myScribe

Future of Writing

In the Disciplines and Professions

White Paper

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Executive Summary

Problem
Over the past 60+ years, extensive research has been conducted on writing instruction. However, despite these efforts, there remains a significant challenge: the lack of scalable solutions to help college graduates meet the standards of written proficiency.

Approach
myScribe seeks to close this gap through application of the following four research-based principles: (1) reduce the writer's cognitive load to increase efficacy and engagement; (2) support and encourage extended prewriting activity; (3) direct writing activities through knowledge of specific writing genres; and (4) support reviewing and revising as integral components of the writing process.

Vision
While AI that creates content may seem to undermine the work of writing educators and the advancements in written communication, we see a different future. We believe that properly harnessed, AI can enhance the writing process, making it more fluid, democratic, and inclusive. Our vision is guided generative AI, which will free up writers' time to focus on critical thinking skills, planning, and communicating substantive ideas. This approach will also address the cognitive and motivational barriers that have hindered the scaling of writing education.

Solution
myScribe is an AI-enhanced online writing environment with a suite of generative and assessment tools supporting the writing process from initial-phase writing to the completion of the final draft. Instead of starting with a blank page, writers using myScribe are supported with a writing task definition, consisting of a common outline and a set of writing task-specific questions that stand in for reader expectations.

One of the key features of myScribe is the AI-based tool called Notes-to-Prose. This tool translates the writer's notes into prose without adding new ideas. In other words, the generative AI is guided to reflect the quality of the writer's notes in prose. This early-stage support significantly reduces the cognitive load of sentence crafting, allowing writers to focus their attention on higher-level planning and organization. This unique capability of myScribe should instill confidence in educators and stakeholders about its potential to enhance writing efficacy.

As the writer develops their draft, myScribe offers AI-based assessment tools utilizing automated feedback and the interactive visualization of the writer's composing decisions. These tools allow writers to evaluate their drafts from several perspectives, including reader expectations, logical flow, content coverage, and sentence clarity.

Introduction

According to psychologist Steven Pinker, "writing is and always has been hard" compared to speech. In conversation, listeners are present and identifiable; in writing, readers are often "unknown, invisible, [and] inscrutable."[1] Since writers are displaced from their readers in time and space, they must convey context through their ability to anticipate mutual and unshared knowledge with their readers using their linguistic know-how.[2]

To muster this anticipatory knowledge and know-how, writing involves a myriad of integrated cognitive, social-cognitive, and linguistic processes including "attention, motor, visual, executive functioning, memory, and language, as well as writing knowledge, processes, and skills."[3] These interconnected processes demand the writer's cognitive resources to function alone and cooperatively. They also compete. For example, with finite time to deadlines, attention to sentence production, grammar, and spelling deducts time from planning and organization, and vice versa.

There have been no scalable breakthrough solutions for helping college graduates and young professionals improve their writing.

The rewards of writing are significant. Writing endows communication with extended planning time across multiple sittings. It creates the capacity to take language "offline", free of conversational constraints. The unconstrained time to plan with language affords a refinement of thought unobtainable in unplanned speech or conversation.[4] However, writing tasks can easily exhaust the writer's cognitive resources, making writers feel overwhelmed when their capacities are overextended.[5] The labor of writing gives rise to a motivational problem. When a task is hard, the effort to execute it, or the time to learn to execute it, needs to be justified. Edmondson characterizes writing as "back-breaking," "mind-breaking," and "lonely." [6] Writing researchers and educators across K-12 and post-secondary education have long understood that education in writing has small odds of success without addressing students' motivation to write[7].

