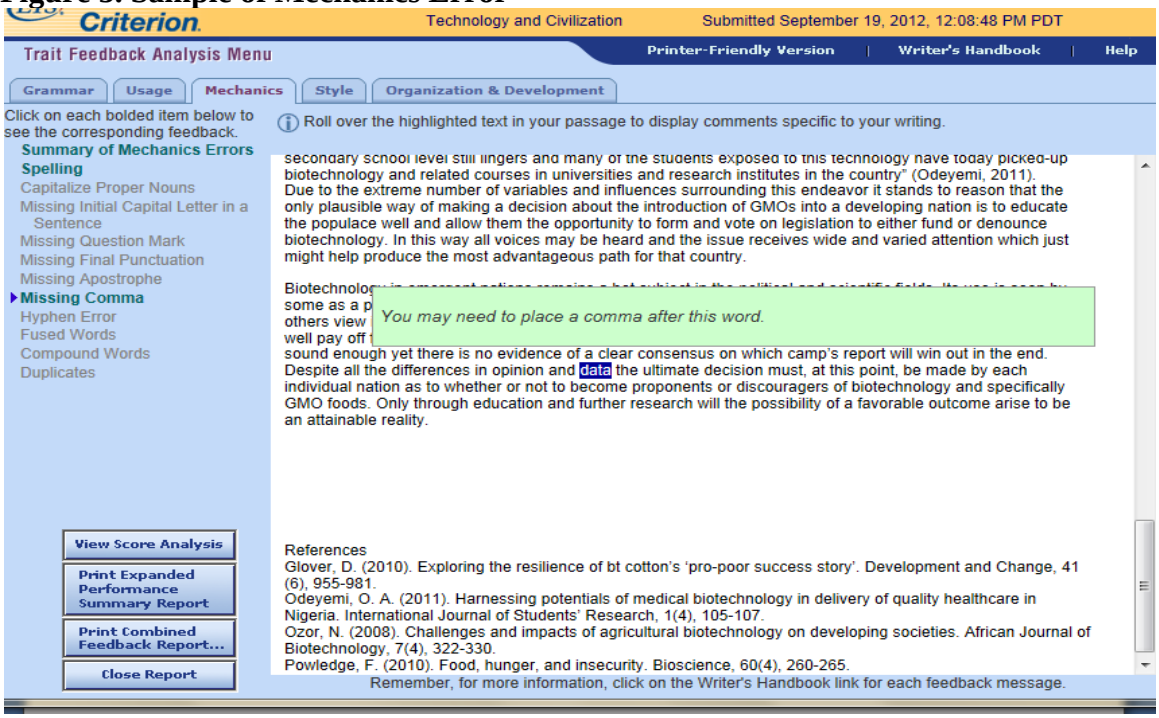


Figure 3 displays sample feedback that the student would receive on an essay. As you can see from Figure 3, Criterion will indicate potential errors under Grammar in nine areas: Fragment or Missing Comma, Run-on Sentences, Garbled Sentences, Subject-Verb Agreement, Ill-Formed Verbs, Pronoun Errors, Possessive Errors, Wrong or Missing Word, and a special category called Proofread This! In the sample shown in Figure 3, the student has clicked on the left hand menu to show his potential errors under Fragment or Missing Comma. When the student moves his mouse over the marked text, the Criterion feedback appears. If the student clicks on the green box, he would be taken to the Writer's Handbook to the section on Fragments and Missing Commas.

Figure 4 displays a sample of the error report that the student receives under the Usage tab. Criterion will indicate grammatical usage errors in eight subareas: Wrong Article, Missing or Extra Article, Confused Words, Wrong Form of Word, Faulty Comparisons, Preposition Error, Nonstandard Word Form, and Negation Error. In the sample shown in Figure 4, the student was advised that an article might be needed before the highlighted word.

Figure 5. Sample of Mechanics Error



The third area evaluated in Criterion is the mechanics of writing. The subareas included in Mechanics are: Spelling, Capitalize Proper Nouns, Missing Initial Capital Letter in a Sentence, Missing Question Mark, Missing Final Punctuation, Missing Apostrophe, Missing Comma, Hyphen Error, Fused Words, Compound Words, and Duplicates. In Figure 5, Criterion recommended that the student might need to insert a comma in the sentence.

