AcaWriter
A Learning Analytics Tool for Formative Feedback on Academic Writing

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Abstract: Written communication is an important skill across academia, the workplace, and civic participation. Effective writing incorporates instantiations of particular text structures – rhetorical moves – that communicate intent to the reader. These rhetorical moves are important across a range of academic styles of writing, including essays and research abstracts, as well as in forms of writing in which one reflects on learning gained through experience. However, learning how to effectively instantiate and use these rhetorical moves is a challenge. Moreover, educators often struggle to provide feedback supporting this learning, particularly at scale. Where effective support is provided, the techniques can be hard to share beyond single implementation sites. We address these challenges through the open-source AcaWriter tool, which provides feedback on rhetorical moves, with a design that allows feedback customization for specific contexts. We introduce three example implementations in which we have customized the tool and evaluated it with regard to user perceptions, and its impact on student writing. We discuss the tool's general theoretical background and provide a detailed technical account. We conclude with four recommendations that emphasize the potential of collaborative approaches in building, sharing and evaluating writing tools in research and practice.

Keywords: writing analytics, learning analytics, genre theory, feedback, rhetorical moves

journal of
WRITING RESEARCH

1. Introduction to AcaWriter and its Theoretical Basis

Academic writing is an essential skill that all higher education students must master to succeed in their degree and professionally (OECD & Statistics Canada, 2000). Students are asked to write documents in diverse styles that are assessed in various contexts within a university. For instance, students write laboratory reports in Science, legal opinions in Law, business reports across business disciplines, research articles for higher degrees, and essays in the Humanities. Alongside these traditional *analytical* genres, students also engage in other forms of *reflective* writing to record their thoughts, feelings, and reactions to an event or situation and reflecting on the learning process, in disciplines from Pharmacy, Engineering, and Education, all while adhering to their disciplinary writing conventions. However, the teaching and learning of academic writing are challenging as there is often a misalignment between students' and educators' expectations of academic writing (Lea & Street, 1998). This misalignment is compounded by the difficulty of providing detailed explicit formative feedback on how to improve writing, due for example, to resource constraints, lack of knowledge regarding writing pedagogy, and inconsistency in writing program delivery (Lea & Street, 1998). Feedback is necessary to improve students' academic writing, as it allows students to review and revise their writing, which is a key element in the writing process (Hayes & Flower, 1980). Feedback allows students to reflect on what they have done and how they can improve, addressing the gap between their performance and their educator's expectations. Formative feedback encourages learners to focus on improvement, rather than grade outcomes. Sharing pedagogic approaches to support this formative feedback can aid educators in teaching students how to write effectively. These factors motivated the development and implementation of an automated feedback tool called *AcaWriter*.

Using technological advances, automated and semi-automated tools have been developed to overcome the issues of time, effort and reliability in evaluating written texts and providing formative feedback (Shermis & Burstein, 2013). The scope of tools that evaluate writing varies from Automatic Essay Scoring (AES) systems that provide a score based on the assessment of standardized writing to Automated Writing Evaluation (AWE) systems that provide additional feedback to students on their writing (Warschauer & Grimes, 2008). Intelligent tutoring systems for writing instruction also exist that act as a strategy-oriented writing aid to help students with well-defined problems (Roscoe & McNamara, 2013). A recent review (Strobl et al., 2019) highlights the differences between writing tools in terms of their purpose and introduces a new category called Interactive Writing Platforms (IWP) that provide prompts and scaffold the writing process for students, but do not process their input or give feedback (Strobl et al., 2019). Such technological advances have provided new opportunities for improving teaching and learning practices.

Learning analytics has emerged as a field in which data from learning is used to better understand the support of that learning (see, for example, LAK11, 2011; Siemens & Long, 2011). Within the field of learning analytics, writing analytics has been of particular interest in supporting the process of writing and providing feedback on written products (see, for example, the workshop series Buckingham Shum et al., 2016; Knight et al., 2017; Shibani et al., 2018; Shibani, Liu, et al., 2019). The focus of this paper is one such writing analytics tool, AcaWriter, which provides scalable formative feedback to students to improve their writing.

AcaWriter is a web-based writing analytics tool that provides automated formative feedback on the rhetorical moves in students' texts. It does this by drawing on Swales' (1990) genre analysis of texts in terms of their moves and communicative goals and Hyland's (2005) notion of metadiscourse. These rhetorical moves are phrases and sentences that indicate or explain to the reader the writer's attitude or position in relation to what has come before in the text or what is ahead or with respect to other texts. These moves include summarizing (for example, "it is therefore clear that"), contrasting (for example, "conversely"), and emphasizing (for example, "it is important to note that"). The sentences conveying the rhetorical moves may contain words or phrases as metadiscourse cues that orient the reader, and thereby support coherent and persuasive writing. Rhetorical moves thus perform a communicative function by helping the reader follow the flow of the text (Swales, 2004).

AcaWriter uses natural language processing (NLP) techniques to identify sentences that communicate a specific rhetorical function. The software includes a computational *parser* which processes each sentence in the text and identifies such rhetorical moves. It is based on the concept-matching framework (Sándor, 2005), which models the metadiscourse cues of identified rhetorical moves as instantiations of syntactically related constituent concepts in sentences. Thus, the syntactically related words of a Background move such as, "recent studies indicate", instantiate the constituent concepts [PREVIOUS] [PUBLICATION] [IDEA]. The tool uses syntactic parsing to extract syntactic dependencies and a dedicated lexicon that contains a list of words and expressions that may instantiate the constituent concepts (as shown above). It then uses pattern-matching rules that identify sentences containing pairs of instantiations of constituent concepts that are associated with rhetorical moves.

