AC 2010-670: PROJECTED WORDS PER MINUTE: A WINDOW INTO THE POTENTIAL EFFECTIVENESS OF PRESENTATION SLIDES

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Projected Words per Minute: A Window into the Potential Effectiveness of Presentation Slides

Abstract

This paper proposes a metric for gauging the potential effectiveness of presentation slides: *projected words per minute*. In comparison with the commonly used metric of words per slide, projected words per minute might be better at assessing the cognitive load that the audience experiences when simultaneously listening to words spoken by the presenter and reading words projected on the presenter's slides. Both of these sources of words contribute to the audience's cognitive load. Although the number of projected words per minute will not directly indicate how effective a slide is, it does provide insight into a slide's *potential* effectiveness.

This paper calculates this metric for representative presentations in two common-practice situations. At the 2008 ASEE National Conference, best paper presentations averaged about 35 projected words per minute. Also, at a 2009 symposium of engineering graduate students at a large mid-Atlantic research university, a representative sampling of presentations averaged more than 40 words per minute.

In addition, the paper calculates this metric for representative presentations that follow alternative slide structures. For instance, in a large set of assertion–evidence presentations created by international science and engineering Ph.D. students for whom English is a second language, the projected words per minute were less than 20. That number contrasts dramatically with the more than 40 projected words per minute from U.S. graduate students. Another alternative slide structure considered is the *slide:ology* structure often found in talks on the popular web-site TED.com. In a technical talk by Bill Gates that follows this *slide:ology* structure, the projected words per minute was 12. A final alternative slide structure is the Larry Lessig approach. In a well received talk that follows this approach, the number of projected words per minute was 45, which is higher than for the other approaches. However, this example deserves more scrutiny because in this approach only a few words appear on the screen at any time. For that reason, the effect on cognitive load could be quite different from the effect of other slide designs.

While these comparisons provide insights into the potential effectiveness of these slides, one should remember that any recommendations for the number of projected words per minute should depend on the level of technical understanding that the audience has about the subject. Also, rather than replacing words per slide as a metric, we advocate that the metric of projected words per minute be coupled to words per slide because the combination reveal much about the potential effectiveness of a slide set.

Introduction

Many reports such as *The Engineer of 2020*[1] call for improving the presentation skills of our engineering students. For many presentations, having effective visual aids is a key for

success. Because presentation slides are the visual aid of choice in most engineering presentations, creating effective presentation slides is an important skill for our engineering students to master.

Several texts on technical communication discuss how to create effective presentation slides. Almost all of these texts advocate not using too many words on a slide—examples include Anderson,[2] Brusaw et al.[3] Johnson-Sheehan,[4], and Woolever.[5] Some texts even provide engineering students with specific guidelines on how many words are appropriate. For instance, Brusaw, Alred, and Oliu[3] advocate no more than 40 to 45 words per slide. In addition, Woolever[5] advocates that students adhere to the six-by-six rule, which means that the presenter should have no more than six lines of text per slide and six words per line. On the web, this six-by-six rule is a popular piece of advice with scores of sites advocating it.

Interestingly, Edward Tufte[6] argues that this six-by-six rule is nothing more than a misinterpretation of George A. Miller's work[7] on processing information. The cognitive psychologist John Sweller[8] goes even further saying that such an amount of text puts "too much load of the brain and decreases [the] ability to understand what is being presented." Sweller goes on to say that because of this cognitive overload, PowerPoint as it is currently being used "has been a disaster…[and] should be ditched."

Implicit within rules about the number of words displayed per slide is the idea that the words are only projected for a short period of time. That is, an overlooked variable when making claims about the effects of the number of words per slide is the *pace* at which audiences are expected to read and comprehend those words. Thus, in understanding the effect of words on audience cognitive load, the *rate* of presentation might be a more useful metric than the number of words per slide because it combines the number of words with the length of time for which those words are presented. For that reason, this paper proposes another metric for gauging the potential effectiveness of presentation slides: *projected words per minute*. In comparison with words per slide, this metric better assesses the cognitive load that the audience experiences when simultaneously listening to words spoken by a presenter and reading words that the presenter is projecting onto slides.

