Abstract Analysis and Revision Assignment Using MS Word Readability Statistics

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Abstract: In teaching technical writing for nearly 20 years, I have recognized the importance of including writing assignments focused on improving students' clarity and effectiveness at the sentence level. I present a writing assignment for STEM students ranging from freshman to graduate-level. Students first find a published abstract in their discipline and then use readability tools to analyze the abstract's style. They revise the abstract for better readability while maintaining professional tone. This assignment reinforces research skills, audience awareness, and reflection on sentence-level stylistic choices.

Introduction

It is well understood that integrating communication assignments within scientific and technical classrooms provides ways for students to deepen their understanding of content and strengthen their skills in articulating that content to others through written and oral modes. In this article, I provide rationale and materials for an assignment focusing on scientific and technical abstract analysis, as well as revision incorporating the use of computer-based readability tools.

This assignment emphasizes multiple, core communication practices taught in all writing classes, from the first year all the way to the graduate level. These practices include the research skills students must employ in finding an abstract in their field. In the process of searching for relevant abstracts and then analyzing their readability, students are also accumulating sources they can draw upon when working on later assignments such as an annotated bibliography or research report. This assignment exposes students

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to Microsoft Word's readability statistics tool. Students rely on this tool to analyze the original abstract as well as to concretely measure the enhanced readability of their revision. The assignment also provides an opportunity for students to consider the abstract as a genre that depends on clear and precise phrasing and to work on their own editing skills. In making sentence-level choices and being mindful of maintaining professional tone, students also become more conscious of the importance of content selection and presentation for their audience.

Literature Review

According to the National Council of Teachers of English's (NCTE) Assembly for the teaching of grammar (2002), "people associate grammar with errors and correctness. But knowing about grammar also helps us understand what makes sentences and paragraphs clear and interesting and precise." As this quote demonstrates, the term grammar is rife with black and white associations of correctness. Yet, as emphasized in the latter half of the quote, grammar knowledge is connected to a larger goal of overall clarity and effectiveness at the sentence-level. While the term *grammar* is used within the literature I review below, in the context of the studies summarized here the term encompasses more than grammatical rules and includes stylistic features contributing to clarity at the sentence level. This broader view of grammar, one that is concerned with applying stylistic features to grammatical rules to achieve prose that is readable and clear, mirrors my definition and emphasis within this assignment.

Using Mechanics and Style to Promote Sentence-Level Instruction

In their review of grammar emphasis in current technical communication textbooks, Boettger and Wulff (2014) revealed that the emphasis on mechanics and style within textbooks tends to be "significantly shortening rather than expanding" (p. 134). While technical communication instruction often prioritizes teaching writing from a rhetorical approach over a sentence-level skills-based approach, there are arguments in the literature supporting the value of instruction on mechanics and style. Many writing teachers already agree that the inclusion of micro-approaches in writing courses can complement current approaches focused on more global issues. However, we lack tools to meaningfully teach sentence-level writing in ways that engage our students. As Wolfe (2014) argues, "our tools for teaching grammar are much less effective" than our tools for teaching higher order rhetorical concepts (p. 39).

Outside of our discipline, students, colleagues, and professionals often think of writing instruction as beginning with mechanics and style (and oftentimes, as ending with mechanics and style). Knievel et al.'s (2010) account of a workshop on writing within a professional engineering context helps illustrate a shortcoming of approaches to teaching technical writing that avoid or diminish the importance of mechanics and style. The authors present their experience designing and providing a writing workshop for senior-level engineers at an environmental engineering company. In their role as consultants, Knievel and colleagues (2010) learned that a focus on grammar and mechanics, which they categorize as "a constellation of different elements of writing that contribute to the writing's clarity, accuracy, and correctness" may "become both a meeting point between academic and engineering interests and a gateway to valuable analysis of company writing" (p. 58). The participants in Knievel et al.'s (2010) training session who paid "rapt attention" during the grammar worksheet section suggest that a formalist approach towards grammar and mechanics may have some value in our classrooms, particularly those involving engineering students (p. 64). The key seems to be an approach that contextualizes grammar instruction within a document's larger rhetorical situation.

Readability Statistics as a Classroom Tool

The NCTE's resolution on the utility of grammar exercises (1985) notes "…ample evidence from 50 years of research has shown the teaching of grammar in isolation does not lead to improvement in students' speaking and writing, and that in fact, it hinders development of students' oral and written language." Composition and technical communication instructors who have tried exercises on mechanics in isolation likely have experienced firsthand that grammar worksheets or quizzes are an ineffective way to teach students to improve their writing.

Further, the Conference on College Composition and Communication (CCCC) position statement on Writing Assessment (2009) notes "the very nature of writing as a complex and context-rich interaction between people," cautioning against using "machine-scored writing in the assessment of writing."