The implementation of AcaWriter in the classroom has taken a genre-based approach, in which writing is viewed as socially situated and purposeful (Hyland, 2007) and makes explicit the way language works to create meaning (Cope & Kalantzis, 1993) and achieve its rhetorical goal. By taking this perspective towards writing AcaWriter is able to be contextualized to fit different learning contexts through targeting their particular genres. In this paper, we provide a detailed presentation of the tool and its underlying theory (next section), before reporting

on the different learning contexts that AcaWriter currently provides automated formative feedback for, through the description of three high-level deployment contexts and evaluation in these contexts. We conclude summarizing our findings across these three contexts, and directions for future research and development for the AcaWriter tool.

2. Detailed Presentation of AcaWriter and its Parsers

2.1 Tool technical background

The AcaWriter tool is presented to the users (students and instructors) as a single browser-based application. It is in fact comprised of three different open-source web applications that interact: the AcaWriter web application, and two underlying technologies, the Text Analytics Pipeline (TAP), and Athanor. Each of these applications is deployed in a cloud environment, however, only the user interface (UI) in the form of AcaWriter is accessible to the end user. The full set of applications is available open-source, with Jupyter notebook guides (which combine code blocks, their outputs, and rich text description) available to support people through the tool design and use (Shibani et al., 2018), and educator resources illustrating how AcaWriter can be integrated into writing improvement tasks[1].

The Athanor server is a web application that provides an API (application programming interface). It first calls the Stanford CoreNLP software that for each sentence of the input text produces a dependency tree, as well as part-of-speech and named entity tags. Then it calls the Athanor rule engine that applies the pattern-matching rules, which assign rhetorical move labels to sentences[2].

The rhetorical moves associated with the text are supplemented by other custom text analysis provided by TAP. TAP provides a unified API for a range of text analysis functions, one of which is the rhetorical moves function provided by the Athanor server. Others include basic text features (n-grams, text cleaning, paragraph counts, etc.).

The user experience of AcaWriter is provided by the AcaWriter UI which coordinates all of the necessary aspects of user interaction including authorization of access, matching users to genre-based feedback associated with fields of study or assignments, collecting the input text from the user, calling the appropriate function from TAP, and providing a visualization of the resultant analytics back to the user. This user experience can be customized in a number of ways, including through the creation of "assignment codes" which, when entered by a user, preload a particular feedback 'genre' for the writing submitted for that assignment. These 'genres' describe particular standards for writing for the particular audience in the given assignments, for example in law or accounting, or for writing research

abstracts and reflective writing as will be discussed further below. These feedback customizations are developed within the AcaWriter tool by mapping the UI to the underlying features from TAP (Knight, Shibani, et al., 2018; Shibani, Knight, et al., 2019)[3], as detailed in the cases below.

2.2 AcaWriter user experience: Learning design and contextualizable genre profiles

The AcaWriter tool contains two primary genre feedback modes to which modifications and additions may be made:

- The analytical genre, which provides feedback on scholarly academic rhetorical moves familiar to research writing and a wide range of university-level writing.
- The reflective genre, which provides feedback on scholarly reflective writing in which students are asked to reflect on how their experience relates to their professional practice and its development.

Basic functionality provides three tabbed pages to users: (1) A report, which shows the input text highlighted with the moves identified, (2) a feedback tab, which provides customizable messages regarding the moves identified, for example, if particular functions are missing, and (3) a resources tab, which can provide learning materials and examples. Each of these tabs can be modified for particular contexts, for example to (1) focus on particular moves (by ignoring the presence/absence of others), (2) Based on the identification of these moves, feedback is provided to students – which may also be customized – for example, give custom feedback indicating that a particular move has not been identified in the writing, or providing a positive message if moves are in a theoretically desirable order and (3) link to discipline-specific guidance and examples.

This specific instantiation of the linguistic rules to identify moves into student-facing feedback has drawn on research and practice in well-established fields such as User-Centred Design, Participatory Design and Co-Design (Buckingham Shum et al., 2019) with instructors and linguists co-designing and developing rules appropriate to the pedagogic context (see, for example, Knight, Buckingham Shum, et al., 2018). The specific genre profiles and their instantiation into feedback are described in full in the empirical work, which indicates how the specific moves reported, feedback regarding those moves, and resources to support students can be customized for a specific learning context (which can be assigned to 'codes' in the system, which when entered by the user display particular feedback).

To implement AcaWriter and integrate it effectively across disciplinary teaching and learning contexts, the tool is designed to support customization of new feedback genres that provide context-sensitive feedback to students that is relevant to their genre of writing. Such contextualization of learning analytics tools like AcaWriter can augment existing pedagogical practices to help students make

effective use of the tools to support learning (Shibani, Knight, et al., 2019). This augmentation is implemented through working with instructors who are subject experts in their respective disciplines to co-design feedback and writing interventions for students that are customized for their disciplinary context. That is, in each of the implementation cases (discussed in detail below), the tool and its evaluation is conducted in the context of specific learning designs, with tasks defined such that a set of theoretically well-grounded tasks can be transferred across different learning contexts.