Disconnect Between Writing Research and Student Performance

There has been significant research on writing processes and effective writing instruction since the 1970s.[8] However, the number of scientifically controlled studies to identify effective writing instruction is "slim" and the results of these few studies are inconsistent.[9] Nonetheless, there are some practices with consistent benefits that teachers unfortunately are not implementing in K-12 classrooms.[10] The most constructive of these practices is to ask students to write more frequently in class. Several studies across these grades have

1 Pinker, quoted in Levitt, 2023
2 Brandt, 2011
3 Hayes, 2012, cited in Graham and Harris, 2019, p. 25
4 Olson, 2016, p. 15
5 McCutchen, 1996
6 Edmondson, 2016, p. xiii
7 Hayes, 1996; Boscolo & Gelati, 2019
8 See the edited handbooks and research summaries of Bazerman and Prior, 2004; Graham & Perin, 2007; Bazerman et. al., 2008; Graham, MacArthur & Fitzgerald, 2013; MacArthur, Graham, & Fitzgerald, 2015; MacArthur, Graham, & Fitzgerald, 2016; and Graham, MacArthur & Hebert, 2018
9 Barshay, 2019
10 Barshay, 2014

replicated that giving students more time to write in class improves writing quality, reading comprehension, and subject matter learning. Yet in a study published in 2011, Applebee and Langer found that U.S. middle school and high school students were writing only 1.6 pages of prose per week and 2.1 pages for the rest of their subjects combined.[11]

Moreover, this scant writing consisted mainly of summary rather than analytic writing. The lack of challenging in-class writing in American classrooms is attributed to workload issues. The more writing, the more feedback burdens on the teacher[12]. The lack of writing practice helps to explain why less than 25% of eighth and 12th-grade American students scored "proficient" in writing[13].

This problem cascades to the post-secondary level. Beyond a lack of practice in classroom writing, there have been no scalable breakthrough solutions for helping college graduates and young professionals improve their writing. Complaints from employers about the poor quality of college graduate writing registered in the 1964 issue of Harvard Business Review[14] still register today. The modern workplace outputs endless streams of emails and reports, and businesses continue to invest billions of dollars in remedial writing training for their employees[15].

The Past of Writing

Writing has continuously evolved over history to lighten the burden of writers based on the emerging technologies that underlie it. The invention of papers, pens, and inks liberated writing from the earlier methods involving inscriptions on clay tablets or bones. To lure professionals away from longhand, the Remington Typewriter Company in the 1870s promised speed and mechanical standardization. "To save time," their advertising pitched, "is to lengthen life."[16] In 1985, the New York Times technology columnist Peter Lewis reviewed a new generation of word processors, "each one promising to transform a personal computer and printer into a magical super typewriter."[17]

Our goal is to work toward a responsible future that embraces AI in writing without dehumanizing it.

Until recently, much of the drudge eliminated by writing technologies has had to do with increasing the speed and accuracy of getting marks on the page or screen. Early writing technologies (e.g., typewriters) focused on speeding the transfer of characters on a physical page. And, over time, technologies have evolved to support writing at the word and phrase level, from spell checking and automatic completion to text prediction. Moreover, some of the more recent writing tools have promised to help writers improve the effectiveness and appropriateness of their writing.

Nevertheless, as newly invented writing technologies promise to cut transcription time, they often confront backlash, typically the unsubstantiated fear that lightening the labor of transcription in the writing process somehow

11 Applebee and Langer, 2011
12 Barshay, 2014
13 National Center for Education Statistics, 2012
14 Fielden, 1964
15 Moore, 2016
16 Polt, 2015, p. 8
17 Lewis, P. New York Times, 1985

degrades the authenticity and quality of the written product. In 1992, Marcia Peoples Halio of the University of Delaware in Newark opined that the Macintosh was saving her students "so much time and drudgery in editing and rewriting" that they were falling down on their writing assignments, choosing "trivial essay topics."[18] The notion that easing the transcription costs of writing produces less engaged and less effective writing is a common historical trope extending back to earlier writing technologies.

Still, over time, the newer technology gradually seeps into the general public as a superior extension of the technology it seeks to disrupt: the quill as the superior reed pen, the typewriter as the superior quill, and the word processor as the superior typewriter. As the technology matures and generations turn over, according to Baron, the new technology "come[s] into its own" and becomes the new focal lens from which to view, even assimilate, the older technologies.

Emergence of Generative AI

The recent surge of generative AI marks a significant watershed in the evolution of writing technologies as well as the writing process itself. Throughout the history of writing tools, technology has focused on improving the efficiency and convenience of transcription. Generative AI is the first technological breakthrough that promises to accelerate not just the transcription of words, but the generation of ideas in writing. Because it intrudes on and threatens to replace the human and creative aspects of writing, this new technology has stirred much consternation. However, there are fundamental limits on the capacity of AI to replace human writers, most notable among these limits:

Devoid of Agency — Human authorship is crucial for responsible communication, bringing accountability, intentionality, and a personal touch to the content.