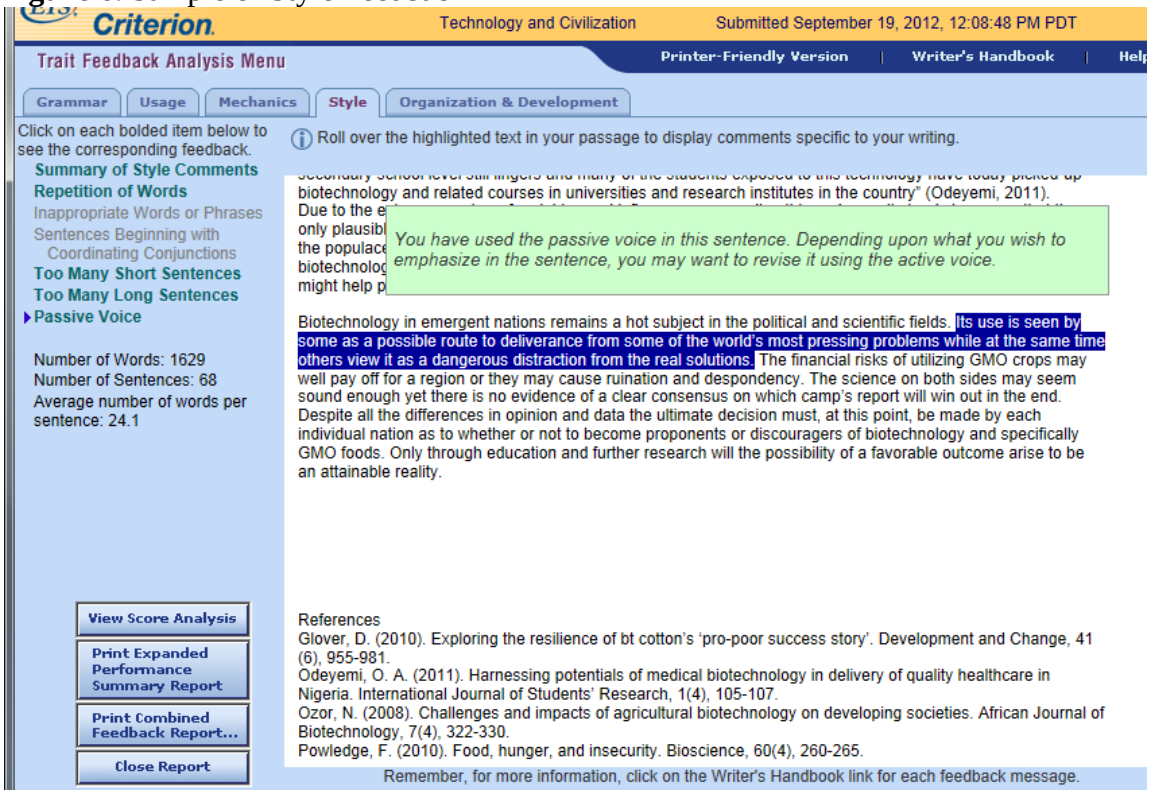
There was a problem with the Criterion feedback in the Mechanics area for this class. As the papers in Tech 198 were technical research papers, most students had non-fixable spelling errors. This was a limitation to the use of the Criterion program. If students cited an author in their

papers or included very technical words, Criterion sometimes would indicate an error. As these Criterion "errors" did not have to be fixed, students were not penalized for them.

For this study, the last two Criterion categories (Style and Organization & Development) were not assessed. The Style category gives students feedback in six areas: Repetition of Words, Inappropriate Words or Phrases, Sentences Beginning with Coordinating Conjunctions, Too Many Short Sentences, Too Many Long Sentences, and Passive Voice (see Figure 6). The Organization and Development category gives students feedback in eight subareas: Introductory Material, Thesis Statement, Topic Relationship & Technical Quality, Main Ideas, Supporting Ideas, Conclusion, Transitional Words and Phrases, and Other (see Figure 7). The Organization & Development category is based on the assumption that the student will write a standard, short, five-paragraph essay.