While I agree with both statements, I have witnessed enough repeated errors in mechanics and poor stylistic choices in student writing to believe that an assignment focusing on the sentence level can be a way to help students improve these issues. Coupling instruction on mechanics and style with the higher order concern of audience awareness provides a way to situate sentence-level instruction within authentic texts, as recommended by CCCC. While computer assessment tools for writing can, as CCCC (2009) warns, "mislead writers to focus more on structure and grammar than on what they are saying by using a given structure and style," if they are relied upon solely, I believe they can be effective if incorporated in writing courses in a way that allows students to understand the micro and macro approaches working in tandem.

The few studies that have examined the impact of readability tools on student writing include Schwartz's (1980) study focused on the use of readability tools within a technical writing course in a university setting. In this pilot study of students who used readability statistics tools, results indicated the potential of such tools, especially if they are complemented with qualitative feedback. Schwartz (1980) noted that in addition to helping students achieve a simpler writing style, the use of the tools could have the added effect of "promoting greater sensitivity to implications of style" (p. 8).

In their study examining the use of a computer readability tool by 10-year-olds, Beaglehole and Yates (2010) learned about the hazard of faulty statistics being generated yet also seized the opportunity to instruct students on how to "use the computer generated objective feedback to make their work more readable" (p. 54). This study highlights the fact that readability statistics are not a silver bullet for writers; as Beaglehole (2010) argues, "their use is restricted if the feedback is not understood" (p. 55). From a second language perspective, Crossley, Greenfield, and McNamara (2008) criticize readability formulas because they focus on the surface-level linguistic features of the text rather than the processes a reader brings to the text (p. 60).

The appropriate application, then, for readability tools, is perhaps most clearly answered by Kincaid, who, together with Flesch, developed the reading ease and readability formulas. In an interview with McClure, when asked if "a readability formula [is] a reading tool or a writing tool? Or both?" Kincaid replied "Neither!" explaining that it is an evaluation tool (McClure, 1987, p. 12). As an evaluation tool, a readability formula can be used as "a quality control measure" when matching content to users (McClure, 1987, p. 12). An instructional approach that helps writing students see the connection between grammar and style at the sentence-level and the rhetorical triangle defined by Bitzer (1968) provides an example of effective use of writing assessment technology in the classroom.[1]

Assignment Overview and Rationale

I designed the Abstract Analysis and Revision assignment (Using MS Word Readability Statistics) five years ago for a first-year writing and research in the disciplines course within the Mechanical Engineering department at New Mexico Tech, a science and engineering-focused institution. It has also been used (without any adaptation necessary) for a junior-level Mechanical Engineering technical writing course as well as graduate-level communication courses for science, engineering, and education students.

The main goals of the assignment are for students to better understand the connection between sentence-level revision and a document's larger rhetorical situation through the use of a computer-aided assessment tool. Using readability statistics encourages focus on sentence-level clarity and at the same time promotes deeper thinking about the connection between micro approaches to revision and higher order rhetorical concerns of audience awareness. Because the assignment occurs early in the semester, I also use it as a way to prepare students to be able to more effectively edit and revise their own work and provide feedback to peers; beginning the semester by revising a faceless author's abstract tends to allow students to flex their constructive criticism muscles more easily.

I openly discuss the goals with students when introducing the assignment. This discussion is aided by including an example from a prior student's abstract analysis assignment.

We read the original conference paper that the abstract was part of in class, then view the original abstract and discuss the ways in which the prior student's revisions not only improved the clarity of the abstract at the sentence-level but also improved the audience's overall understanding of the research.

While graduate-level students have had more prior instruction on Bitzer's (1968) rhetorical situation than first-year students and junior-level students, I incorporate the rhetorical triangle through use of case study examples that illustrate audience, purpose, and context, into class discussion at all levels (changing the case studies I cite depending on the particular audience). Although I have used numerous textbooks in the past, most recently I have required Margot Northey and Judy Jewinski's (2016) *Making Sense: A Student's Guide to Research and Writing (Engineering and the Technical Sciences)* in all of my courses because I have found it to be a brief but quite informative text for stressing the fundamentals of writing. I supplement the book with case studies and external examples that are directly related to students' particular disciplinary research.

This assignment requires students to work individually to first find an abstract from either an academic journal article within their discipline or a professional/academic conference related to their current course project or research. Since students' ability to successfully revise these abstracts hinges on their overall understanding of the content, students must read the lengthier article or conference paper. Students are then required to analyze the abstract's language, using MS Word's readability statistics to determine grade level, reading ease, and passive voice percentage and then revise the abstract with the goal of improving these areas of readability and simplifying the abstract's content for better clarity. In their final submission, students turn in a document that includes the original abstract and citation along with a screen capture of the readability statistics and their revised abstract with a screen capture of their revised readability statistics. Students are told from the start that there is no magic number that they need to aim for (as far as readability statistics go); instead, they should focus on improving the abstract significantly while not sacrificing important content or changing the tone so much so that the abstract would no longer be appropriate for its original intended audience.