No Nuanced Situational Awareness — Human involvement in writing is essential because individual human writers uniquely grasp specific immediate and historical contexts, incorporating cultural and emotional nuances.

Limited Learning — In educational settings, the use of generative AI is often unaligned with the critical thinking and research skills that students and writers generally develop through the writing process.

While the accuracy of generative AI will certainly improve in the future, agency, situational awareness, and development of critical thinking through writing are fundamental to human communication and unlikely to be replaced by advanced technology.

This does not mean we advocate banning generative AI from the writing environments of the future. Our approach rather assigns a larger role to the human in the executive control of the writing process that cannot be replaced by AI. According to our approach, writing technologies are successful when they lighten the load of the writer wherever the load can be lightened without displacing the writer's agency or accountability.

As outlined in the Introduction, the disconnect observed between academic research on writing and the actual performance of students and professionals

18 Lewis, 1992

in the workplace can be attributed to two primary factors. On the one hand, students often develop an aversion to writing due to its inherent cognitive challenges. On the other hand, because of the arduous labor of providing meaningful feedback on numerous or lengthy assignments, instructors are unable to assign sufficient writing practice to students. To mitigate these factors, we need to lower the cognitive burden of writing for students, increasing their motivation to write. Further, we need to build writing environments that offer students autonomous feedback, reducing the human workload of teachers. Generative AI used responsibly can help on both fronts. Our goal therefore is to work toward a responsible future that embraces AI in writing without dehumanizing it. We believe that generative AI, deployed strategically, will further enhance our ability to write, and all while keeping the human writer at the helm of the writing process.

The Threat to Writing "Thoughtfully" in the Age of AI

Writing is a thoughtful activity. It affords the opportunity to think things through, make decisions, learn about and solve problems, coax insight from data, calm situations, or disrupt them. All writing—from academic to workplace—requires thoughtfulness[19], which is often captured in the expression "critical thinking." Critical thinking is the ability to comprehend, explore, organize, and express complex ideas, sift, synthesize, and evaluate evidence, and apply this accumulated knowledge to construct and refute reasoned arguments across disciplines and subject matter domains[20]. Critical thinking, in this sense, spans both a method of inquiry and a means of discovery, helping writers not only clarify their thinking but also apply that clarity to engage iteratively and deeply with the material they are working with. In educational settings, the development of critical thinking often occurs organically within writing assignments in specific disciplines[21]. These assignments prompt students to analyze disciplinary concepts, evaluate evidence, and construct well-reasoned arguments, fostering not just writing proficiency but also deepening their critical thinking capabilities within their field.

The future for writing with AI must never conflate the thoughtful engagement of the writer with the unnecessary toil that machines can mitigate.

However, the advent of AI in writing seems double-edged when it comes to thoughtful writing and critical thinking. On one hand, AI has the potential to reduce the cognitive load of writing by assisting with grammar, syntax, and even generating ideas, freeing the writer from some of the clerical burdens of the craft. On the other hand, there's the legitimate concern that AI assistance will obliterate the need for thoughtfulness and critical thinking in the writing process. The prospect of this obliteration paints a dystopic future where students let AI write their papers, and teachers let AI grade them! Under this nightmarish scenario, AI's claim to reduce the cognitive burden of writing is, in reality, a Trojan Horse that threatens the annihilation of writing as a uniquely human pursuit and a vital source of cognitive and emotional human growth.

19 Maimon et. al. 2022
20 Quitadama & Kurtz, 2007
21 Bean & Melzer, 2021

We suggest those fears arise from misidentifying what makes writing human. What makes writing a uniquely human activity has never been about the act of arranging words on the page. Rather, it is about the decision-making and accountability-taking behind those words. It is about producing a text over which a writer can stand and take responsibility and authorship. As machines increasingly take over the "scribing" aspects of writing, it will become all the more imperative for human authors to justify the decision-making behind the actions of their scribe.