2.3 AcaWriter instructor experience

The software is targeted at two primary end user groups: academics and students. Through a "Manage Assignment" menu, academics (who are generally subject instructors) may create an "Assignment code" to be provided to students, that (1) marks students who use the code as submitting against that particular assignment (and associated feedback-genre), and (2) can set up specific feedback, at present from a set of pre-defined 'feedback genres'. These genres provide some feedback specific to the task, as described in the following sections. The instructions to academics explain that:

> When using AcaWriter to manage your assignment, it's important to choose the correct genre type. This allows AcaWriter to provide you with the relevant feedback support on your writing. There are a number of different genres you can choose from, and these can be found in the dropdown menu on the left-hand side of the page. Each genre will provide you with different

Figure 1. Sample AcaWriter 'add a new assignment' screenshot; instructors may base their assignment feedback on a general analytical or reflective genre, or on previously modified discipline-specific genres (e.g., reflective pharmacy writing).

types of feedback, and you can learn more about the feedback by clicking on each of the genres and reading the corresponding descriptions. After you've added a new assignment, the system will automatically generate a unique assignment code. This assignment code can be given to the students. Students then login to AcaWriter and subscribe to this assignment by selecting the tab "Enter my assignment code", create a draft for their assignment and keep refining and adjusting the text based on iterative feedback generated in AcaWriter.

As shown in Figure 1, selecting a genre allows creating a new document to get feedback for, and displays a short explanation on the right, with a link to *More info.*

Figure 2. Detailed writing task descriptions with introduction, learning design overview, description of the analytics genre profile (how the analytics are mapped to feedback provided) and research regarding its implementation linked to instructor instructions.

This takes the academic to the detailed *Writing Activity with Writing Analytics* description as shown in Figure 2.[4] It describes the application of the technology to the particular pedagogic context through expressing a particular learning design (tasks students undertake), the way the tool is modified for that design (the genre profile), and any research context and evaluation of relevance to the context. These foster the sharing of approaches to using AcaWriter, reflecting the need for technologies to develop both technical and social infrastructure in order to achieve implementation.

2.4 AcaWriter student experience

On signing in, students are offered tabs to either create a new document choosing from the generic *Analytical* or *Reflective* feedback genres or enter an assignment code provided to the student by the instructor as in Figure 3. The assignment code automatically selects the genre allowing the student to receive customized feedback for their subject.
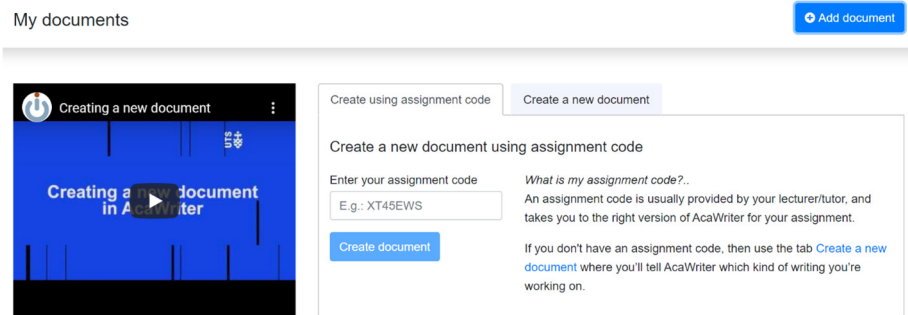
Figure 3. AcaWriter user interface for adding a new piece of writing.

An information portal for students and staff has been developed, presenting the above orientation information to different groups.[5]

3. Empirical Studies

The AcaWriter tool has been implemented across a number of contexts. Here we describe three such implementations at a large metropolitan university in Australia:
- First, we describe work to implement the *analytical genre* first in the context of an undergraduate law class, subsequently adapted to an undergraduate accounting class, both within the context of specific course assignments. These implementations are described separately, reflecting the design iterations undertaken to develop the work (in law), and then transfer it (to accounting). The final design iteration is discussed for both law and accounting. While both

sites are presented alongside evidence of impact (particularly in legal education), the focus of the accounting context was to determine if the AcaWriter implementation could be successfully transferred to another undergraduate context.

- Second, we describe the work to implement the analytical genre in a postgraduate research writing context. Specifically, this section provides evidence to determine if the AcaWriter tool can be successfully adapted and used in a postgraduate research writing context to teach Ph.D students the structure of academic writing, in a European/Australian model in which candidates undertake three years of research, with no coursework requirements.
- Third, we describe work to implement and evaluate the use of AcaWriter to provide feedback in the *reflective genre*, in the context of a pharmacy course.

Across this work, a design-based approach to the research and implementation was taken (Brown, 1992; Collins, 1992). Design approaches offer "a systematic, but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang & Hannafin, 2005, pp. 6–7). The focus of this approach is hence on developing theory and practice through iterative practical design problems (in our case, improving student writing across disciplinary contexts) rather than experimental design approaches. Together these three studies provide evidence for our main research questions:

1. Can the AcaWriter tool be customized to varied learning contexts to improve student writing?
2. Do students and instructors perceive AcaWriter to be useful to improve academic writing in their specific context?

4. Disciplinary academic writing contexts: law & accounting

4.1 Disciplinary academic writing context one: Legal education

The law context provides evidence for the question, does the use of the analytical AcaWriter tool result in improvements in students' writing?

Learning context and background (law)

The first learning context in which AcaWriter was applied was a core undergraduate law subject on civil practice, described in detail in Knight et al., (2018). Law places core emphasis on clear and persuasive writing with the use of appropriate arguments. The specific type of writing that students were asked to produce in this

subject was argumentative law essays of about 2000 words. These academic essays outline legal arguments for or against a particular proposition from a list of assigned, provocative topics, with a key requirement that students adopt a position for or against the proposition contained in the essay question. In the written assignment, the instructor had developed a marking rubric consisting of the following elements: Statement of argument, Statement of essay plan, Identification of issues, Analysis, Sustained thesis and Original insight, and Engagement with literature/cases. As part of the submission process, students were required to submit a self-assessment of their essay. The unit was located in the middle of the overall course structure, and hence students were familiar with the conventions of submitting written university assignments. However, early in the marking process, the instructor observed that students would often overestimate the quality of their writing, and thus required more support to develop their evaluative judgment (Boud, 2000) of the criteria. AcaWriter was contextualized to this subject to help students write better essays using a new feedback genre that aims to help students self-assess their essays based on the assessment criteria.