This paper first presents a theoretical basis for this metric and then applies the metric to several situations. Two of these situations are common practice situations in engineering education: (1) presentation of research at a national ASEE conference, and (2) presentation of research by graduate students. Three other situations involve alternative slide structures: (3) the assertion–evidence slide structure;[9, 23] (4) the *slide:ology* slide structure,[10] which is similar to the *Presentation Zen* structure;[11] and (5) the Larry Lessig method of presentation.[12] The paper concludes with recommendations of how many projected words per minute would be appropriate for engineering presentations.

Theoretical Basis for Metric

Since 2001, harsh criticism of presentation slides has surfaced in several popular publications.[8, 13, 14, 15] A common thread is that slides often overwhelm audiences with information—a situation that John Sweller states as arising from placing too many words on the slides.[8]

The question arises, How many words are too many words? In his research on multimedia learning, Mayer[16] has found that audiences learn more effectively from spoken words and pictures than from spoken words, pictures, and accompanying text. This principle, called the redundancy principle of multimedia learning, is not intuitive. One might argue that having the accompanying text will allow the audience to select either reading or listening to take in the information. However, Mayer's experimental results on this question refute this argument. In his experiments, audiences comprehended and retained more information from spoken words and pictures than they did from spoken words, pictures, and accompanying text.

One explanation for these results is that reading and hearing identical verbal information simultaneously can reduce the comprehension by audience members, particularly when individuals have to split their visual attention between text and other elements presented on the screen.[16] Also, the more text that is placed on the slide, the more tempting it is for the speaker to simply read from that slide. What might be intended as reinforcement of the oral presentation by the speaker is instead additional language-based information that the audience must process. Even if information is processed only to determine that the oral and written information is the same, it requires precious cognitive resources that could be directed towards understanding the speaker's message. For these reasons, audiences can learn more deeply when the speaker orally explains a graphical depiction.

Mayer's results might lead one to assume that the optimum number of words per slide is zero. However, Mayer's experiments compared no written text with full text. In typical PowerPoint presentations, the amount of text written is a subset of what the speaker says. In addition, in Mayer's experiments, the audience could understand everything that the speaker said. In many engineering presentations, particularly those with second-language audiences, that degree of understanding is reduced because the audience member has a less than optimum listening comprehension. In such situations, having certain words on a slide could benefit the audience. In addition, in an engineering presentation, particularly in a large room, having some words on a slide would allow an audience member to catch up if he or she became distracted during a portion of a presentation and missed a key transition.

The question arises again, How many words are too many words? The metric of projected words per minute answers this question better than the metric of words per slide does. Because the presenter speaks at a rate of so many words per minute, the number of words that the audience is expected to read per minute must be low enough that cognitive overload from the sum of the two rates does not occur.

Application of the Metric in Different Situations

To analyze what can be learned from this metric, this section applies the metric of projected words per minute to different types of presentation. Two of these situations are common practice situations in engineering education: (1) presentation of research at a national ASEE conference, and (2) presentation of research by graduate students. Other situations involve alternative slide structures: (3) the assertion–evidence slide structure;[9, 23] (4) the *slide:ology* slide structure,[10] which is similar to the *Presentation Zen* structure;[11] and (5) the Larry Lessig method of presentation.[12]