Moreover, these fears also arise from associating critical thinking and thoughtfulness with linguistic craft. In its common identification with creative writing, "writing" merges idea development and linguistic craft. The ideas to be expressed and the words to express them are inextricably intertwined. This understanding of writing is true when it comes to creative writing, but in academic and workplace writing, the linguistic experimentation and variation is controlled and writers follow accepted conventions of the relevant disciplinary/professional communities. This alternative understanding of writing requires conventional, predictable, transparent, and even formulaic language in various sections of the text. Thus, linguistic crafting can be welcome, yet it is not a necessary condition for thoughtfulness and critical thinking.

Consequently, the future for writing with AI must never conflate the thoughtful engagement of the writer, which is indispensable, with the unnecessary toil that machines can mitigate. We envision that properly harnessed AI, which respects the core principles of the human writing process, can offer writers extra time to dedicate to developing higher-level critical thinking abilities such as planning and articulating ideas clearly and persuasively. Moreover, it enables us to tackle cognitive and motivational obstacles that envision a scalable breakthrough solution for helping college graduates and young professionals improve their writing.

Four Principles Central to Addressing the Writing Problem

Before presenting our proposed approach to shaping the future of writing, it is instructive to delineate the research-informed principles underpinning our project's vision. Our strategy in tackling the challenge of writing revolves around four core principles.

Principle 1. Reduce the writer's cognitive load to increase engagement

High cognitive load can overwhelm working memory. Reducing the load frees up cognitive resources, improves problem-solving, and enhances motivation and engagement. Across the many cognitive components of the writing process,[22] empirical research suggests that translation and transcription are prominent Achilles' heels. Using think-aloud protocols of experienced adult writers writing sentences about their jobs, Kaufer et al.[23] were surprised to find that sentence craft quickly leads writers down rabbit holes: Translating ideas into prose is choppy and turbulent, not the smooth or seamless process one might expect. Writers compose sentences in bursts, which are shaky and error-prone deliberations, involving halts and pausing.[24] Sentence parts

22 Hayes and Flower, 1980; Flower and Hayes, 1981
23 Kaufer et al., 1986
24 Hayes, 2009, 2012

are proposed, accepted, or discarded before new parts are entertained. The bursts last six or seven words before pausing for two seconds or longer. The pauses reflect freezes (e.g., "What do I say next?") or revisions in midstream (e.g., "I want to say…I mean that…not sure now") that cause grammatical disfluencies.

Word processors reduced much of the tedium of transcription by allowing writers to move, copy, and paste text instantly. However, rote transcription (including the orthographic motor skills to produce text) does not cause the rabbit holes seen in translating ideas into prose. Hayes and Chenoweth[25] asked writers to transcribe text from one computer window to another, and they found no evidence of the burst-and-pause cycles of the translation that goes into sentence craft. In a later study, Hayes and Chenoweth[26] found that the bursts and pauses of sentence craft do not depend on the complexity of the planned ideas and meanings. They found burst-and-pause cycles arising in sentence production even when writers were asked to make trivial conversions in prose, such as converting passive into active sentences. Hayes[27] concluded that the bursts and pauses of sentence craft arise from our limited memory capacity for the chunks that make up a sentence.

Principle 2: Support extended prewriting activity during the writing process

Prewriting activities, including brainstorming, outlining, and note-taking, help writers develop and organize their ideas. The think-aloud protocols of Hayes and Flower[28] and the study of Glynn et al.[29] suggest that generating effective writing requires significant allocations of time for planning and organization. Yet, prewriting time often inadvertently slips away in competition with other later processes. Even when writers implicitly understand the importance of prewriting, the time they assign to it is often compromised because of the cognitive load (see principle 1) and resulting time sink of drafting, i.e., sentence crafting.

Although principles 1 and 2 are analytically distinct, they are closely connected in practice. Writers know that their deliverables must be presented as well-formed sentences. Should sentence drafting become too high of a slog, writers often place their priorities there to ensure there is something to submit by the deadline. Much-needed planning time of the overall organization is sacrificed. Expanding the time for planning requires reducing the time and load of sentence crafting.