Methods (law)

Implementation site and participants (law)

Following the design-based approach discussed earlier, the AcaWriter tool and the writing intervention for law students were developed over the course of five semesters in design iterations, with roughly 280 to 400 students in each cohort. Improvements to the task design and the tool were made in each iteration based on the feedback from the previous iteration (from instructors and students), until a stable design was reached and evaluated, discussed in detail in Shibani, Knight, and Buckingham Shum (in press). This final iteration – discussed below – used the most recent version of the tool and task design. Evaluation data comes from 90 students who completed all parts of the writing intervention without technical issues in class.

Implementation and materials (law)

To contextualize AcaWriter feedback for law, the types of rhetorical moves AcaWriter could identify were mapped to writing criteria elements of a law essay. With this mapping as the foundation, three tabs of feedback from AcaWriter were developed: the first tab provided a highlighted report of the key rhetorical moves for that genre of writing that were found in the students' writing. A sample analytical report with highlighted moves is given in Figure *4.*

Figure 4. Sample analytical report for law in AcaWriter highlighting rhetorical moves in the writing. Top pane indicates the editor (left) and feedback (right); bottom pane shows the detailed feedback.

The second tab provided further feedback messages for the student based on the rhetorical moves that are missing in their writing. A screenshot of this second tab showing feedback messages is given in   Figure *5*.

The third tab provided examples and mapping to the assessment criteria for students to learn more about those rhetorical moves. In the context of the law essay, the rubric elements were mapped directly to one or more rhetorical moves (see Table 1). The mapping of rhetorical moves to assessment criteria and the crafting of context-sensitive feedback for the subject were conducted with the instructor who is a subject matter expert.

Table 1. AcaWriter tags mapped to Law assessment rubric elements with example sentences.

Assessment Rubric Element	AcaWriter Tag	Example Sentence
Engagement with law and scholarly literature	B – Background	The Concept of good faith has previously been thought to be a work-in-progress in Australia
Statement of thesis/ argument	S – Summary	This article will trace the origins of good faith and its development in the common law.
Essay plan	S – Summary	This essay contains three parts. The first part will talk about […]
Critical analysis, evaluation, original insight	C – Contrast E – Emphasis	However, where the obligations are found in statute and they conflict with contractual obligations, it is important to note that the former must prevail.
Drawing together themes and reaching a logical conclusion	S – Summary	In conclusion, the reasonable behavior required under the standard of good faith does not preclude strong bargaining techniques […]

Figure 5. Sample feedback messages for law from AcaWriter on missing rhetorical moves.

Pedagogic design and procedures (law)

To introduce students to rhetorical moves in academic writing and the use of AcaWriter to improve their writing, learning tasks were designed to integrate AcaWriter into the law subject by co-designing them with the subject instructor. This was to ensure that the students were well-inducted to use the tool appropriately and understand its relevance for their subject-related writing. The task design of the law intervention is shown in Figure *6.*

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┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐
│Introductory │   │  Matching   │   │  Viewing a  │   │ Assessment  │   │  Revision   │
│reading/ video│──▶│ rhetorical  │──▶│   sample    │──▶│of given text│──▶│  of given   │
│on rhetorical│   │ structures to│   │ essay with  │   │    (low     │   │    text     │
│writing for the│  │instructor's │   │  revisions  │   │  quality)   │   │  *With      │
│   context   │   │   rubric    │   │             │   │             │   │  AcaWriter  │
│  (Offline)  │   │             │   │             │   │             │   │             │
└─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘

      ┌─────────────┐   ┌─────────────┐   ┌─────────────┐   ┌─────────────┐
      │  Guide for  │   │             │   │   Further   │   │    Peer     │
      │future use of│◀──│  Feedback   │◀──│ revision and│◀──│ discussion  │
      │AcaWriter for│   │   Survey    │   │    self-    │   │     and     │
      │  their own  │   │             │   │ assessment  │   │  feedback   │
      │   essays    │   │             │   │ *With AcaWriter│ │             │
      └─────────────┘   └─────────────┘   └─────────────┘   └─────────────┘
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Study Conditions:
- ➤ *With automated feedback from AcaWriter for revision
- ➤ Without automated feedback from AcaWriter for revision

Figure 6. Task design of writing intervention using AcaWriter in Law.

The writing task in the law context was a one-time activity that was facilitated in class during a tutorial session. The task started with an introductory reading or a video in which the instructor explained the concept of rhetorical moves and discourse markers and their application for the students' own writing genre. The students then logged in to an online platform called AWA-Tutor/ AWAT (Shibani, 2018) which facilitated the writing activities, as described in Shibani et al. (2017).

1. First, students completed a matching exercise by dragging and dropping elements of the assessment criteria to sentences with rhetorical moves to understand the mapping between them.

2. Then, they viewed an exemplar text that was marked up with revisions, in order to develop their understanding of how introducing rhetorical moves could improve the quality of an essay.

3. They then assessed an exemplar text, using guided questions; a text they revise or redraft in the next stage.

4. In the next stage, revision, the students revised or redrafted the exemplar provided in step 3. At this revision stage, a between-groups design was adopted in which students either received automated feedback from AcaWriter to revise their essays, or did not. This design was implemented in order to study the impact of AcaWriter on student revisions and their perceptions of the writing intervention. This task design also exposes students to a shared

exemplar text to improve, and allows shared discussion around that text, and thus has pedagogic value.

5. After this main revision task, students discussed with their peers to provide feedback on each other's revised essays from that point, which they applied to further revise the text in the next step.