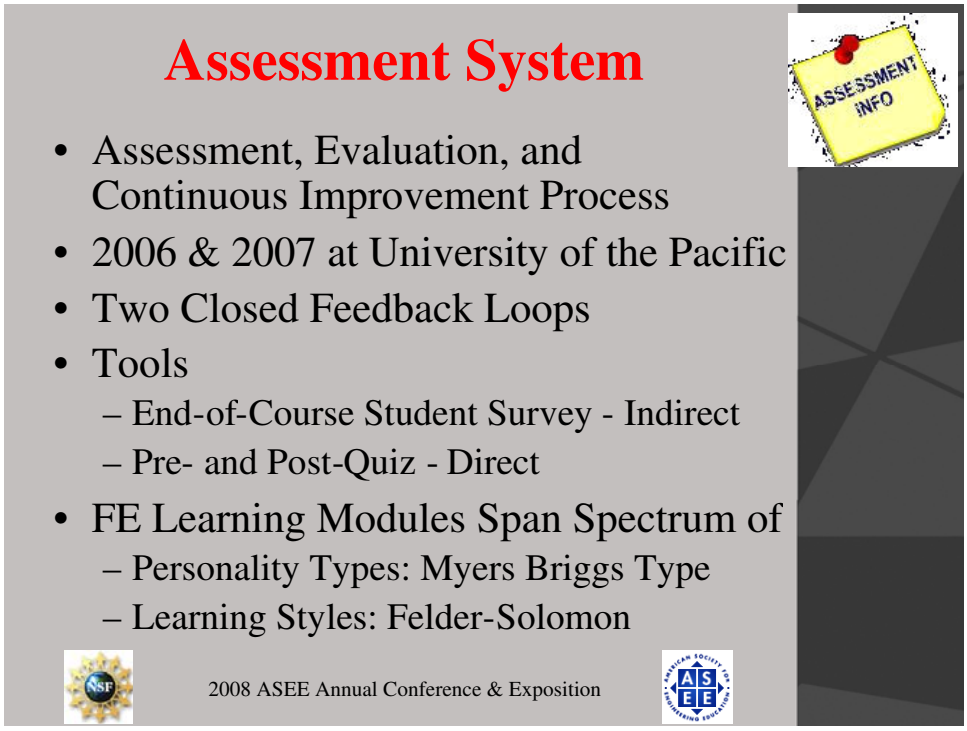
For all five of these situations, we had copies of the slides so that we could count the number of words per slide. For application situations 1 and 2, we had time limits for the presentations so that we could *estimate* the projected words per minute. For application situations 3, 4, and 5, we had films of the presentations so that we could *calculate* the projected words per minute in each presentation.

The first application situation consisted of slides delivered at the 2008 ASEE National Conference in Pittsburgh. For this situation, we considered 48 sets of slides: 3 sets were from plenary sessions, 31 sets came from best paper nominations, and 14 sets came from the Educational Research Methods Division, which is widely considered to be the most selective division in the conference. An implicit assumption is that significant effort went into these slides, making them appropriate representatives of this category. Moreover, because of their interest in education, we assumed that the presenters at this conference were more likely than presenters at typical technical conferences to be sensitive to methods that promote audience comprehension. The audience for this presentation consists of other engineering educators.

The overwhelming majority of these slides followed the common practice of PowerPoint slides,[17] which is heavily influenced by PowerPoint's default slide master. This common practice is characterized by topic-phrase headlines supported either by bullet lists or by bullet lists and graphics. Figure 1 shows two typical examples from this data set (identifying logos and features have been removed). Of the 1009 slides in this sample, 85% had topic-phrase headlines and 69% had bullet lists.

Although we did not have film recordings of each speaker, we knew the maximum length that each speaker was allowed to present. Therefore, we have a good estimate for the *maximum* length that the slides were projected and therefore a good estimate for the *minimum* number of words per minute that the presenter expected the audience to read. In actuality, because most presenters fielded questions for a portion of their talks, the audiences at the conference were actually expected to read more words per minute than what our analysis reflects. For these 48 presentations, the mean number of projected words per minute was about 35, as shown in Table 1.

Is this number high? Is this number low? Although these questions are difficult to answer without more data, these questions raise a research question that deserves attention: On a set of slides for a technical presentation, how many written words per minute can an audience comfortably comprehend and retain?