Principle 3: Direct writing activities through knowledge of genre

Principle 2 ensures that prewriting is allocated ample time but does not by itself assign a coordinated direction and focus to that time. Genre-specific knowledge, as expressed in principle 3, ensures such direction and focus in the development of a well-formed writing task. Genre knowledge allows writers to pin down the expectations of readers, the conventions, tropes, linguistic structures, and author-reader relationships that readers expect to encounter. Genre, in this sense, guides the entire writing process: prewriting, sentence-generating, and revising. Experienced writers recognize that genre

25 Hayes and Chenoweth, 2006
26 Hayes and Chenoweth, 2007
27 Hayes, 2009
28 Hayes and Flower, 1980
29 Glynn et al., 1982

is not a straitjacket but a resource for enriching the reader's experience in furtherance of the writer's goals.

Research in genre has focused on academic and ESL writing.[30] Geisler[31] shows the crucial role of genre in the display of written expertise in disciplines like philosophy. Yet genre knowledge also pervades prewriting knowledge in non-academic—e.g., professional, trade, literary—contexts.[32] Professional and creative writing programs commonly teach these professional, trade, and literary genres in college writing classrooms to prepare students for the transition from school to work.

Genre, in sum, oversees the communication and learning goals of the writing, and the nature of the writing task, be it a classroom genre or a professional genre. Genre, as a principle of writing, is non-identical with the first principle of reducing the cognitive load of writing. But, genre knowledge pins down numerous composing decisions about the nature of the writing that the writer would otherwise have the burden of making on their own.

Principle 4: Support review/revision processes during the writing process

Research on writing processes has found that integrating drafting, reviewing, and revising is essential for writers to produce effective writing." [33] Reviewing and revising ensure clarity, coherence, and effectiveness of communication. It further ensures the development of the critical thinking and reflective analysis needed to spot and correct overlooked perspectives, suboptimal choices, and errors. But even more, it is responsible for fostering continuous improvement and growth as a writer.

Future of Writing—Our Approach

For the past twenty-five years, guided by these principles, we have explored how digital tools incorporating Natural Language Processing and interactive visualization might alleviate writers' cognitive load and enhance their writing process. These experimental digital writing environments were designed to offer automatic feedback, thereby maintaining a writer's engagement without the need for supervision from teachers.[34] Our involvement in this endeavor predates the rise of generative AI; but, we have discovered that strategic deployment of generative AI complements our vision of placing the human writer at the forefront of the writing process, while also democratizing access to the writing process for a broader population.

AI makes writing more "effective" by restricting the actions of writing to those that can only be entrusted to a human.

Guided Generative AI

AI that creates content has the potential to dismantle the work of writing educators. However, we envision that, properly constrained, it can make writing more fluid, democratic, and inclusive. We believe what we call

30 e.g., Swales, 1990; Swales & Freak, 2000; Hyland, 2004, 2009, 2012
31 Geisler, 1994
32 Kaufer & Butler, 2000
33 Flower & Hayes, 1981; Graham & Perin (2007).
34 Kaufer & Ishizaki et. al., 2003; Ishizaki & Kaufer, 2011, 2020; Wetzel et. al. 2021; Brown & Wetzel, 2023; Laudenbach, 2024.

guided generative AI will give writers more time to invest in the higher critical thinking skills of planning and communicating substantive ideas clearly and compellingly. It will also help us address the cognitive and motivational issues that have prevented us from scaling writing education to the masses.

Early drafting is often painful because it takes place in a fog. Writers often can't understand their preliminary thoughts until they see them realized as sentences. They write not to express their refined thought but to examine their early thinking, warts and all. However, writers often fall down the rabbit hole of sentence craft at this early stage and mistakenly begin to polish sentences when they should be planning them only well enough to build a visible prototype of their thinking. In particular, beginning writers or students can get so bogged down in the morass of sentence craft that they rarely experience the successes and pleasures of higher-level thinking and problem-solving that writing can deliver.

One responsible use of AI offers writers a tool to convert their notes into prose without adding ideas. The AI is guided to mirror in prose the quality of the writer's notes. Should the writer's notes be hazy and not well-thought-through, the AI-produced prose should reflect that haziness. Should those notes be more precise and thorough, the AI-produced prose should reflect that precision and thoroughness. The AI ensures that the sentences produced stay within the bounds of the human writer's original ideas. Guided generative AI, in this light, creates language to help writers rapidly prototype and test notes on their paragraph-sized ideas and organization. It turns notes into a paragraph, making the notes easier to read, study, evaluate, and learn from.

