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Computer-Assisted Research Writing in the Disciplines

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Abstract
It is arguably very important for students to acquire writing skills from kindergarten through high school. In college, students must further develop their writing in order to successfully continue on to graduate school. Moreover, they have to be able to write good theses, dissertations, conference papers, journal manuscripts, and other research genres to obtain their graduate degree. However, opportunities to develop research writing skills are often limited to traditional student-advisor discussions (Pearson & Brew, 2002). Part of the problem is that graduate students are expected to be good at such writing because if they "can think well, they can write well" (Turner, 2012, p. 18). Education and academic literacy specialists oppose this assumption. They argue that advanced academic writing competence is too complex to be automatically acquired while learning about or doing research (Aitchison & Lee, 2006). Aspiring student-scholars need to practice and internalize a style of writing that conforms to discipline-specific conventions, which are norms of writing in particular disciplines such as Chemistry, Engineering, Agronomy, and Psychology. Motivated by this need, the Research Writing Tutor (RWT) was designed to assist the research writing of graduate students. RWT leverages the conventions of scientific argumentation in one of the most impactful research genres – the research article. This chapter first provides a theoretical background for research writing competence. Second, it discusses the need for technology that would facilitate the development of this competence. The description of RWT as an exemplar of such technology is then followed by a review of evaluation studies. The chapter concludes with recommendations for RWT integration into the classroom and with directions for further development of this tool.

Disciplines
Early Childhood Education | Educational Technology | English Language and Literature | Language and Literacy Education | Technical and Professional Writing

Comments
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Introduction

It is arguably very important for students to acquire writing skills from kindergarten through high school. In college, students must further develop their writing in order to successfully continue on to graduate school. Moreover, they have to be able to write good theses, dissertations, conference papers, journal manuscripts, and other research genres to obtain their graduate degree. However, opportunities to develop research writing skills are often limited to traditional student-advisor discussions (Pearson & Brew, 2002). Part of the problem is that graduate students are expected to be good at such writing because if they "can think well, they can write well" (Turner, 2012, p. 18). Education and academic literacy specialists oppose this assumption. They argue that advanced academic writing competence is too complex to be automatically acquired while learning about or doing research (Aitchison & Lee, 2006). Aspiring student-scholars need to practice and internalize a style of writing that conforms to discipline-specific conventions, which are norms of writing in particular disciplines such as Chemistry, Engineering, Agronomy, and Psychology.

Motivated by this need, the *Research Writing Tutor (RWT)* was designed to assist the research writing of graduate students. *RWT* leverages the conventions of scientific argumentation in one of the most impactful research genres – the research article. This chapter first provides a theoretical background for research writing competence. Second, it discusses the need for technology that would facilitate the development of this competence. The description of *RWT* as an exemplar of such technology is then followed by a review of evaluation studies. The chapter concludes with recommendations for *RWT* integration into the classroom and with directions for further development of this tool.

Research writing competence

Writing is a skill that includes complex thinking processes and strategies. Additionally, writers need to know who their audience is, why the audience would read their texts, and in what contexts their texts are meant to appear. Writers should also be aware of the disciplinary practices of their audience, which are reflected in specific genre norms (Perelman, 2012). From the perspective of writing and genre theories, this general description of writing is essential when considering research writing competence.

Cognitive writing theory

Graduate students are novices to research writing. Theoretically, the distinction between novice and expert writers has been articulated in terms of knowledge-telling versus knowledge-transformation (Bereiter & Scardamalia, 1987). Novice writers tell their knowledge about a topic and move from one idea to the next. Expert writers, on the other hand, transform knowledge. For them, writing is a reflection-intensive activity that involves repeated planning, translating, and revising (Dunlosky & Metcalfe, 2009; Hacker, Keener, & Kircher, 2009; Flower & Hayes, 1980). Specifically, planning is considering what ideas to include and how to present them. In theoretical terms, writers create an abstract internal representation of the text by inventing ideas and setting procedural goals. Translating is putting ideas into language, or creating the written representation of the text. Revising includes evaluation and modification of the written text to ensure that it accurately renders the intended thoughts. Expert writers not only present elaborate content, but also make effective language choices to realize

communicative goals.

Cognitive models of writing highlight revision as one of the most fundamental components of the writing process and expertise (Butterfield, Hacker, & Albertson, 1996; Hayes, 2000; Hayes & Flower, 1983). At this writing stage, expert writers compare their intended representation of the text with the actual written representation. When the two representations are in conflict, they detect and diagnose the problem. This stimulates a decision of what strategy to use to modify the text. Thus, competent revision principally depends on controlling the activation of these complex higher-order thinking processes. What characterizes novice writers is ineffective detection of problems in their writing. To develop expert-like problem-solving abilities, they need to practice revision guided by feedback that makes them think and detect ineffectively expressed meaning.