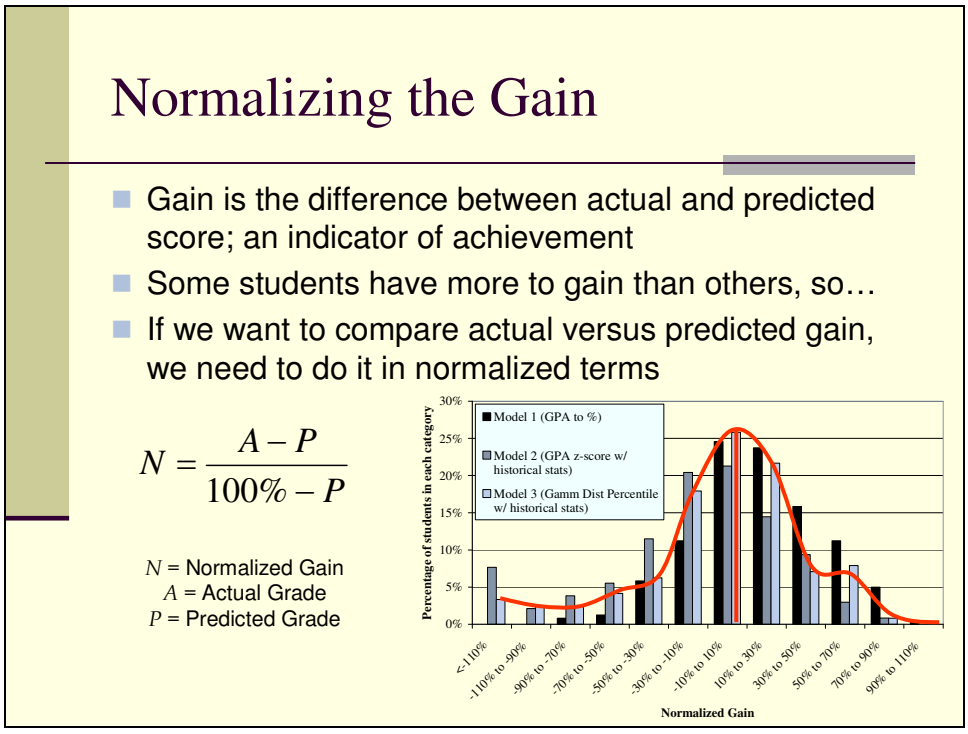


Figure 1. Representative slides for application situation 1: research presentations at the 2008 ASEE National Conference. The overwhelming majority of slides from this sampling follow slide the current common practice of presentation slides.[17]

Table 1. Projected words per minute for five different situations.

Situation	Projected words per minute
Common-practice slides by researchers at ASEE conference	~ 35
Common-practice slides from engineering graduate students	~ 40
Assertion-evidence slides from international Ph.D. students in science and engineering	18
Slide:ology slides from an engineering talk on TED.com by Bill Gates	12
Larry Lessig slides from a conference keynote address by Dick Hardt, CEO of Sxip Identity	~ 45

A second application situation consisted of 15 presentations (289 slides) given by engineering graduate students at a 2009 research symposium of engineering graduate students at a large mid-Atlantic research university. The audience for this symposium was a general technical audience. More than half of these 15 presenters were native speakers of English. In this study, we assume that these students are a representative subpopulation of graduate students in the United States. As with the slides from engineering education researchers, the overwhelming majority of slides from these graduate students follow the common practice of slides found in engineering and science.[17] Figure 2 presents two prototypical slides from this collection.

Although we did not have film recordings of each speaker, we knew the maximum length of time that each speaker was allowed. Therefore, we have a good estimate for the *maximum* length that the slides were projected and therefore a good estimate for the *minimum* number of words per minute that the presenter expected the audience to read. In actuality, because most presenters fielded questions for a portion of the 20 minutes, the audiences at this symposium were actually expected to read more words per minute than what our analysis reflects. For these 15 presentations, the mean number of projected words per minute was about 40, pointing to an average of 160 total written words per minute to be comprehended by the audience.

The third application situation consisted of 33 presentations (for a total of 231 slides) created by international Ph.D. students in science and engineering. These 33 students came from 16 different countries in Europe, Asia, Africa, and South America. Although all presentations and presentation slides were in English, none of these presenters had English as a native language. The presentations, which targeted a general technical audience, occurred at a workshop on research communication, which taught the participants the assertion–evidence structure.[9, 23] For that reason, all of these slides followed the assertion–evidence structure. In other words, all the slides except for title slides had a sentence headline (no more than two lines), and all the slides had some sort of visual evidence. Figure 3 presents two prototypical slides from this collection.

Because we filmed the presentations, we knew for how long each presenter spoke. Therefore, we knew how long the slide sets were projected and how many words per minute the presenters expected the audience members to read. For these 33 presentations, the number of projected words per minute was 18, meaning that audiences were expected to comprehend on average 138 written words per minute.