Guided generative AI will narrow the psychological distance between ideas and expression and relax the bottlenecks that have kept them siloed. It can make writing more fluid while reducing pain points. It can further address issues of social justice—It will make the writing process accessible and more inclusive, particularly for underprivileged students with limited access to writing instruction as well as second-language learners. Generative AI is the first technological breakthrough that promises to accelerate not just the transcription of words, but the translation of the writer's ideas from notes to grammatical English sentences.

Scaffolding the Review Process

Writing often requires an iterative process through multiple drafts. Throughout the writing process, writers must review the draft carefully from multiple perspectives, including accuracy, coverage of topics, flow of ideas, persuasiveness of arguments, appropriateness of the voice/tone, etc. As noted above, integrating drafting, reviewing, and revising ensures constant human monitoring of sentence production, promoting accountability and ownership of the writing. However, many students remain unaware of the importance of review and revision processes, and often disregard the careful reading and review of draft after draft because of the significant cognitive load. Imagine a 6 page project proposal. Without a substantial and time-consuming investment in reading and re-reading any single draft, we cannot tell how ideas are organized, or whether or not a line of argument has been established or is logical and sound. We believe that automated feedback from AI and intelligent visualization can decrease the cognitive load on review and revision,

encouraging writers to engage in multiple revisions, and discouraging them from developing a blind trust in the raw output of generative AI.

Guided Analytic AI

In addition to generating a piece of writing, AI has also been used to analyze an existing piece of writing and comment on its effectiveness and appropriateness. While many users reported that they were impressed by its comments and revision suggestions, it suffers from problems similar to the ones we have outlined above for the generative use of AI. For example, comments may not take into consideration the immediate and nuanced situational constraints in the communicative situation. Students may blindly accept ineffective comments, hindering their learning.

AI properly constrained can make writing more fluid, democratic, and inclusive.

However, we believe there is a way to harness the power of AI by guiding the analytic use of AI. Instead of relying on AI's knowledge alone to assess the quality of a piece of writing, we can guide the AI based on research findings on what makes writing more effective for a specific writing task. For example, research suggests that lexical overlaps across paragraphs in a text correlate to the perceived coherence of the text. We can then ask AI to focus on lexical overlaps across paragraphs to assess the quality of flow.

Making the Invisible Visible

Another possible way to reduce the cognitive load is to visualize invisible features in writing. The practice of visualization, or the use of visual representations to communicate data and information, has a long history. Its roots can be traced back to the era of cave paintings, marking the earliest known use of visuals to convey information. As science began to flourish in the 18th and 19th centuries, the use of visual representation grew in tandem, becoming an integral part of scientific communication. This trend continued into the late 20th century with the advent of computational visualization.

The benefits of visualization are manifold. For one, visual representations can simplify complex information, making it easier for individuals to comprehend and internalize key concepts. These visual depictions of data and information can expedite decision-making processes by providing a clear overview and facilitating the comparison of different options. Additionally, visual content tends to command attention more effectively than text, leading to increased levels of engagement and interest.

We believe that visualizing the invisible features of writing, such as coherence and information density of sentences, will greatly enhance the writer's ability to review and revise their drafts.

A Solution—myScribe

myScribe is an AI-enhanced writing studio that aims to implement our vision of the future or writing. myScribe provides writers with a series of tools that support writers from the initial phase of writing to the completion of the final draft. This section presents our current implementation of myScribe, which has been developed based on the research-based principles outlined above.

Jump-starting Writing Process with Situation (genre) Specific Expectations

The Writing Task Panel in myScribe, representing reader expectations and the kind of "how" and "why" questions a reader conventionally brings to a specific writing task, derives from decades of empirical studies on the centrality of "task representation" in writing research. The task representation depicts how writers frame their texts in ways that reflect not only the verbal and visual composition of the text but also the external and situation-specific motivations, purposes, and goals writers rely on to frame their writing tasks. Researchers[35] have independently shown that a writer's grasp of task representation can significantly elevate their writing. Hence, myScribe provides writers with sophisticated scaffolding for writing within and across writing contexts.