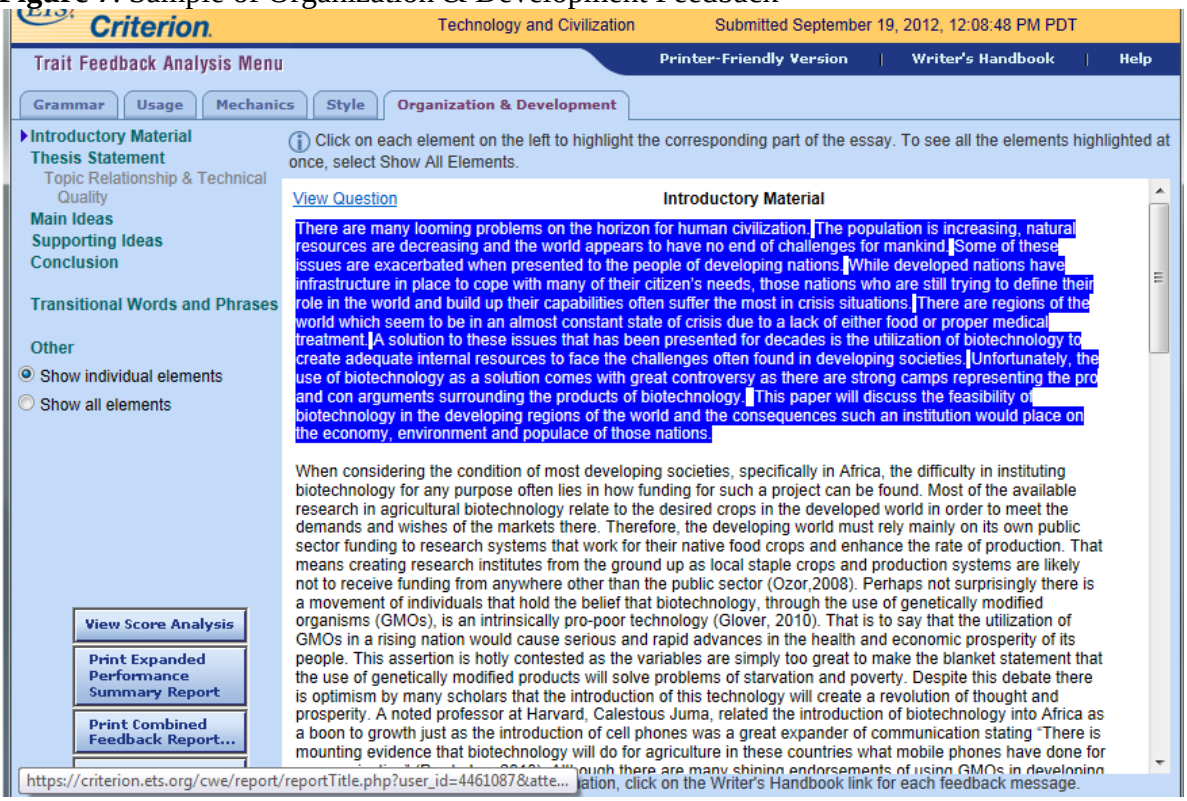
As this class includes students from many majors at SJSU, the instructor determined that these categories would not be assessed. Each discipline has its own writing style and requirements so the Tech 198 instructor decided that usage of these two categories would not be appropriate.

Figure 6. Sample of Style Feedback



When an instructor creates an assignment in Criterion, he/she can choose the type of feedback the student will see. If the essay is designed to be under 1,000 words, the students can get a holistic score (from 1 to 6 with 6 being the highest score). As the requirements of the Tech 198 assignments were to write essays of at least 1,250 words, the instructor used the other feedback feature of Criterion, Trait Feedback Analysis. For this analysis, the instructor assessed the students on Grammar, Usage, and Mechanics.

Figure 7. Sample of Organization & Development Feedback



Assessment of Criterion in Tech 198

As discussed above, students in the Fall 2012 Tech 198 class were required to submit four research papers to Criterion for a grammar check: Research Exercise 1 Draft Paper, Research Exercise 1 Final Paper, Research Exercise 2 Draft Paper, and Research Exercise 2 Final Paper. 87 of the 134 students enrolled in the class submitted all four papers to Criterion. Most of the remaining students chose not to complete the rough drafts for either Research Exercise 1 or Research Exercise 2. Each final research paper was worth 20% of a student's final grade and each rough draft was worth 5% of the final grade.

For the rough and final drafts for both Research Exercises, the instructor reviewed the Criterion report for the last essay submitted by each student. For Research Exercise 1, the instructor focused on the grammar errors in Criterion. Table 4 shows the numbers of errors and the average number of "fixable" errors for the 87 students who completed all four assignments. This data shows that the number of grammatical errors decreased over the four assignments.