Genre theory

Research writing involves constructing, deconstructing and reconstructing knowledge to be shared with other scientists (Badley, 2009). It is essentially a rhetorical behavior (Jolliffe & Brier, 1988) that requires novices to use the specific conventions of scientific writing. A theoretical notion that describes conventions is the notion of genres, which are classes of texts defined by a discipline's values and communicative purposes (Berkenkotter & Huckin, 1995).

The research article genre is perhaps the most wide-spread means of scientific communication. It has become a central focus in the field of English for Academic Purposes (EAP), which has embraced Swales' (1981) approach to genre theory. Swales provided a rhetorical framework grounded in the concept of *moves*, or communicative goals. For example, the Introductions of research articles are described as having three moves: Establishing a Territory (Move 1), Establishing a Niche (Move 2), and Occupying the Niche (Move 3). Each of these moves is realized by *steps*, or rhetorical strategies that convey specific functional meaning. For instance, to achieve the goal of Move 2, writers may use such steps as Highlighting a Problem or Indicating a Gap. The meaning of the latter can be realized through the use of such expressions as "scarce evidence for," "hindered by insufficient knowledge," "not previously explored," etc. In such manner, this framework establishes a systematic connection between rhetorical intent and language choices, which mirror the writer's internal and written representations of the composed text.

Need for technology

Swales' EAP genre approach has been widely adopted in academic writing instruction, increasingly using large machine-readable collections of texts, called corpora. Many researchers recommend the use of search engines to query corpora for key words in context, co-occurrence of vocabulary items, and grammatical, syntactic and positional patterns of search words (e.g., Friginal, 2013; Lee & Swales, 2006). However, few technologies have been created for scientific writing (e.g., *DicSci, TYOS, SWoRD, MAKE, Mover, We-Write Persuasively*), and they do not generate feedback to support expert-like revision. Existing Automated Writing Evaluation (AWE) systems that do generate feedback on students' texts (e.g., *Criterion, MyAccess!, Writer's Workbench, Writing Power, Writing Roadmap, Folio,* etc.) are designed for essays and are thus not suitable for research writing. Plus, they have been criticized for inadequately representing

the cognitive and rhetorical aspects of the writing construct (Perelman, 2012).

The need for feedback technologies to enhance higher-order aspects of writing is addressed by large-scale projects. For example, the U.S. Department of Education's Institute of Education Sciences has funded the development of the *Writing Pal* program described by Crossley, Allen and McNamara in this volume, which enhances writing strategy instruction through automated strategy feedback. The National Science Foundation has recently funded two big projects: one to develop a socio-technical system for teaching written argumentation (Ashley, Litman, & Schunn, 2013), and the second to develop an intelligent ecosystem for science writing instruction (Schunn, Litman, & Godley, 2014). *RWT* expands these efforts to research genres and their rhetorical complexity.

Research Writing Tutor (RWT)

RWT was designed to complement advanced academic writing instruction. It integrates rhetorical feedback with scaffolding, or instructional techniques, derived from discipline-specific corpora of published research articles to enable students to progress toward deeper understanding and autonomous use of genre conventions. The current version of *RWT* contains three independent yet interactive modules for learning, demonstration, and feedback. Each of the modules aims to create conditions for practice necessary for the development of research writing competence.

Learning Module: 'Understand writing goals'

The Learning Module is designed to help teachers impart genre knowledge and to help students learn the conventions of research writing. The content of the materials included here draws from the results of a pedagogically-driven study of a corpus of 900 research articles published by experts in 30 disciplines. This study yielded cross-disciplinary move/step frameworks for Introduction, Methods, Results, and Discussion/Conclusion (IMRD/C) sections (Cotos, Huffman, & Link, 2015). For example, the Results section contains three moves: (1) showing valid progression to findings, (2) reporting the results, and (3) establishing the meaning of results. Each move contains series of step strategies. Move 3, for instance, may be realized by: explaining specific results, suggesting reasons for what may have caused the results, reflecting on anticipated or unanticipated results, and comparing results with previous research.

The Learning Module incorporates multimodal instructional materials about the move/step conventions of each IMRD/C section. The materials define the moves, explain their purposes, provide content suggestions, specify the rhetorical functions of the steps, and supply examples from the corpus. Similar materials offer so-called *Language Focus* guidelines that highlight patterns of language use. The *Language Focus* of Results, for example, describes the use of:

- Verb tenses: Present Tense is generally used to locate data in a figure or a table. Past Tense is used to report specific results. Either Present or Past Tense can be used to make strong claims about the results. Modal and tentative verbs and verb phrases are used to make less confident comments (e.g., may, might, suggest, seem, appear, tend, be possible, be likely, etc.).
- Means of comparison: Adjectives are used in the comparative or superlative degrees. Verbs of variation are used to report how variables fluctuate over time (e.g., rise,

fall, increase, decrease, remain constant). Verbs of correlation are used to report the relationship between two or more variables (e.g., correlate with, associate with, related to).