Writing task definitions, including an overview of the task and reader's expectations, can either be manually crafted by a researcher specialized in genre-based writing pedagogy, or generated automatically using AI. Advanced users have access to myScribe's Writing Task Editor to customize writing task definitions.

Translating Notes into Prose

Notes-to-Prose reduces the cognitive load of sentence craft early in the writing process when the primary allocation of attention needs to be on higher-level planning and organization. During the times when planning remains or should remain dominant, Notes-to-Prose supports the production of prose when writers benefit from having language generated efficiently to test the efficacy of their local (paragraph-level) plans.

The writing of the future will require humans to have more rigorous and systematic knowledge of what makes writing human.

Flower and Hayes[36] report that the experienced adult writers they studied relied on higher-level planning activities for 80% of their early-phase writing. They describe the many constraints writers must juggle, including task, cognitive, and textual constraints. These constraints interleave with the major phases of writing they identified: planning, sentence generation, and revision. They found that experienced writers better manage these constraints than inexperienced writers. However, the constraints can grow overwhelming for any writer if not well-managed. Glynn et al.[37] found that in a persuasive writing task, subjects who were instructed not to worry about sentence mechanics on a first draft generated final drafts with more and better ideas. The Notes-to-Prose tool is designed to relax sentence generation constraints in the early phases of the writing process when language production is subordinate to idea generation and when language is used as an instrument to rapidly prototype and evaluate paragraph-size plans.

Notes-to-Prose is the only tool in the myScribe suite that constitutes generative AI from the vantage of the writer. That is to say, only one tool in myScribe offers writers the kind of linguistic help that could conceivably raise concerns about plagiarizing the ideas of others or producing ideas beyond the writer's ability. In environments where generative AI is forbidden, the notes to prose

35 Bereiter & Scardamalia, 1987; Hayes and Flower, 1980; Flower, 1989; and Geisler, 1994a, 1994b
36 Flower and Hayes, 1980
37 Glynn et al., 1982

tool can easily be disabled. In such environments, all other tools in the myScribe suite would remain available.

The remaining myScribe tools support the review and revision process through AI-enhanced feedback and intelligent visualization. AI and visualization provide feedback that neither teachers nor peers have time to give. Further, the feedback doesn't interfere with the fact that review and revision remain human-controlled processes. To make the text match the writer's optimal target, writers must still rely on their own judgment and decision-making. Focusing on the full spectrum of the writing process, myScribe not only provides a valuable tool for generating drafts but also fosters an engaging, thoughtful, and personalized review and revision experience that keeps the human at the helm.

Assessing Expectations

Since the Notes-to-Prose tool generates paragraphs that adhere to the content included in the writer's notes, it is the writer's responsibility to make sure that their paragraphs provide the information expected by the audience of the text. myScribe offers an AI-powered solution designed to automatically evaluate a segment of text against a predetermined reader expectation outlined in the writing task definition. It lightens the cognitive burden placed on writers, eliminating the need to remember and meticulously apply a multitude of potentially intricate expectations. This not only enhances efficiency but also fosters greater accuracy and consistency in meeting the specific criteria set forth for the writing task. With myScribe, writers can focus their energy and attention on crafting content that resonates with their audience while relying on the tool to provide timely and targeted feedback, ultimately facilitating the creation of high-quality written work.

Assessing Content Coverage

Once most of the content for the document or a section is drafted, writers need to verify whether or not they have covered all the key ideas and information or if any unnecessary information has been inadvertently retained. myScribe provides an AI-based tool that allows the user to list the main topic/theme of the text along with a list of subtopics. By examining the distribution of topics and subtopics within a text, writers can perceptually isolate areas that may require further development or reduction. The content coverage tool reduces the cognitive load of keeping track of the content inventory in a draft. It eliminates the need to recall this inventory from memory or from the constant rereading of the evolving text.