Introduction and Background

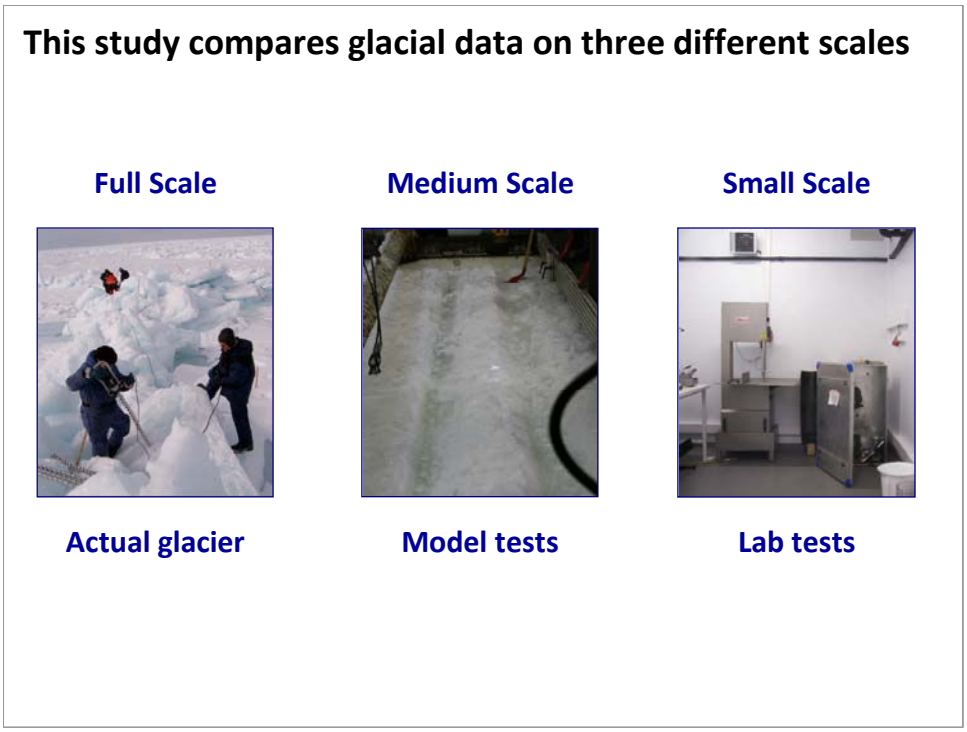
- Honking misunderstood and misused
- Current amelioration – media and education (personal views of honking)
  - Don't account for many other factors
- Regional differences important for worldwide reduction
- How does honking compare to other forms of aggressive driving?

Safety

- **Special handling requirements due to cryogenic temperatures and properties of hydrogen**
  - Fuel system requires hydrogen impervious materials and joints
  - Added complexity and cost to fuel systems
- **Hydrogen is colorless and odorless, undetectable by people**
  - Sensors required along length of fuel system and fuselage
- **70 Hydrogen Fueling station operating in the U.S. and Canada**

August 19, 2009

Figure 2. Representative slides for application situation 2: research symposium of U.S. graduate students. The slide structure follows the current common practice of presentation slides.[17]