Additionally, this module contains short videos where an instructor first introduces a given move and explains each step of the move using representative excerpts from the corpus. Then, she prompts students to determine the steps in a series of examples and demonstrates how to interpret the functional meaning and language use in those step examples. This way, she models a reflective process that students could apply when revising their own writing.

Demonstration Module: 'Explore published writing'

Numerous EAP studies show that corpus-based activities can foster enhanced awareness and writing improvement (Boulton, 2010; Henry, 2007; Tono, Satake, & Miura, 2014). Identifying similarities and differences in collections of expert writing is particularly helpful for novice second language writers (Hyland, 2004). Moreover, systematic analysis of text structure, rhetorical composition, and characteristics of language use facilitates genre learning (Tardy, 2009) and promotes critical literacy (Hammond & Macken-Horarik, 1999).

The Demonstration Module is designed to create conditions for such outcomes by integrating the corpora complied and analyzed in Cotos et al. (2015). The genre conventions are illustrated through three interrelated components: *Research Articles*, *Section Structure*, and *Move/Step Examples*. The former presents complete research articles in their original published form, modelling the end documents to be prepared by students. The *Section Structure* component contains sub-corpora of separate IMRD/C section texts annotated based on the move/step frameworks introduced in the Learning Module. Each annotated sentence carries a color representing a move. The colors visualize the rhetorical composition of individual texts and are the same across sections to ensure consistency in the enhancement of corpus input: blue represents Move 1, red – Move 2, green – Move 3, and gold – Move 4. The structure of multiple texts can also be displayed on the same page, making it possible for students to notice patterns in the move composition of disciplinary texts. Additionally, scrolling over a sentence brings up a gloss specifying the rhetorical step it represents (Fig. 1).

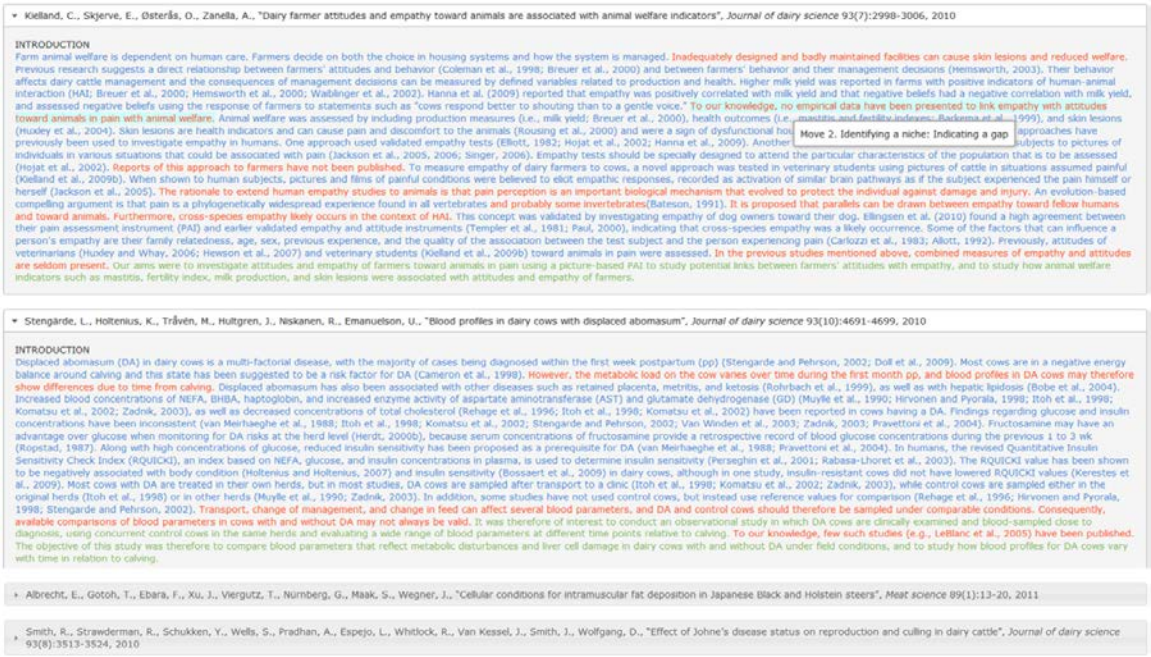

Figure 1. Annotated corpus in Demonstration Module

The *Move/Step Examples* component offers a search engine, known as a concordancer in EAP. Like other concordancers, it consists of a database holding the annotated sub-corpora. By hierarchically selecting a discipline, section, move, and step from respective drop-down menus, the students can retrieve all of the examples of a searched step. Figure 2 shows examples of the step that identifies a gap. Highlighting the part that carries the step's functional meaning makes salient various language choices: "no information is available," "have not been fully understood," "there is little information available," and "are lacking in the literature." Furthermore, the concordance examples can be expanded by a click to show the annotated source text (similar to Fig. 1). This allows students to observe how the given step is interwoven in the discourse and what kind of content may precede or follow it.