It is also interesting to note that t-tests comparing the individual students' grammatical errors were significant. A t-test comparing the number of errors on Research Exercise 1 draft with Research Exercise 1 Final paper was significant ($p<0.001$). A t-test comparing the students' grammatical errors on the two papers for Research Exercise 2 was also significant ($p<0.001$).

Eighty-seven students submitted both draft papers to Criterion. Table 4 shows that the average number of errors for Research Exercise 1 draft was 2.87 as compared to 1.7 for Research

Exercise 2 draft paper. A t-test comparing the students' grammatical errors on the two draft research papers was also significant ($p<.01$). Students did better on their second rough draft (Research Exercise 2 draft) than they did on their first one (Research Exercise 1 draft). This implies that the students were using the system to learn from their mistakes and they made fewer mistakes the second time around.

Table 4. Number of Grammar Errors on Each Writing Assignment

	RE 1 Draft	RE 1 Final	RE 2 Draft	RE 2 Final
Grammar errors	No. Students	No. Students	No. Students	No. Students
"0" errors	22	34	34	42
"1" error	17	21	15	27
"2" errors	10	12	14	9
"3" errors	11	4	9	6
"4" errors	8	7	7	2
"5 or more" errors	19	9	8	1
Average errors	2.87	1.62	1.7	0.89

In addition to the number of grammatical errors, we compared the grades on both research exercises for the Fall 2012 class with the grades from the Spring 2012 class to see if there was a difference. In general, for this class, students receive higher grades on Research Exercise 2 as compared to Research Exercise 1.

Table 5. Student grades on Research Exercise 1 and Research Exercise 2, Spring 2012 vs Fall 2012 classes

Research Exercise grades	RE1 Spring 2012		RE 1 Fall 2012		RE2 Spring 2012		RE 2 Fall 2012	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
A+, A, A-	0	0.0%	8	6.0%	6	13.0%	21	15.8%
B+, B, B-	15	32.6%	41	30.8%	18	39.1%	51	38.3%
C+, C, C-	19	41.3%	50	37.6%	16	34.8%	28	21.1%
D or lower	10	21.7%	20	15.0%	4	8.7%	6	4.5%
*Did not submit final paper	2	4.3%	14	10.5%	2	4.3%	27	20.3%
Total No. Students	46		133		46		133	
Average (excludes *)		73.5%		77.4%		77.3%		82.0%

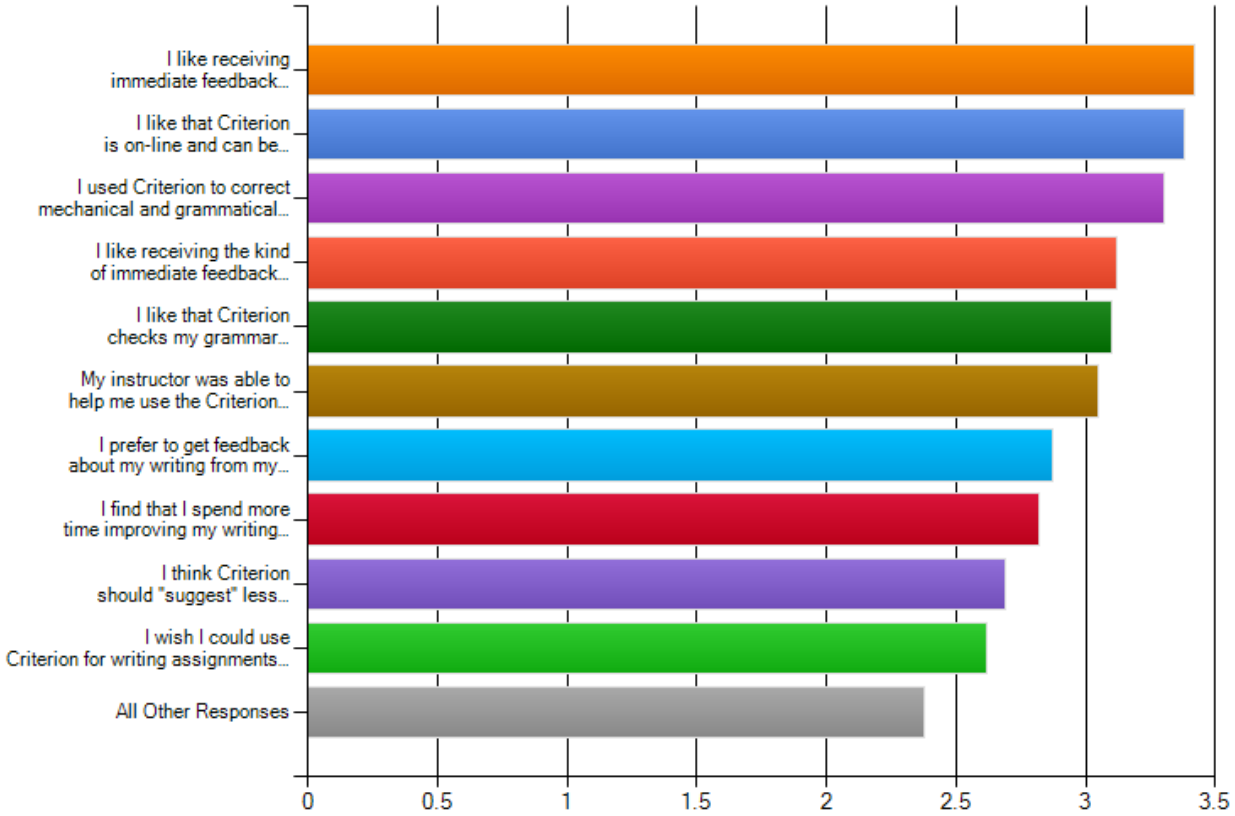
When comparing the student grades on their final essays between the Spring 2012 and Fall 2012, the grades on both Research Exercise 1 ($p<0.01$) and Research Exercise 2 ($p<0.01$) were significantly higher for students in the Fall 2012 class (see Table 5). As discussed above, most of the students in the Spring 2012 class rewrote and resubmitted their research exercise papers for regrading. The analysis of the students' grades for comparison is based on the final, rewritten papers for Spring 2012. In contrast, in Fall 2012, the draft research exercises were not given a grade. The instructor gave each student grammatical and content feedback on the draft essays in Fall 2012. This feedback was similar to the comments that the instructor gave to the students on their first "graded" versions of their research exercises in Spring 2012. However, since Criterion