For many students, this assignment is the first time they have used MS Word's readability tools. In class, I show them how to perform a readability check. While several students know how to use screen captures, not all do, so I also demonstrate how to do that.

The most recent versions of Microsoft Word may not have the same capabilities for the readability statistics tool as earlier versions. Microsoft Word 2016, for example, will not automatically include passive voice percentage unless add-ons are included. While in most cases there are add-ons that are easy enough to configure, an alternative option is to require students to research their own grammar-checking tools online. Multiple free ones are available that include passive voice trackers. In presenting this assignment, I am afforded the opportunity to engage in a discussion with students regarding passive voice and its role in technical and scientific communication. While one of the goals in the assignment is for students to reduce passive voice in order to achieve better clarity and a more direct style, we examine examples in class and identify cases when passive voice promotes clarity.

The grade level category uses the familiar-to-many Flesch-Kincaid metric which equates prose to the U.S. school grade level at which a typical student would be able to read. For example, a score of 7.0 represents prose which could be read by seventh graders. During class discussion of this assignment, we talk about the fact that the general public can read at an average of an eighth-grade level. I wait for the students to speak up and question the appropriate level of audiences for published academic abstracts. We agree that an eighth-grade level may be too low in this context but discuss the benefits of an abstract that might be equated to a high school reading level as opposed to post-post graduate reading levels (21.4 is the highest I have seen to date).

The Flesch reading ease score includes a 0 (incomprehensible) to 100 (easy to understand) scale that measures the relative difficulty of reading a sentence. This scale is based on a formula developed by Flesch in the 1940's which measures average sentence length in words and average word length in syllables. While I do not share the specific calculation in class with students, I direct interested students (they are engineers and tend to be interested in equations) towards Flesch's work. In class, I share reading ease indexes for familiar publications to help students have a benchmark.

As students begin revising the abstract, inevitably many of them discover that even though we have discussed the difference between passive and active voice in class and worked through examples, they may still not have a firm understanding of the difference. Through trial and error reconstructing sentences and running readability statistics these students have reported back to me that they often experience an "Aha!" moment and finally grasp the concept through their own manipulation of content at the sentence and word level. These passive vs. active voice epiphanies have occurred not just with first-year students, but with upperclassmen and graduate students as well.

Some students fear that a published professional document may not have room for improvement. When students run readability statistics on the abstracts, they are often surprised at the poor reading ease scores and excessive passive voice used. Those who were skeptical about the assignment when it was introduced are relieved to discover it is not difficult to find professional abstracts that could be revised for clarity. In revising the abstracts, students consider word choice carefully, strive for manageable sentence length, and quickly learn the difference between active and passive voice construction. For many students, the assignment becomes a competition to see how much passive voice they can reduce, how high their revised abstract will score on the reading ease score, and how low they can score on the Flesch-Kincaid grade level test and still maintain professional tone. Inevitably, the assignment provokes productive conversations regarding the benefits and drawbacks of passive voice and the role of jargon within a discipline. Especially for first-year students, the abstracts they work with will inevitably contain terms and acronyms they do not know. A side benefit of this assignment is whether students include these terms in their revised abstract or not, they learn new technical terms as part of the process and thus are adding to their technical vocabulary and broadening their understanding of the topic pertaining to their research projects.

Assignment Outcomes

Those who do not succeed on this assignment have either misunderstood the requirements or not attempted to restructure any sentences within the abstract, instead just swapping out a few words here or there. Those cases are rare, however, as the majority of students in my classes have performed very well on it. Students name this assignment more frequently than any other as one they found valuable within the comments section of the formal course evaluations as well. In a class of 20 students, at least three students typically include mention of this assignment in the open-ended "What are the best characteristics of this course" section. Below are examples from my most recent course evaluation in a junior-level course.

- *The readability statistics assignment pushed me out of my comfort zone and provided me with an approach towards my writing that I will continue to rely on.*
- *The abstract assignment gave me practical knowledge I will be able to use in my career.*
- *I never heard of the readability tools and using them helped me finally figure out the difference between passive and active voice.*

In the assignment I share here, I include the instructions I communicate to students when introducing this assignment as well as a copy of the rubric I use to grade the assignment, featuring points assigned for improvements in the three readability categories as well as points for overall quality of the revised abstract. While I only require students to submit one revision (their best one resulting from the trial and error process), the first sample assignment I have included here demonstrates multiple attempts by one student. In addition to the screen captures accompanying each version of the abstract, this student also went beyond the assignment requirements and included graphs depicting his progress. The second sample assignment is more typical of what I receive from the majority of students.