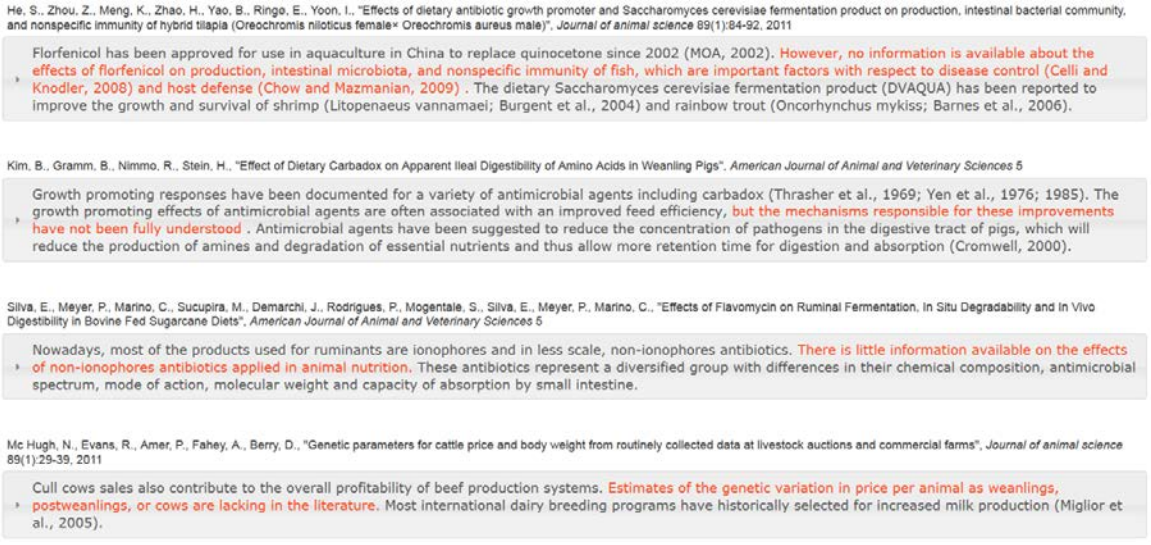

Figure 2. Concordance examples in the Demonstration Module

Feedback Module: 'Analyze my writing'

Previous works demonstrate the pedagogical value of corpus-informed feedback provided as pre-cast concordance links (Todd, 2001), concordance-based teacher feedback embedded in students' texts (Gaskell & Cobb, 2004), and intelligent interactive feedback (Birch-Bécaas & Cooke, 2012; Chang & Kuo, 2011; Cho & Schunn, 2007). Writing produced by students exposed to corpora was found to improve, exhibiting patterns similar to those in published articles (Bianchi & Pazzaglia, 2007; Charles, 2014; Cortes, 2011).

The Feedback Module of *RWT* builds on these strengths. It provides students with a platform where they can receive automated feedback on their own writing. Unlike traditional AWE systems, *RWT*'s feedback draws students' attention to the rhetorical conventions of a research genre, as opposed to grammatical correctness and elements of style in essays. The backbone of this module is an analysis engine that is trained to classify every sentence of a student text into moves and respective steps (for details see Cotos & Pendar, 2016). The results of classification are translated to different types of macro and micro-level feedback generated when students submit their drafts for automated analysis.

The macro-level feedback focuses on rhetorical composition and is visually operationalized in two ways (Fig. 3). Specifically, the submitted draft is returned color-coded for moves. This form of feedback depicts the move structure of the draft just like the Demonstration Module depicts the move structure of expert texts. The second form of feedback is both visual and numerical in that it summarizes the move distribution in the draft with range bars and pie charts. Here, the draft is compared with the texts from the corpus in the student's discipline. This goal-orienting feature of the feedback (Fisher & Ford, 1998) is expected to increase motivation by allowing students to monitor their writing progress in relation to published writing. If students need a reminder of what the moves entail, they can access a brief definition by hovering over the question marks next to the moves.