6. Finally, students completed feedback questions on the usefulness of the activity and were provided a guide to working with AcaWriter on their own essays in the future.

This set of tasks was co-designed with the instructors, to address a number of pedagogic needs. First, they engage students with the assessment criteria and their application to exemplars. Second, the tasks exemplify and provide space to practice the activity of revising a text to improve it. Third, the tasks support students in developing their ability to assess the quality of texts, including through self-assessment, to understand the quality of their writing and how they can improve it.

Measures of impact (law)
A number of measures were adopted to assess the impact of the AcaWriter tool and intervention on student writing, and the student's perceptions of the usefulness of the learning design (with and without the tool).

Perceived usefulness (law). To study the impact of AcaWriter interventions, student and staff perceptions of the writing intervention and automated feedback were studied. Students' responses to the questions in the final feedback survey (the penultimate step in **Figure** *6*) were used to study their perceived usefulness. Students from both groups (receiving and not receiving automated feedback) answered the questions: 'How did you find this task in helping to improve essay writing' (rating scale of 1-5, where 1-not useful at all and 5-very useful), and 'Please explain why'. Students who received AcaWriter feedback in the task were also asked what feedback they found helpful and what they did not find helpful. Qualitative responses were analyzed using the questions as a deductive (top-down) guide, and an inductive approach to understanding the types of responses made and their implications for our design work, as detailed in prior studies (Shibani et al., in press, 2017; Shibani, Knight et al., 2019). As such, this approach was intended to understand the typology of responses, rather than to quantify the qualitative analysis through the development of a coding scheme. Representative examples are given to exemplify the kinds of responses made.

Analysis of revisions made (law). To further study the impact of AcaWriter on students' writing, we analyzed the revisions students made to a draft that was provided to them from the online activity described in the Pedagogic design and

procedures section. Analysis of these revisions using the between-groups design allowed comparison of revised texts between groups, by using a standardized base or initial draft from which all students worked.

Student revised texts were scored using the standard rubric on which their own essays were assessed, and which the draft they were given was aiming to address. These were scored by a subject expert. This assessor was an experienced grader, with expertise in scoring these assignments developed over a number of semesters, including through making use of exemplars and tutor-moderation as part of their own practice. Texts were scored across the criteria in Table 1, on a simplified scale of 0-3 (0 indicating that a text had been degraded or reduced in quality on that criterion, 1 indicating no change, 2 indicating minor improvement, and 3 major improvement).

Rhetorical moves (law). In addition, the number of rhetorical moves detected by AcaWriter in the revised text was counted automatically for each revised text of student; the original base text did not contain any rhetorical move.

Results (law)

Perceived usefulness (law)

From 90 students who completed all parts of the activity in law, responses to the question 'How did you find this task in helping to improve essay writing' indicate the mean perceived usefulness score for students who received AcaWriter feedback ($M = 3.67$, $SD = 0.79$, N = 46, 61% selecting 'Useful' or 'Very useful') was higher than those who did not receive AcaWriter feedback ($M = 2.95$, $SD = 0.96$, N = 44, 32% selecting 'Useful' or 'Very useful') during the revision task. The effect of AcaWriter feedback in the activity was found to be significant in a Welch two-sample t-test: $t(83) = 3.9$, $p < .001$ with a large effect (Cohen's $d = 0.82$, 95% CI [0.38, 1.25]).

Further qualitative responses from students in Law showed that many students found the activity helpful and appreciated the feedback provided to support their writing.

> I find it very useful that there is a new tool which goes beyond grammar, spelling etc and assists in ensuring the essay will follow a better structure and include discourse markers. (Law student)

> This task has provided a lot of clarity on the impact discourse markers make on essay writing. These will be extremely useful to apply in my future essays. (Law student)

Indeed, some students made specific reference to the ways that the feedback encouraged them to think about their word choice, and how that communicated their stance (or rhetorical position) to the reader, for example:

> I think what is being taught is something I was already aware of. However, by being forced to actually identify ways of arguing, along with the types of words used to do so, it has broadened my perspective. I think I will be more aware of the way I am writing now. (Law student)

> There was a variety of feedback that was useful in revising the essay, including the importance of using rhetorical moves to enhance the quality of the text, deepen the argument and allow for the reader to obtain a more developed understanding of what the essay is trying to convey. This drew my attention to how using discourse markers improve the essay and allow for the reader to be able to flow on with the essay with ease, comfort and guidance. (Law student)

Analysis of revisions made (law)

As described above, the AcaWriter interventions included tasks that asked students to revise a draft that was provided to them. Out of the total 88 valid revised drafts, 45 were from students in an AcaWriter feedback group, and 43 from students in a group who did not receive feedback.

On average, the AcaWriter feedback group obtained higher scores for the revised essay ($M = 7.98$, $SD = 2.49$, N = 45) than the no-feedback group ($M = 7.16$, $SD = 1.21$, N = 43). Welch two-sample t-test showed borderline significant difference between groups: $t(64) = 1.96$, $p = 0.055$, with a small observed effect (Cohen's d = 0.41, 95% CI [-0.02, 0.84]), suggesting a need for further evaluation to assess impact. From the scores of students' valid improved essays (N = 88), performance bands were created as Improved, Degraded and Neutral, based on the lower and upper quartiles of grade summary statistics. If the score was greater than 8, it was classified as improved, if less than 7, it was classified as degraded, and neutral otherwise. The proportion of students in the feedback groups falling in those categories is shown in Figure 7 which indicates a larger proportion of students in the AcaWriter group improved their text than in the no-feedback group.