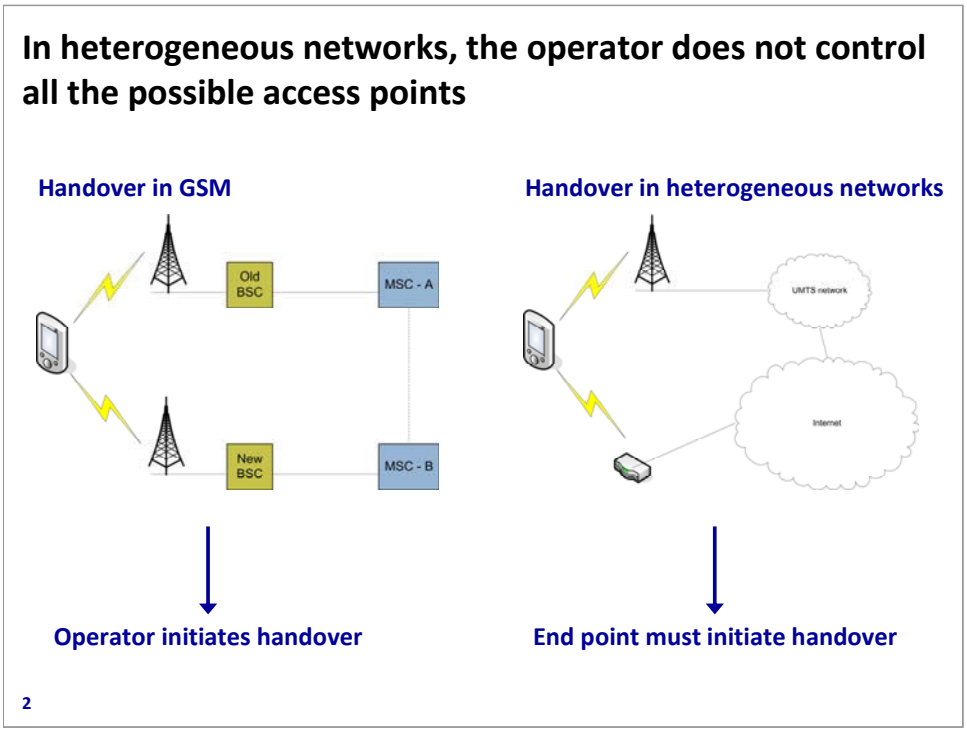


Figure 3. Example slides from application situation 3: assertion–evidence slides created by Norwegian Ph.D. students—top[18] and bottom.[19]

More important, the post-workshop slides of the Norwegian participants had *fewer than half* of the words projected per minute than the slides of the U.S. graduate students. This difference was also statistically significant ($t = 4.87$, $df = 16.46$, and $p < 0.000$). This difference in number of words projected per minute indicates that in their workshop presentations, the Norwegian presenters fashioned more words on the spot than the U.S. graduate students did in the symposium presentations. In other words, the Norwegian students fashioned words extemporaneously while explaining graphics, as opposed to the U.S. students reading words from bullet lists. That result is surprising because for all of the Norwegian presenters, English is a second language. Moreover, the audience members of the Norwegian graduate students were not expected to read nearly as many words per minute as the audiences for the U.S. graduate students were. For that reason, the audiences for the Norwegian graduate students were less likely to experience cognitive overload than were the audience members for the U.S. graduate students.

The fourth application consisted of slides from a talk given by the Bill Gates on TED.com, which is a popular web-site featuring presentations of ideas in technology, entertainment, and design.[20] The audience for TED.com talks is the general public. Gates's slides followed the slide structure of Nancy Duarte in *slide:ology.*[10] This structure is similar to the teachings in the popular text *Presentation Zen.*[11] This structure is characterized as having an explicit purpose for each slide (no purpose corresponds to having no slide), anchoring each slide with an image or graph, and showing only words that are essential for understanding. Shown in Figure 4 is a typical slide from the talk by Gates.

Figure 4. Example slide from application situation 4: *slide:ology* slide created by Bill Gates for a TED.com talk.[20] During this slide, Gates explained a process for achieving the goal of fostering ideas capable of producing enough energy for the world, but reducing carbon dioxide emissions to zero.

In this presentation, as is common for slide sets that follow this approach, the number of projected words per minute was about 12 (in the talk, 228 words were

projected over a span on18 minutes and 39 seconds). One important aspect is that the principal audience for this talk was the general public. For that reason, the audience's expectations for technical depth were not as deep as they would have been for a technical talk. Likewise, the familiarity of the audience with some of the terms and principles was not as high as it would have been with a technical audience.

The final application consisted of slides that follow a Larry Lessig approach. Professor Larry Lessig is an economist from Stanford who began using a unique approach to designing slides in his economics lectures. In the approach, short phrases and images flash on the screen as the presenter talks. Moreover, the words are often shaped, sized, formatted, or positioned to reflect their meaning. Others have adopted versions of the approach, including Ron Galloway, the creator of the documentary *Rethinking PowerPoint.*[21] An excellent example of this type of talk is a keynote address of a technical conference. The address was given by Dick Hardt, the CEO of Sxip Identity. Shown in Figure 5 is an example sequence of slides from that talk. Interestingly, the projected words per minute for this talk is higher than for any application scenario: about 45 words per minute.

Figure 5. Example slide sequence from application situation 5: a Larry Lessig approach done by Dick Hardt.[22] In most of the slides from this particular sequence, which progresses top-down in three columns, the words spoken occur in synch with what appears on the screen. In other slides such as the last slide of this sequence, the slides are simply images that correspond to what is being said. This presentation has many slides, and this segment represents only a small portion.