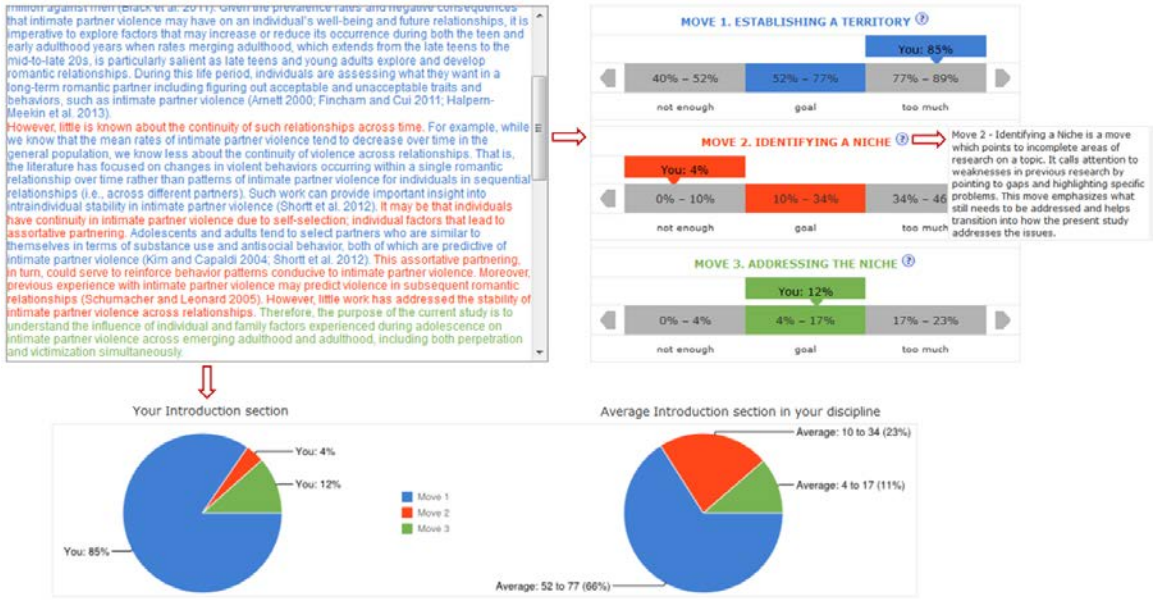

Figure 3. Types of macro-level move feedback in the Feedback Module

The concept of functional steps is operationalized through both macro-level and micro-level feedback (Fig. 4). Expandable from the range bars for each move, *RWT* details whether the steps are comparable to the target discipline. It also draws the student's attention to the steps that may be lacking or may need to be improved. In support of writer's cognitive processes, this feedback is hyperlinked with the components of the Learning and Demonstration Modules. The *Learn More* links open a new tab with instructional materials about the step that might need to be scaffolded. The *Examples* links bring the students to the concordance with step-specific excerpts from the corpus.

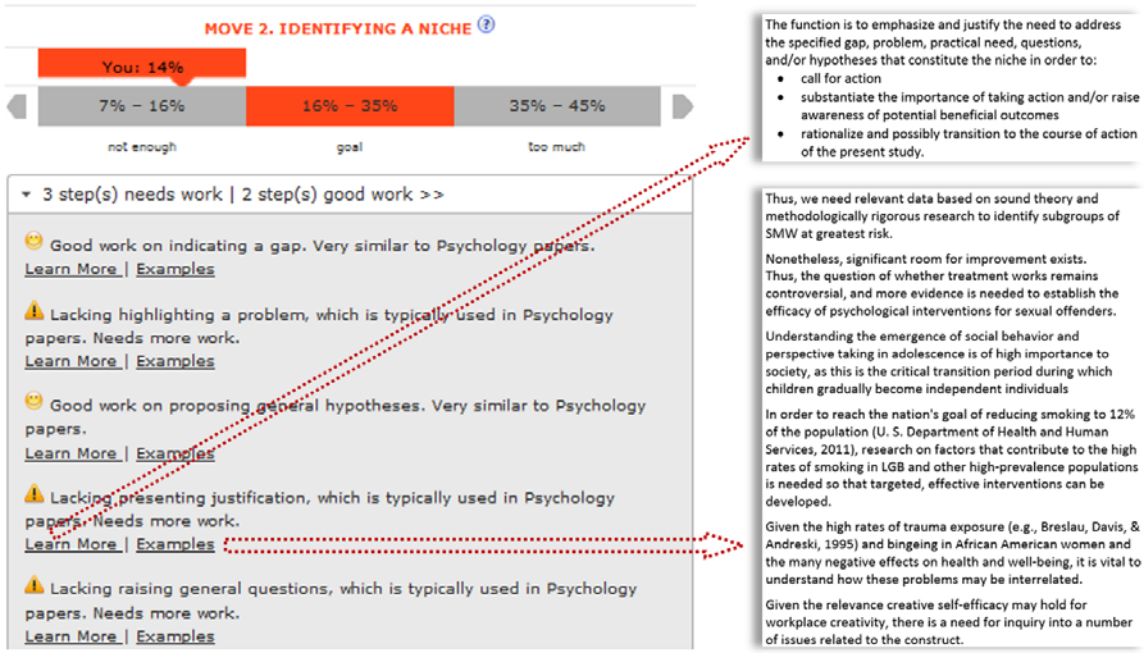

Figure 4. Types of macro-level step feedback and scaffolding in the Feedback Module

The micro-level feedback is about the students' use of steps. It is connected to the move color-coding of the draft and appears as the student hovers over sentences. This type of feedback takes the form of interactive comments or clarifying questions about the rhetorical intent of a given sentence. The highlighted sentence in Figure 5 may not explicitly convey functional meaning, so the feedback prompts the student to think about it by asking whether this sentence intends to provide some general background to a claim (the step classified by the system as most probable for this sentence). Continuity to this instance of prompted reflection is maintained by the 'thumbs' and the note-taking features. In Figure 6, the student chose 'thumbs down' indicating disagreement with the computer's interpretation of what she meant, and made a comment that she would further use for revision. All of the sentence-level feedback prompts and student notes can be exported for self-planned revision.