Final Reflections

While this assignment is one I am committed to including in each course I teach, there are some inherent challenges. In the first few semesters I taught this assignment I noticed some students were hesitant to make structural changes in their revision. These students tended to keep the same number of sentences, using the same organizational style as the original abstract. Their strategy involved swapping out words here and there and only rearranging ideas within a sentence in order to make passive constructions active. To address this issue, I modified my lecture introducing the assignment to emphasize that in order to succeed students would need to be willing to make structural revisions. Now when I introduce this assignment I remind students they have full license to rearrange points, eliminate redundancies, and remove unessential information; my emphasis here has made a difference. In terms of evaluation, the most challenging aspect I face is determining whether students have effectively understood and maintained the intent of the original abstract. While students are required to read the larger pieces to which their abstracts are connected, I do not spend the time to read the full articles for each student's assignment. Most of the time I have a fair idea from comparing the original abstract to student revisions to believe the students are effectively maintaining the original meaning. In cases when I am uncertain, I will skim the length of the original article. Although my evaluation categories do not specifically assess students' ability to capture the essence of the article's content, I can use the Overall Quality of Revised Abstract category to deduct points from a student abstract that is stylistically well written but straying from the original meaning. In closing, teaching this assignment for multiple years has been rewarding, and ultimately it has served as the best tool I have developed for helping students consider and improve their writing at the sentence level.

Assignment–Abstract Analysis and Revision Assignment Instructions

See the Supplementary Files for this article at thepromptjournal.com for a PDF facsimile of the original formatting of this assignment.

(Using MS Word Readability Statistics)

This assignment requires you to find a published abstract in a peer reviewed journal or professional conference proceedings and revise it with emphasis on improving readability and style. You will apply the research skills we've been working on in class to first locate an abstract pertaining to your final project topic. Next you will use the readability statistics tool in MS Word to determine the scores for reading ease, grade level, and passive voice in your original abstract. Finally, you will improve upon these scores by applying revision strategies to rewrite the abstract, aiming to increase the reading ease score, lower the grade level score, and lower the percentage of passive voice while still maintaining appropriate professional style.

Day 1: In class you will have time at your workstation to begin searching for abstracts in your discipline. I will circulate and look over your shoulders and provide on-the-spot feedback. I will also answer any questions and provide instruction for those who need help enabling the readability statistics tool or performing screen captures.

Day 2: The assignment is due. (Note: this time sequence assumes a class that meets 2xs a week).

Evaluation

While there is no magic number to shoot for, your assignment will be evaluated by the overall quality of your revised abstract as well as demonstration of *significant* improvement in at least two of the three readability categories (and improvement in all three readability categories).

Tips

- Choose an abstract with room for improvement in the three readability categories (most will have room for improvement, but you may have a difficult time if you find an abstract with 5% passive voice for example)
- Pay attention to the average words per sentence metric as you're revising the abstract. In general, the longer the sentence, the less readable it will be. Remember that Subject+Verb+Object sentence structure is most accessible by readers.
- Don't be afraid to restructure the organization of the abstract (rather than approach revising each sentence one by one). Consider reorganizing sentences, looking for unnecessary redundancies, and eliminating information that may not be appropriate for an abstract.
- Since the abstracts you find will be discipline-specific, you may choose to leave certain jargon in. Consider the actual intended audience for the abstract and what terms those readers would be expected to know. (Even if it includes technical terms or jargon, your revised abstract should still have clarity and logical organization).
- Be careful that your revision is not changing the overall meaning of the original abstract's content.

Drafting and Submission

We will not peer review drafts of this assignment in class; however, you will most likely revise your abstract multiple times as you work to improve the statistics. I am happy to work with you during office hours if you have questions or would like feedback on a draft of this assignment.

Upon submitting your final version, include the original abstract with corresponding citation (formatted in the preferred style of your discipline) and an accompanying screenshot of the readability statistics (see Figure 1 below). Within this same document you will also include your revised abstract with an accompanying screenshot of the readability statistics.

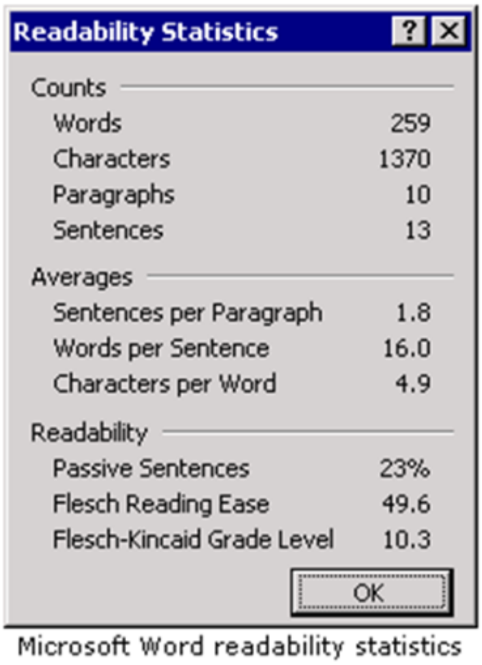

Figure 1: Readability statistics screenshot example

To enable the readability statistics tool in Microsoft Word

- Click the **Microsoft Office Button**, and then click **Word Options**.
- Click **Proofing**.
- Make sure **Check grammar with spelling** is selected.
- Under **When correcting grammar in Word**, select the **Show readability statistics** check box.