A significant difference was found between the two groups' revision performance in a chi-squared test: X-squared (2) = 12.75, p < 0.005. This effect can be attributed to the automated feedback in the AcaWriter feedback group, which helped students to improve their essays including through incorporating rhetorical moves. Students in the no-feedback group produced more degraded or neutral essays than improved essays.
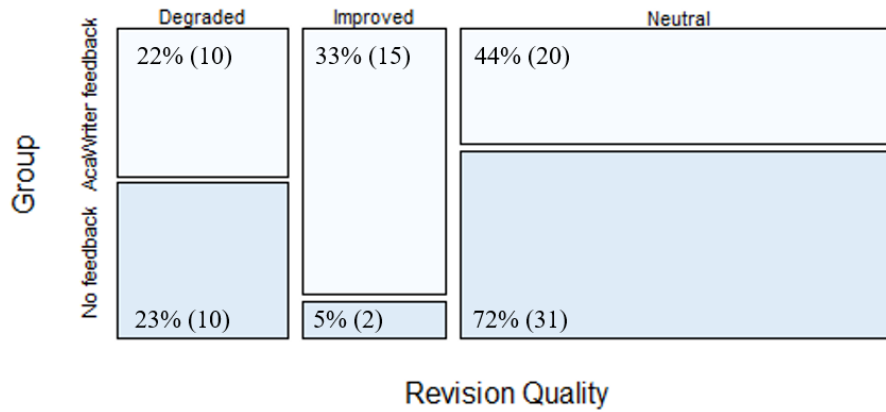
Figure 7. The proportion of students in AcaWriter and no-feedback groups categorized by revision performance (numbers indicate row-wise proportion % (n), while the vertical display shows proportion in each revision quality category).

Rhetorical Moves (law)

A further analysis was conducted to compare the number of rhetorical moves across the two groups in law. The number of moves was measured by running the essays through automated analysis from TAP. Importantly, the original text included 0 rhetorical moves, yet to meet the needs of the assessment criteria, rhetorical structures were required, as indicated by the explicit feedback provided in the tool.

Students in the AcaWriter feedback group introduced a statistically significant higher number of rhetorical moves (M = 3.76, SD = 2.8, n = 45) than students in the no-feedback group (M = 1.16, SD = 1.02, n = 43) in their improved essays: $t(56) = 5.81$, $p < 0.001$. The effect size was large (Cohen's $d = 1.22$, 95% CI [0.75, 1.68]), indicating that using the automated feedback from AcaWriter helped students to understand how the use of rhetorical moves mapped to their assessment criteria, and how to apply them to the provided draft to improve it. These rhetorical moves also had a moderate positive correlation with the grades discussed earlier: $r = 0.46$, $n = 88$, $p < 0.0001$, showing that there is a relationship between the presence of rhetorical moves and essay quality.

4.2   Disciplinary academic writing context 2: Accounting education

Building on this work, the second learning context was an undergraduate management accounting subject. The following section provides evidence regarding the question, can the analytical AcaWriter tool be transferred to another undergraduate context?

Learning context and background (accounting)

Throughout their degree accounting students are expected to develop, practice and refine their ability to communicate in a professional business manner. This subject focused on enhancing students' written communication skills, specifically their ability to 'convey information clearly and fluently in high-quality written form appropriate for their audience'. This skill development was targeted through formative tasks associated with an individual writing assignment of about 1500 words. In the current study context, students were asked to write a business report, proposing and substantiating a definition of performance for a specific organization (selected from a pre-defined list). The report was assessed against four elements of assessment criteria: 1. Organizational analysis, 2. Defining performance, 3. Justification of their definition of performance, and 4. Written communication. The cohort comprised a diverse mix of local and international students, with varying levels of English language ability. To help students improve their written communication in their business reports, a feedback genre in AcaWriter was contextualized for the subject, involving co-design with accounting academics, based on the learning and technology design conducted in law.

Methods (accounting)

Implementation site and participants (accounting)

The accounting subject had roughly 400 to 600 business students in each cohort and ran every semester. The cohort had a wide mix of local and international students, who had varying levels of English ability. Two instructors from the subject worked with the researchers to co-design AcaWriter feedback and writing intervention for students. They used the validated task design from the law intervention and transferred it to their new disciplinary context. Data presented in the paper comes from 302 students (all receiving AcaWriter feedback) who completed the online activity in week 1 of the task design, and the marks of 403 students in the overall cohort.

Implementation and materials (accounting)

AcaWriter feedback was contextualized for Accounting by mapping the rhetorical moves AcaWriter can identify to criteria elements of the business report students wrote for the subject. Similar to law, three tabs of feedback from AcaWriter were developed for the accounting context. The first tab displayed the analytical report of the student's writing with the key rhetorical moves highlighted in the writing as shown in Figure 8.

Figure 8. Sample analytical report for Accounting in AcaWriter highlighting rhetorical moves in the writing.

Feedback to improve their writing was provided in the second tab by showing missing rhetorical moves that were deemed important for a business report. Examples of phrases from the business writing context that can highlight those moves were provided in the feedback messages as shown in

Figure **9.** Sample feedback messages for Accounting from AcaWriter on missing rhetorical moves .

Figure 9. Sample feedback messages for Accounting from AcaWriter on missing rhetorical moves

The third tab in AcaWriter for Accounting provided the mapping between rhetorical moves and the assessment criteria elements, and reflective questions that encouraged students to reflect on their use of rhetorical moves, as shown in Figure 10.

Organisational analysis
Where does your report provide contextual information about the organisation's objectives, strategy, structure and activities?

Defining performance
Where does your report provide your perspective (P) about how to define performance or success for the organisation?
Where does your report provide emphasis (E) to highlight the most important aspects of performance for the organisation?