Although the projected words per slide for this scenario is higher than for any other scenario, one does not have the sense of cognitive load occurring, as we often experienced watching presentations in scenario 1 and scenario 2. Why was that the case? One reason might lie with the fact that only very few words appear on the screen at any one time. In essence, this style leads the audience to read short groups of words as is advocated in strategies for speed reading. Moreover, the presenter aids the audience with that task because the presenter has already created the groupings. Another reason could be the rapidly changing visual stimulus keeps audience members' attention and prevents them from becoming distracted, thereby helping them to feel like they are following the presentation. Yet another reason that cognitive overload does not appear to occur could be that there is an almost perfect synchronicity between visual attention and auditory attention. In other words, the audience is hearing exactly what they are seeing.

Concluding Discussion

This paper has defined a new metric, *projected words per minute*, for assessing the potential effectiveness of slides. The paper has provided a theoretical foundation for this metric and has applied the metric in five different situations. Two of the situations involved common practice slides and three of the situations involved alternative slide structures that different authors tout as being more effective than the common practice.

For both of the common practice situations, the projected words per minute were relatively high (see Table 2). That the engineering education conference attendees had a lower average for projected words per minute than the engineering graduate students is logical, because the attendees had more experience making presentations than the graduate students did. Perhaps the graduate students were not sure what was most important to put on the slides, or perhaps the graduate students needed the extra words to help them do the presentation.

What is surprising is that the international Ph.D. students had a much lower number for projected words per minute (18) than either the conference attendees (35) or the U.S. graduate students (40). In essence, these Ph.D. students delivering a presentation in a second language (English) fashioned more words on the spot than either the conference attendees or the U.S. graduate students did. One would assume that this letting go of the words on slides would be much harder for a non-native speaker of English not only because of the inherent language barrier but also because of the additional stress of presenting in a second language. Put another way, one would expect more words per slide for a non-native speaker of English than for a native speaker of English. However, most likely because this third group of speakers used the assertion–evidence structure (as opposed to the common practice topic–subtopic structure in the first two situations), that was not the case. A next research step would be to compare how much audiences comprehend and retain from those two types of presentations: the common practice presentation versus the assertion–evidence structure.

The fourth situation consisted of a *slide:ology*, or *Presentation Zen*, slide presentation about an engineering topic being delivered to a general public. This situation had the lowest number for projected words per minute—about 12. Because this

presentation targeted a non-technical audience, an interesting research question would be to see how the level of audience (specific technical, general technical, and non-technical) affects projected words per minute. Another interesting research question would be to assess how much a non-technical audience comprehends and retains from a presentation that follows this *slide:ology* approach for slides versus a similar presentation that follows the common-practice approach of a topic phrase headline supported by a bullet list of subtopics (and sometimes also by a graphic).

For the final situation, slides from a well received presentation[22] that follows the Larry Lessig approach, the number of projected words per minute was the highest (45). Given how well received this presentation was (the talk was selected to be the keynote for a conference), it is unlikely that cognitive overload occurred for the audience. One explanation resides in the single text block with relatively few words being projected on the screen at one time. This explanation raises the research question for how the number of text blocks and total number of words on a slide projected at one time affect the metric of projected words per minute.

The success of Hardt's presentation, the corresponding high number of projected words per minute, and the low number of words per slide indicates that projected words per minute is best used as a metric when coupled with the metric of number of words per slide. Table 2 presents this coupling.

Table 2. Words per slide and projected words per minute for five different situations.

Situation	Mean number of words per slide	Projected words per minute
Common-practice slides by researchers at ASEE conference	33	~ 35
Common-practice slides from engineering graduate students	41	~ 40
Assertion-evidence slides from international Ph.D. students in science and engineering	28	18
Slide:ology slides from a TED.com talk by Bill Gates	8	12
Larry Lessig slides from a conference keynote address by Dick Hardt, CEO of Sxip Identity	2	~ 45

As seen in this table, the mean number of words per slide for the international Ph.D. students (28) was not much different from the mean number for the engineering education researchers (33). However, the pace of those presentations by the Ph.D. students was dramatically different—audience members of the engineering education researchers were expected to read almost twice as many words per minute as the audience members of the international Ph.D. researchers.

The takeaway from this analysis is that neither words per slide nor projected words per minute is enough to characterize the potential effectiveness of slides—but a careful presenter should consider both.

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