Abstract Analysis and Revision Assignment

(Using MS Word Readability Statistics) Grading Rubric

Student:

Reading Ease (30 pts. possible)

Original # ________ Revised version # _________

Comments:

Grade Level Score (30 pts. possible)

Original # ________ Revised version # __________

Comments:

Passive voice (30 pts. possible)

Original # ________ Revised version # __________

Comments:

Overall quality of revised abstract (10 pts. possible)

Grade: __________/(100 possible points)

Student Writing Sample #1

Original Abstract

Rocha, B., C. Silva, and A. Suleman. "Design of a PZT Sensor Network Based on Guided Lamb Waves for Structural Health Monitoring of Metallic Structures." *ASME 2010 International Mechanical Engineering Congress and Exposition Vancouver, British Columbia, Canada.* Volume 13: *Sound, Vibration and Design*, pp. 471-480.

A Structural Health Monitoring (SHM) system of metallic structures based on guided Lamb waves is presented. Lamb waves are reflected on discontinuities in material properties and geometries such as damage. Lamb waves present advantages when applied on thin structures due to their low amplitude damping which enables them to travel longer distances. The selection of transducers, their size and selected locations in the structure are described. Additionally, the design, development and implementation of a new signal generation and data acquisition systems is presented in detail. The requirements leading to the development and selection of these systems are explained and particularly the selection of the actuation signal is discussed. A damage detection algorithm based on the comparison between the damaged structural state and a healthy reference state is used to detect damage based on reflected Lamb waves. Subsequently, the detection algorithm based on discrete signals correlation was further improved by incorporating statistical methods. Tests performed on a plate with multiple surface cuts, through the thickness cuts, loosened rivets and cuts originating from rivets resulted in repeatable detections of 1 mm damages with a probability of detection greater that 95%. New tests are currently being performed on composite panels with embedded Fiber Bragg Grating (FBG) optical sensor network to detect the fast propagating Lamb waves.

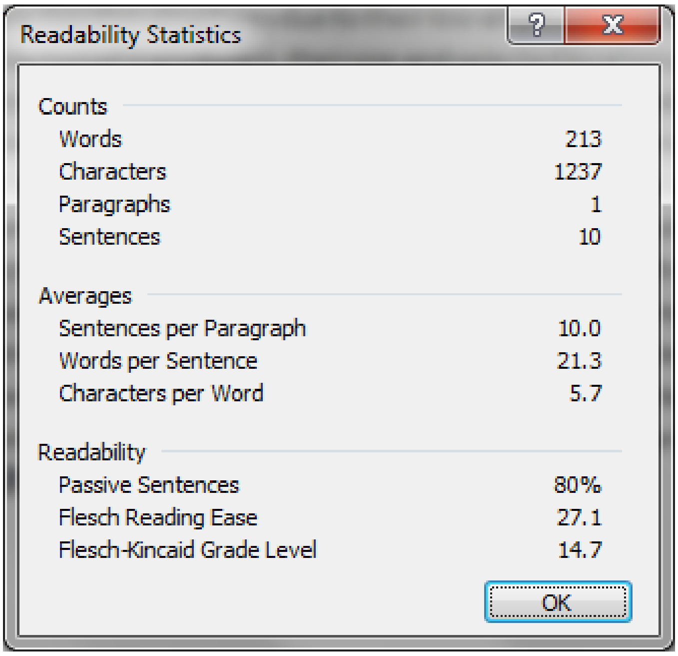

Figure 2: Statistics (Student Writing Sample 1)

Updated Abstract Revision 1

This paper presents the results of a structural health monitoring (SHM) system for metallic structures based on guided Lamb waves. These Lamb waves are reflected on discontinuities within the material including damaged locations. Lamb waves are ideal for thin structures because of their low amplitude damping which enables them to travel longer distances in the material. This paper outlines the selection of transducers (including their size and location) as well as the design, development, and implementation of a signal generator and data acquisition system. This paper also discusses the requirements which led to the development and selection of these systems. The damage detection algorithm used is based on comparison between a healthy reference state and a damaged state. This detection algorithm was improved by incorporating statistical methods. Tests on a plate with multiple surface cuts, through the thickness cuts, loosened rivets and cuts originating from rivets were performed. These tests resulted in repeatable detections of 1 mm damages with a probability of detection greater that 95%. This study is being expanded to include composite panels with embedded Fiber Bragg Grating (FBG) optical sensors.