was used in the class, there were fewer grammatical errors in the Fall 2012 research papers as compared to the Spring 2012 papers. For example, 13 of the 44 papers (29.5%) submitted in Spring 2012 for Research Exercise 2 were returned due to excessive grammatical errors. In contrast, in Fall 2012, only three (2.2%) Research Exercise 2 Final papers were returned to the students for an excessive number of grammatical errors.

Student Assessment of Criterion

In addition to the assessment of student improvement using Criterion, the instructor surveyed the class about their experiences and opinions of this program. Forty-one usable surveys were completed using SurveyMonkey; this equates to a 31% response rate.

Figure 8. Student assessment of Criterion



Students were given several statements about their experiences with Criterion using a 4 point Likert scale (1=Strongly Disagree; 2=Disagree; 3=Agree; 4=Strongly Agree). The items indicating the highest level of student agreement are shown in Figure 8. The items receiving an overall rating of 3 or above were the following statements:

- I like receiving immediate feedback on my writing (rating=3.43)
- I like that Criterion is online and can be used 24 hours a day
- I used Criterion to correct mechanical and grammatical errors in my writing (rating=3.30)
- I like receiving the kind of immediate feedback on my writing that Criterion offers (rating=3.13)
- I like that Criterion checks my grammar and spelling (rating=3.10)

- My instructor was able to help me use the Criterion program more effectively (rating=3.05)

Summary

Due to the history of low writing skills in the Tech 198: Technology and Civilization course at SJSU, the Fall 2012 instructor in Tech 198 piloted ETS Criterion Online Writing Evaluation Service in the class for the two research papers required. The hypothesis was that the use of ETS Criterion would improve students' writing in the class, therefore reducing the amount of time required to grade the students' research papers. Overall, this research shows that adopting Criterion has better served students who previously had difficulties writing. The unique tools that Criterion offers allows students to receive real-time feedback on their submitted work, get access to detailed descriptions of their mistakes, and revise their essay's in a timely manner; thereby, improving the efficiency of the instructor and the confidence and writing capacity of the student. This is evidenced at San Jose State University in the comparison between two sections of Tech 198: Technology and Civilization's spring and fall 2012 classes. Based upon the data collected, it can be said that, with the introduction of Criterion in fall, students reduced the number of grammatical errors on their assignments and increased their grades on their research papers, compared to the Spring 2012 semester. Given the positive results the instructors and advised the General Education committee to continue the use of Criterion in the Tech 198 course, as well as extend it to other SJSU classes.

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