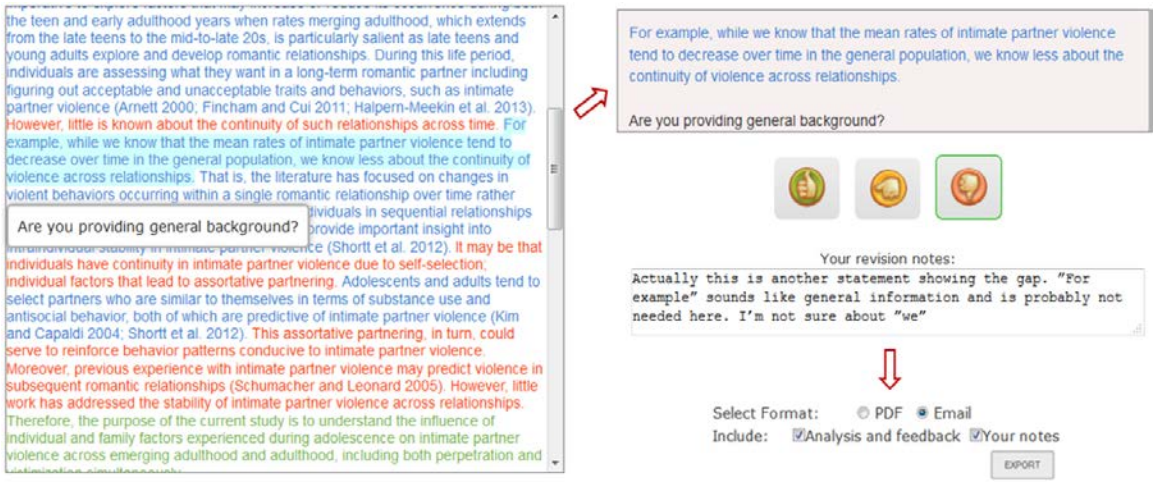

Figure 5. Micro-level step feedback and note-taking in the Feedback Module

Accessing and navigating RWT

RWT is a web-based application in continuous development, which is why, for the time being, it is only accessible at Iowa State University in the United States. It is available to students and instructors at no cost. They need to create an account profile and log in with their institutional credentials (net-ID and password). The profile information includes the name, department, discipline, user status (e.g., doctoral/master/certificate/non-degree student, postdoctoral associate, or faculty), instructional setting (e.g., writing course, seminar, workshop) and English native/non-native speaker background. The homepage briefly introduces the tool, also linking to a short video demo, and encourages users to get started by creating a profile (Fig. 6). The users can also contact the team for help if needed. Although access to *RWT* is restricted during ongoing development, guest accounts for external users can be created upon request. Ultimately, the goal is to launch this tool as open access.

Figure 6. *RWT* homepage

RWT's current interface is the same for all users. It is easy to navigate and is set up to engage students in greater levels of interaction. Clicking on *Understand writing goals* leads to a choice of the section the students are studying, as well as to the *Language Focus* guidelines. *Explore published writing* extends to the three components of the Demonstration Module, and *Analyze my writing* contains two options – to begin a new draft or continue one that is in progress. To start a new draft, students select a relevant discipline and IMRD/C section, enter the title of their paper, write or paste in the drafted content, and click on ANALYZE for feedback. When a draft for one section of their paper has been created and revised, students can add the next section. The drafts of a given section are automatically saved and can be accessed on the same editing page. The drafts of all the sections are also archived and are accessible through the *Continue Draft* button according to the title of the paper.

Evidence of effectiveness

Empirical evidence showing how *RWT* can benefit novice scholarly writers is being continuously accumulated. Research results unveil its potential to trigger reflective processes and strategies, to have a positive impact on motivation and learning gains, and to suit users with the characteristics of targeted students.

Enhanced cognition

An important intended use of *RWT* is to activate higher-order thinking processes during revision, which is a key stage in the development of writing expertise. The various features of the tool were found to increase students' cognitive capacity in a number of ways (Cotos, 2011). Specifically, think-aloud and screen-recording data from sixteen student-participants showed that the move-level feedback provided by the prototype

version of *RWT* helped students engage in critical reading of their drafts. Most importantly, they were able to detect a mismatch between what they meant and what they actually conveyed. Students also noticed that:

- their ideas were not always explicitly stated,
- they needed more content,
- the way they organized the content was not as logical as it seemed,
- their drafts lacked some moves or steps that were commonly used by published authors in their discipline,
- their language choices were not always appropriate for their intended meaning.