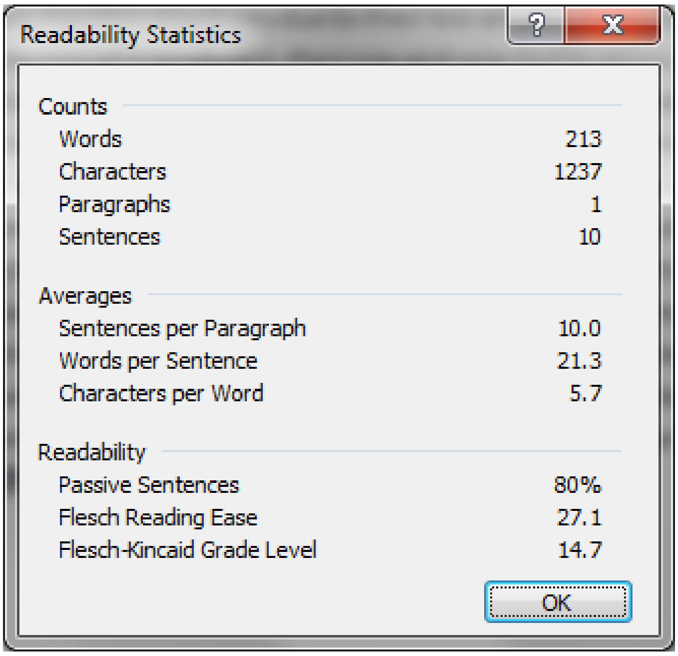

Figure 3: Statistics on Revision 1 (Student Writing Sample 1)

Updated Abstract Revision 2

This paper presents the results of a structural health monitoring (SHM) system for metallic structures based on guided Lamb waves. Discontinuities in the material, including damaged locations, reflect waves. Lamb waves are ideal for thin structures because they have low amplitude damping. This enables them to travel further in the material. This paper outlines the selection of transducers (including their size and location) as well as the design, development, and implementation of a signal generator and data acquisition system. This paper also includes the requirements leading to the development and selection of these systems. The damage detection algorithm used compares a healthy reference state to future, possibly damaged, states. Incorporating statistical methods improved this detection algorithm. The team performed tests on a plate with surface cuts, cuts completely through the material, loosened rivets, and cuts originating from rivets. These tests resulted in repeatable detections of 1 mm damages with a probability of detection greater that 95%. In the future, this study will include composite panels with embedded Fiber Bragg Grating (FBG) optical sensors.

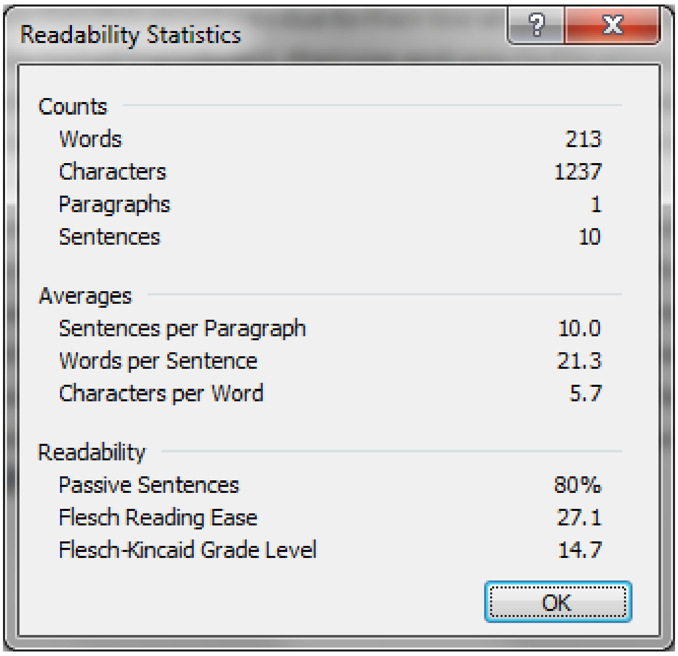

Figure 4: Statistics on Revision 2 (Student Writing Sample 1)

Updated Abstract Revision 3

This paper presents a structural health monitoring (SHM) system for metallic structures based on Lamb waves. Discontinuities in the material, including damaged sites, reflect signals. Lamb waves are ideal for thin structures because they have low amplitude damping. This enables them to travel further in the material. This paper outlines the selection of transducers, including their size and location. The paper also outlines the design, development, and implementation of a signal generator and data acquisition system. Included are the requirements that led to the development and selection of the systems. The damage detection algorithm used compares a healthy reference state to future, possibly damaged, states. Incorporating statistical methods improved this detection of damage. The team performed tests on a metal plate with surface cuts, deep cuts, loosened rivets, and cuts from the rivets. These tests resulted in repeatable detections of 1 mm damages with a probability of detection greater that 95%. In the future, this study will include composite panels with embedded Fiber Bragg Grating (FBG) optical sensors.