Justification of your definition of performance
Where does your report provide convincing, persuasive justifications for your definition of performance by proposing novel (N) or critical insights, contrasting ideas or tension (C)? Where does your report justify your definition of performance with reference to prior work or background (B)?

Written communication
Where in your report do you use appropriate summary statements (S) to signal the content, sequence and goals of the report?

Acawriter Move	Sample Sentences
Summary	(S) This report defines performance for Nike Inc as a whole from the three main perspectives of economic, social and environmental performance. (S) This section will explain how sustainability can result in the achievement of organisational objectives and contribute to company success.
Perspective, Emphasis	(P) Importantly, research has suggested a link between stronger brand perception and customer loyalty. (E) Therefore, to effectively measure performance for the Canadian Head Office of Lululemon it is essential to consider how the transformational self-improvement ethos of the company is achieved by analysing non-traditional metrics.
Background	(B) Previous market analysis shows that Nike is the world's largest supplier of athletic shoes, equipment, and apparel. (B) Such an evaluation by a global organization has been observed previously.
Contrasting ideas and Issues	(C) These requirements maintain product quality as unethically produced garments could be of lower quality, damage its reputation and ultimately contradict the companys objective. (C) While the companys corporate mission is to maintain its market position as a leading brand for an active and mindful lifestyle, a holistic approach to defining performance is necessary given that Lululemons strength lies in its premium image
Novelty	(N) This closer connection with their customers allows Nike to create new ideas and convert them into products quicker while also being in touch with their demands. (N) Nike believes that through investing in employees and communities, they can inspire while also creating a new method of growth (Nike 2018c).

Figure 10. Mapping of AcaWriter rhetorical moves to assessment criteria for business reports.

Pedagogic design and procedures (accounting)

As in the law context, in the accounting context, the AcaWriter tool was introduced in a writing intervention with tasks to induct students into its effective use. The writing tasks were spread out over six weeks (half a teaching session) as illustrated by the task design in Figure 11.

| Week 1: Writing tasks with exemplar reports and marking rubric (Online Homework) | → | Week 2: Peer discussion (In-class exercise) | → | Week 4: Submission of own draft report | → | Weeks 4-6: Self and peer evaluation of draft, Revision for submission | → | Week 7: Final submission of own report |
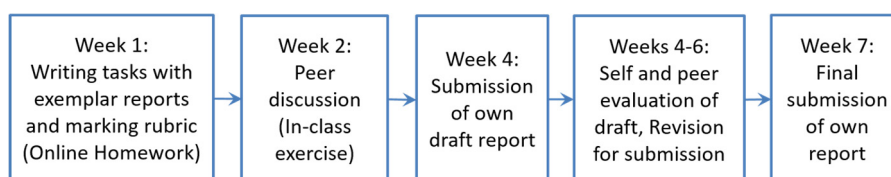
Figure 11. Task design of writing intervention using AcaWriter in Accounting.

In week 1, students completed an online homework activity. This activity was similar in structure to the law writing intervention, but the students completed the tasks independently at home before coming to class. In the activity, students were provided with an example text based on students' work from the previous semester. Working with this text, students reviewed instructor feedback and comments, assessed the work using the assignment marking rubric, and practiced using AcaWriter by reviewing feedback and making changes to the text. The instructor explained the use of rhetorical moves in business writing using a recorded video embedded as part of the task. This online activity thus inducted students into the use of AcaWriter feedback for their disciplinary context, and was the main part of the writing intervention. In the following tutorial, the students shared their experiences of using AcaWriter with their peers. Students also used AcaWriter feedback to develop their own reports for the assignment. Having prepared a mandatory at draft in Week 4, students then used AcaWriter, in conjunction with several other tools and feedback sources (Turnitin, peer and self-evaluations) to improve their written communication in their assignment prior to submission in Week 7.

Measures of impact (accounting)

Perceived usefulness (accounting). The same measure of perceived usefulness was used in accounting to study student feedback (although there is no comparison group in this context since all students received AcaWriter feedback). Perceived usefulness provided us with an understanding of student perceptions about the tool and the intervention.

In addition, the impact of the tool and design work was investigated through instructor interviews to understand the transfer of the tools and tasks from the law to the accounting contexts. While sample quotes demonstrating impact are provided in the current paper, a comprehensive study and extended quotes on

instructor perspectives are reported in other work (Shibani et al., in press), in which a deductive-inductive approach to develop themes is described (Eisenhardt, 1989; Thomas, 2006), as with the survey data the aim of this approach is not to create an exhaustive coding scheme, but to provide an interpretive typology to understand the interview case data.

Final assignment score (accounting). In addition, an analysis of marks scored by students in the assignment was conducted to provide an indication of writing performance. The final marks scored by students in their assignment contributed to overall credits to pass the subject and was used as the performance indicator. The instructors and tutors scored these assignments based on the assessment rubric for business reports and moderated the results between the markers for consistency of marking.

Since the main writing intervention described above was an online homework task, not all students completed it. Whether students completed the activity or not was used to study the association between completing the intervention and the final assignment mark scored by the student. To complete the online activity, students were required to complete all tasks in the online platform AcaWriter Tutor (AWAT), which required watching the introductory instructor video, viewing an exemplar marked up by instructors, assessing a sample report, improving it using AcaWriter feedback, and providing feedback on the task.

Results

Perceived usefulness (accounting)

In accounting, data was analyzed from 302 students (all receiving AcaWriter feedback) who completed the online activity in week 1. Analysis indicated that 66% of students selected 4 or 5 (highest) in relation to the perceived usefulness score ($M = 3.8$, $SD = 0.90$) showing that many students found the activity useful to improve their report writing.