Noticing of these problems was triggered by both the color-coded feedback and the numerical feedback. Two other studies (Chapelle, Cotos, & Lee, 2015; Cotos, 2014) describe the cognitive reactions that were fostered by the feedback. The color-coded feedback prompted students to question what might have caused the mismatch, check whether the feedback was accurate or not, and hypothesize about what should be done to improve a problematic move. Numerical feedback facilitated setting operative goals. Because instant feedback was available for every text modification, students were able to consistently reflect and evaluate how well their ideas were translated to writing.

Revision strategies

Another study provides insight about the role of cognition in strategic text revision (Cotos, 2012). Open-ended questionnaires from 37 Masters and 68 PhD students specializing in a range of 34 disciplines showed that most students (90%) believed that the *RWT* feedback influenced their usual revision process and helped many of them (74%) develop new revision strategies. A random sample of 16 students was observed, interviewed, and their interaction with the tool was screen-recorded. Students' actions during revision showed that they first addressed the numerical feedback, trying to improve the move that was the farthest from the average in their discipline. At this point, the changes they made were sporadic, inconsistent, and often unsuccessful. Gradually, students' focus shifted to functional meaning. Their revision process turned into a very detailed self-verification, as they were checking the move colors against the intended steps sentence by sentence. When receiving feedback that was in disagreement with their rhetorical intent, students searched for move-specific phraseology in the annotated corpus. This appeared to be a constructive strategy often resulting in successful text modifications.

Genre learning and writing

Interaction with both the prototype and the current version of *RWT* can help students learn and apply genre concepts. Cotos (2014) reports that 80% of 88 students who completed questionnaires believed that they learned the moves well, 7% very well, and only 13% a little. Responses to a qualitative survey suggest that 77% thought they could transfer what they learned to their actual writing. Many students (59%) presumed that learning occurred because the corpus-based affordances helped them acquire a better understanding of the moves and steps. Another 22% attributed learning to the feedback and its ability to draw their attention to the rhetorical composition of their drafts. Some students (12%) noted that rhetorical feedback was helpful for learning how to operate with the genre concepts. An additional factor was the practice of revision exercised

through multiple resubmissions of modified text. Students explained that this practice opportunity helped them consolidate their unseasoned genre knowledge. The more they revised and resubmitted, the more problems they could detect and thus the more successful modifications they were able to make.

Students' knowledge of rhetorical conventions before and after interacting with the tool was assessed through pre and post-tests. There was a significant difference in the pre-test scores and the post-test scores indicating learning gains after students' interaction with *RWT*. Similarly, statistical analysis comparing 210 first and final drafts demonstrated that students' writing improved significantly. It is worth mentioning that students mostly improved content, language use, and structure.

Affect and motivation

Interaction with *RWT* was found to exert impact on students at affective and intrinsic levels. Most of the students (92%) in Cotos (2012) noted that they were excited to see improvement when new feedback was returned, and their desire to improve increased progressively. A third of these students shared a feeling of accomplishment. In some instances, repeated unsuccessful text modifications caused disappointment and frustration. As the revision continued, however, positive experience appeared to be more frequent compared to negative. This was in part due to the fact that the students were coming to realize how important it is to be rhetorically and linguistically explicit. Corpus-based scaffolding features and comparison with published disciplinary texts also boosted motivation.

Learner fit

A user study investigated the appropriateness of *RWT* for the revision task and for graduate students in different disciplines (Cotos & Huffman, 2013). The tool was introduced to 9 students in a writing course that focused on producing a publishable quality research article. Multiple types of evidence showed that all *RWT*'s features facilitated revision. *RWT* also promoted the necessary degree of learner control. Students tended to interact with *RWT*'s features in deliberate and exploratory ways, controlling their own pace and accessing certain types of feedback when they thought it was most appropriate. All of them evaluated the different forms of feedback as helpful because they were directly applicable to performing the writing task. The discipline-specific nature of the feedback was perceived suitable for individual learners.

Huffman (2015) explored 11 students' first-time interaction behaviors with *RWT* in a similar writing course. The results of time-on-task analysis showed that, as in Cotos and Huffman (2013), the students exercised the necessary degree of learner control by selecting what feedback and scaffolding to interact with depending on what they needed at a certain point in the revision process. Some students chose to use multiple features, and others maintained interaction with fewer features in a sequenced cyclical manner. Students' most frequently interacted with their color-coded drafts and with the 'thumbs' to then take notes on whether or how to go about modifying specific sentences. The Demonstration Module was accessed particularly often. It was perceived as helpful because the corpus-based examples provided visible rules for how published authors compose their discourse both structurally and rhetorically. Whether opting for one or another type of interaction behavior, the students believed that *RWT* enabled them to self-

regulate during revision.