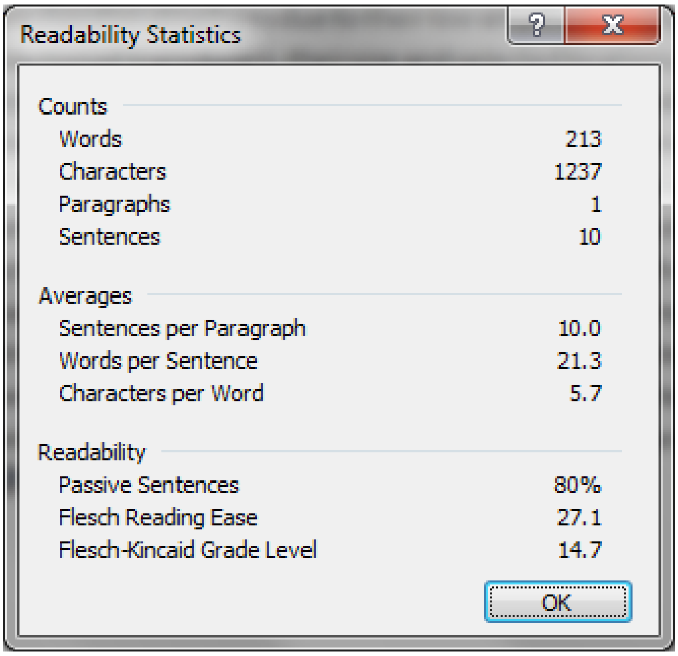

Figure 5: Statistics on Revision 3 (Student Writing Sample 1)

Progress

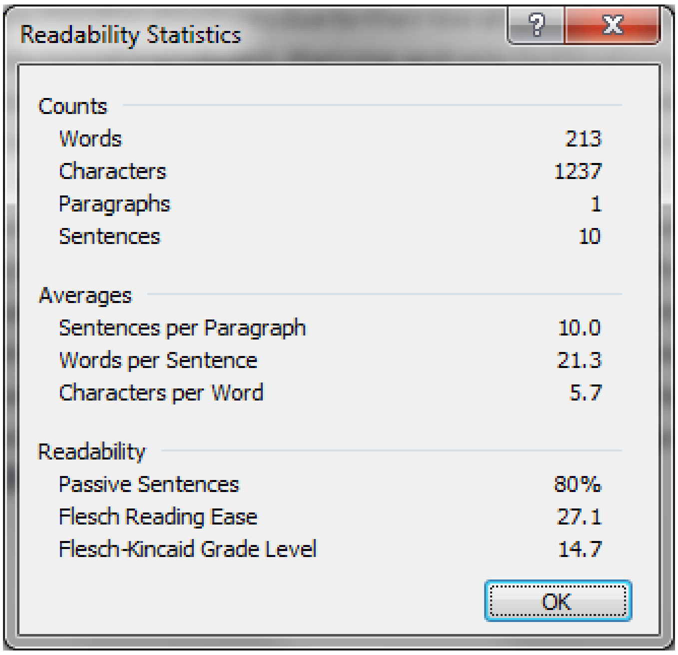

Figure 6: Progress (Student Writing Sample 1)

- Passive Voice decreased from 80% to 0%
- Reading Ease increased from 27.1 to 39.0
- Grade Level decreased from 14.7 to 11.2

Student Writing Sample #2

Walvekar, V., et al. “Bird Strike Analysis on Leading Edge of an Aircraft Wing Using a Smooth Particle Hydrodynamics Bird Model.” *ASME 2010 International Mechanical Engineering Congress and Exposition Vancouver, British Columbia, Canada. Technical Publication* IMECE2010-37667

http://www.asmeconferences.org/Congress2010/TechnicalProgramOverview.cfm#1

Abstract

With the increase in air travel, the recent occurrences of birdstrikes on aircraft pose a major threat to human life; hence, there is a need to develop aircraft structures with a high resistance to such occurrences. According to the Federal Aviation Regulation (FAR

25.571) on Damage-Tolerance and Fatigue Evaluation of Structure (Amdt. 25-96), an airplane must be capable of successfully completing a flight during which likely structural damage might occur as a result of impact with a four-pound (1.8 kg) bird at sea-level cruise velocity or 0.85 percent of cruise velocity at 8,000 feet (2,400 m). Since the actual physical testing of a birdstrike is expensive, time-consuming, and cumbersome, this paper presents a methodology, based on the use of analytical finite element modeling and analysis, to certify an aircraft for a birdstrike. The modeling and simulations are carried out as follows: the bird is modeled using the smooth particle hydrodynamics (SPH) technique in the LS-Dyna nonlinear finite element code. To validate this model, birdstrikes are carried out on rigid and deformable plates. The results, including displacement, Von-Mises stresses, forces, impulse, squash time and rise time, are obtained from the simulation, and non-dimensional values are plotted and compared with results from the test data. The detailed CAD geometry of the leading edge of an aircraft is modeled in CATIA V5. Meshing, connections, and material properties are then defined in the Altair Hypermesh 9.0 program. The results obtained from the birdstrike simulations on this leading edge are compared to data from the experiments, and the process is validated. Parametric studies are carried out by designing the aircraft leading edge for different values of nose radius and by assigning appropriate thickness values for leading-edge components and impacting the SPH-modeled bird at different velocities. The methodology and results obtained from simulation can be utilized in the initial design stages as well as for "certification by analysis" of an aircraft for birdstrike requirements as per federal regulations.