Assessing Coherence

Effective writing hinges significantly on good organization. Specifically, crafting a text that is coherent is important. Research suggests that coherence in texts is often achieved through the logical and cohesive use of words and phrases across paragraphs. Taking a corpus-based approach, Crossley and McNamara[38] identified several linguistic features as potential candidates for predicting the perceived quality of coherence. They found that a feature they call 'global coherence' across paragraphs was most positively correlated to the perceived quality of writing. Their measure of global coherence—e.g.,

38 Crossley and McNamara, 2016

givenness of words/phrases or lexical overlaps and their semantic similarity across paragraphs—contributes significantly to the judgment of writing quality and a sense of coherence.

myScribe provides two tools that allow writers to assess the coherence of their drafts. The first tool, "Assess Logical Flow," uses AI to comment on whether or not topics are logically cohesive across paragraphs (i.e., global coherence). It identifies logical inconsistencies or breaks in coherence by comparing segments of text against logical topical structures. A logical flow helps readers navigate through the content effortlessly, ensuring that they can follow the author's train of thought and grasp the main ideas effectively, and minimizing the potential for confusion or ambiguity in the reader's understanding

The second tool, "Term Matrix" is an interactive visualization of how themes in the text are distributed across paragraphs. This tool helps writers quickly identify recurring themes and keywords in a text. Good organization in an effective text relies on a strong topical structure, which entails careful and deliberate placement of words and phrases. A well-defined topical structure ensures that the content is logically arranged and easy to follow, guiding readers through the main points and supporting details in a coherent manner.

Improving Sentence Level Clarity

Paying careful attention to sentence-level clarity, often referred to as style, is critical for crafting effective writing. Clear and concise sentences enhance comprehension, ensuring that ideas are communicated accurately and efficiently to the reader. A polished writing style fosters engagement and maintains the reader's interest, facilitating a smoother flow of information. Additionally, precise sentence construction enhances the credibility of the writer, showcasing their professionalism and attention to detail. myScribe provides two separate tools to help writers improve sentence-level clarity.

The first tool, "sentence density visualization," shows the list of noun phrases before and after the main verb in a sentence. This tool helps writers quickly see how many chunks of ideas are present before and after the verbs in each sentence. According to research in psycholinguistics, sentence complexity, often influenced by the number and arrangement of noun phrases, significantly affects comprehension difficulty[39]. By visualizing the information density of individual sentences, the sentence density visualization tool is designed to reduce the intrinsic cognitive load associated with isolating sentences that readers are likely to find difficult to process.

The second tool, "copy editing," uses AI to provide revision suggestions for sentence clarity as well as mechanics (i.e., grammar, spelling, and punctuation) with a detailed rationale for the suggested revisions. The copy-editing tool is intended to reduce the cognitive load associated with these lower-level writing tasks and speed up the editing process. Providing rationales for revision suggestions ensures that writers won't accept composing decisions blindly.

39 Gibson, 1998; Traxler et al., 2002

Conclusion

The advent of AI yields new opportunities to distinguish the human essentials of authorship from the bookkeeping and overhead that can be handled by algorithms. AI does not make writing "easier" in the sense of eliminating the human challenge. AI rather makes writing more "effective" by focusing the actions of writing on actions that can only be entrusted to a human. AI promises to help more of the human race enjoy the fulfillment of expressing themselves and the world they cohabit through the written word. Decades of research on writing have helped us understand the challenges of writing and improved ways to teach and motivate it. By making the writing process more effective and satisfying for human beings, we are likely to see the gap closing between all we have learned from research and student and workplace performance.

We have suggested that no responsible AI should intrude on the human writer's critical decision-making, judgment, reflection, and accountability. This means that in the future of writing, authorship will have less to do with who "produced" the prose and more to do with who stands behind it, who stakes their reputation on it, and who is willing, section by section, paragraph by paragraph, sentence by sentence, and word for word, to defend every decision behind its composition. Those accountabilities require both extreme craft knowledge and analytic knowledge. The writing of the future will require humans to have more rigorous and systematic knowledge of what makes writing human.

We have witnessed recurrent calls to "value" writing for over half a century. These are well-meaning efforts to signal the problem, yet we have not seen scalable solutions to date. We believe that with the use of guided generative AI, we have a chance to develop such solutions and define the future of writing.

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