Utility

A study by Ramaswamy (2012) examined perceived usability and usefulness of *RWT*'s Feedback and Demonstration Modules, as well as the level of trust depending on the context of use. Three groups of graduate students were surveyed: one group consisted of 9 students enrolled in a graduate writing course, the second group consisted of 24 students who participated in a month-long series of research writing seminars, and the third group consisted of 6 students who had never received any formal instruction in research writing. Interestingly, the less students knew about research writing, the more they tended to rely on the move feedback and trust the step feedback provided at sentence level. Students who had sufficient knowledge of genre conventions, but no teacher support, were more reflective. They liked having the computer provide rhetorical feedback because it helped them think and self-analyze their writing. A participant even compared the feedback with the comments students receive from their major professors. Overall, the students' evaluated *RWT* as being user-friendly and easy to navigate, with consistently-designed and well-integrated features, and visually appealing. In terms of usefulness, the different types of feedback were rated as comprehensible, stimulating deeper thinking, and motivating revision actions. Students expressed willingness to continue using this tool in the future, whether independently or as part of formal instruction.

Integrating the technology for learning

RWT is not bound to a specific curriculum. Each of its three modules can be used to complement classroom activities in ways that are appropriate to the learning objectives, which is why *RWT* does not impose a pre-determined path conditioned by prerequisite steps. The materials in the Learning Module can be assigned by teachers as homework either before the research article conventions are introduced in class, or after that for the purpose of knowledge consolidation. In lieu with EAP corpus-based approaches, teachers can use the Demonstration Module to devise discovery tasks (see Johns, 2002), in which students explore disciplinary corpora. Their observations of how moves occur in different texts and what language is used to communicate specific shades of meaning can provide a sound foundation for class discussion and draft-planning activities. The Feedback Module can be best used for the purpose of self-analysis once the students produce their first draft. In this process, note-taking in response to the sentence-level feedback can become a systematic revision strategy. It is highly recommended for teachers to model self-analysis with *RWT* in class in order to make sure that students engage in productive self-reflection and are able to detect mismatches between the mental and written representations of their texts.

Although initially designed to enhance graduate writing pedagogy, *RWT* can be used in other learning environments and levels of instruction. For example, it has been introduced to graduate students who seek scientific writing assistance in workshops, peer writing groups, and individual consultations with writing tutors at Iowa State. In these relatively autonomous learning environments, students can determine their own needs-based ways of interaction with *RWT*. Generally, they begin with the Feedback Module and use the other two modules when needing to understand genre concepts. *RWT* could

also be used with advanced writers in high school, particularly where the learning of sciences includes research experiences and capstone project reports. Irrespective of the context of use, the tool's most essential advantage is integrating genre and disciplinary conventions in a platform for independent writing practice.

Limitations and future directions

RWT is a pioneering genre-based system, which draws on theoretical tenets, EAP pedagogical principles, and disciplinary corpora of research writing. Its modules facilitate the learning of scientific writing conventions. The rhetorical feedback in the Feedback Module, in particular, warrants students' engagement in an interaction that stimulates necessary reflective processes and promotes revision for improvement.

Implementations of *RWT* in different contexts of use and the study of students' interactions with this tool provided directions for future improvements. Arguably, corpora from 30 disciplines are helpful to a rather broad representation of students. However, students whose discipline is not included in *RWT* may find it less suitable for their writing needs. Growing this tool to incorporate all possible disciplines is certainly very ambitious and perhaps even unrealistic. Nonetheless, empirical evidence obtained so far suggest that all three modules can be useful regardless of whether the discipline is present in *RWT* or not (provided that students are explained how existing features could be efficiently utilized). For example, the sentence-level feedback is helpful to anyone because it can facilitate self-reflection that is needed to trigger cognitive activities important for the revision process. Similarly, because the linguistic choices expressing certain rhetorical intent are functional rather than disciplinary, the concordancer in the Demonstration Module can be used irrespective of the discipline. In other words, students in any discipline can choose expressions like "is well-established and rapidly expanding," "has led to significant interest," "has been at the forefront of much research," and "has received considerable attention," to claim centrality of their topic.

At this point, *RWT* falls short compared with other writing systems in that is does not have an interface for teachers, who might prefer to have access to all students' drafts and custom-tailored progress reports. Additionally, *RWT* has no technical ability to allow teachers to embed their own comments on various aspects of writing quality that fall outside genre conventions. To design new components for teachers, classroom-based investigations will be conducted, and teachers' input will take the center stage. Embedded peer feedback is also a desirable addition, which could create a collaborative environment for groups of students who share similar writing goals and research interests. Furthermore, research is needed to better understand how *RWT* might be used more efficiently and to design new features that would help students frequently and strategically activate and monitor cognitive processes (similar to Roll, Aleven, McLaren, & Koedinger, 2007). The automated analysis performed by *RWT*'s engine also anticipates a scale-up. While it yields acceptable move/step classification measures (Cotos & Pendar, 2016), feedback accuracy remains to be improved. Also, the system classifies sentences only into one move and one step, but often sentences in published texts represent more than one rhetorical function. Another goal is to analyze step sequences and to generate feedback comparing student writing with the sequencing preferences in their discipline. With its current features and new enhancements, *RWT* will help novices become experts in research writing.

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