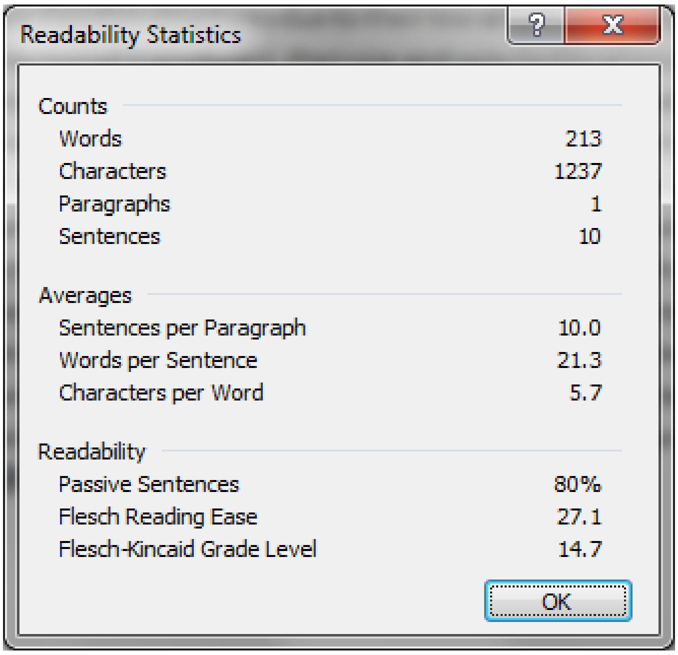

Figure 7: Statistics (Student Writing Sample 2)

Abstract

Frequent birdstrikes on aircraft pose a major threat to human life. With the increase in air travel, there is a need to develop aircraft structures with a high resistance to birdstrikes. According to the Federal Aviation Regulation, an airplane must be capable of completing a flight during which structural damage might occur from the impact of a four-pound bird at sea-level cruise velocity at 8,000 feet. The physical testing of a birdstrike is expensive, time-consuming, and cumbersome. This paper presents a method to certify an aircraft for a birdstrike. Using smooth particle hydrodynamic techniques, the simulation birdstrikes are carried out on rigid and deformable plates. The simulations show displacement, Von-Mises stresses, forces, impulse, squash time and rise time. CATIA V5 is used to create CAD geometries of the leading edge of an aircraft. The Altair Hypermesh 9.0 program can show meshing, connections, and material properties. Comparing the results from the birdstrike simulations to data from the experiments validate the process. Parametric studies are carried out by redesigning the nose radius and thickness of materials for the aircraft while impacting the bird at different speeds. The methodology and results obtained from simulation can be utilized in the initial design stages as well as for “certification by analysis” of an aircraft for birdstrike.

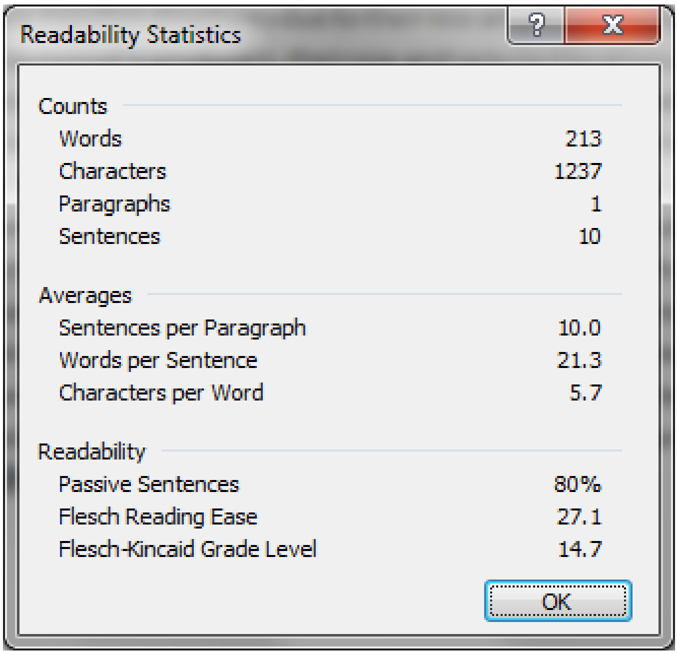

Figure 8: Statistics on Revision (Student Writing Sample 2)

Notes

[1]For further reading on the history of the Flesch-Kincaid reading ease and readability metrics, see Kincaid et al. (1975).

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