Further qualitative responses showed that many students found the activity helped to improve their writing and appreciated the feedback provided:

> By doing this exercise, it shows me a clear idea on how we could approach our writing for the upcoming individual report assessment task. Not just that, but will generally help in gaining confidence in writing a clear and concise business report future uni projects or for work. (Accounting student)

> It's like having a tutor or another person check and give constructive feedback on your work. (Accounting student)

> It was interesting to see what AcaWriter was able to pick up and the feedback it gave allowed me to edit the sample doc a lot faster than normal. (Accounting student)

Final assignment score (accounting)

To further study the impact of the AcaWriter intervention, marks that measure student performance in their writing assignment were obtained from the instructors. These marks were available for all students of the cohort. The assignments were scored from 0 to 30 for written communication and this mark was used for analysis, N = 403, M = 20.67, SD = 4.87, with a large range from 5.5 to 29.5.

Results show that students who completed the online activity with AcaWriter scored higher marks for their assignments on average (M = 21.15, SD = 4.87, n = 274) than students who did not complete the activity (M = 19.64, SD = 4.72, n = 129). Welch two-sample t-test showed a significant difference between groups: t(258) = -2.98, p < .001, with a small observed effect (Cohen's d = -.31, 95% CI [-0.52, -0.10]), although caution should be drawn in interpretation given the potential confounding factor of student motivation.

Instructor feedback on AcaWriter in both law and accounting

The instructors who taught the subject and marked students' writing (in both academic writing disciplinary contexts) also thought AcaWriter and the writing interventions helped them to efficiently provide individual formative feedback to a large cohort of students:

> I got a lot of positive feedback from students about the fact that it was automated and I think that's an important part of the story because what we're talking about is saying to the students, paste your essay into this tool and then it's going to give you some feedback because your lecturer doesn't have enough time to do that for you. (Law staff)

> We can't afford to give formative feedback when we have 400 students because it already takes us maybe about 20 hours to mark one class of these assignments and so we can't have the tutors spend that time again giving formative feedback. So, we had to do it in a way that is time efficient. (Accounting staff)

These instructors also noticed how the provision of this formative feedback resulted in increased performance in their students' writing:

> I noticed a change and it was profound that suddenly the discourse markers were everywhere… And suddenly I noticed their essays were better. And they will be better in court and they will be better lawyers for it. (Law staff)

Overall, since we've been working with CIC around written communication over the course of the last four of five semesters, we have seen a marked improvement in students' written communication. Overall, their individual assignment pass-rate is going up… We are seeing improvements in the number of students who are either

meeting or exceeding the expectations around written communication (Accounting staff)

5. Higher Degree by Research (HDR) context

As well as for undergraduate reports and essays, the analytical AcaWriter tool has been adapted for use in a postgraduate research writing context to provide students with ad-hoc feedback on the structure of their academic writing. In this context, AcaWriter not only identifies the presence or absence of rhetorical moves but also provides feedback on the order of the moves as is expected in academic writing. This section describes and provides evidence of the impact of the implementation in this learning context.

5.1 Learning context and background (HDR)

It is often assumed and expected that higher degree research students know 'how to write'. However, supervisors report that writing is a challenge for research students (Aitchison et al., 2012), that students lack familiarity with, and struggle to learn, disciplinary writing and rhetoric (Aitchison et al., 2012; Maher et al., 2014; Thompson, 2016), and that students with English as a second language have particular difficulty understanding the rhetorical nature of research writing (Paltridge & Starfield, 2007). This writing includes both the dissertation or thesis document itself, as well as increasing pressure for junior scholars to produce scholarly peer-reviewed outputs (Catterall et al., 2011; Lee et al., 2010; Lee & Kamler, 2008). Thus, while writing is fundamental to the success of research students, many lack skills in applying their discipline-based discourse conventions with few possessing requisite experience in writing for an academic audience at the start of their candidature (Torrance et al., 1992).

For HDR students to succeed in their degree, they need to position themselves in their discourse community by conforming to disciplinary writing conventions. One way for students to analyze the writing conventions used in the introduction sections of articles within their discipline is by using the Create a Research Space (CARS) model developed by Swales (1990; Swales & Feak, 2004). The CARS model allows students to explicitly see how authors achieve an authoritative voice in their introductions. Each of the CARS moves has a specific rhetorical function that is achieved through appropriate linguistic expressions. Identifying the rhetorical function and language choices used to achieve the rhetorical move explicitly conveys the link between the rhetorical goal and the language used. By exposing this link directly students are able to see how rhetorical moves and language used are important in situating themselves within their discourse community.

To provide students with formative feedback on their research writing, a feedback context was developed based on this Create a Research Space (CARS) model in AcaWriter. The CARS model was chosen as it systematically shows the

connection between rhetorical intent and the language used to achieve that rhetorical function. The CARS model has also been used to teach HDR students the structure of research article introductions in pedagogical contexts (Cai, 2016; Kuteeva, 2013),including – as described in this issue – in other learning technologies (see, Cotos, Huffman and Link, 2020). At present, AcaWriter provides feedback on students' research article abstracts and introductions.

Methods (HDR)

Implementation site and participants (HDR)

Pilot work has been conducted to evaluate the HDR context. This intervention was piloted with groups of three or four students in three separate sessions. Overall, 12 students participated in the study, helping us to gain a preliminary understanding of whether the writing analytic tool and learning design were useful for students. The students were at different stages of the doctoral journey. Five students were within the first year of their candidature (which, follows the UK/Australian model of a three year doctorate, with no coursework requirements), six were in their second year, and one in their final year. Eleven were international students and one was a domestic student. Three students withdrew from the intervention after the first workshop.

Implementation and materials (HDR)

AcaWriter's parser was mapped to the CARS model to create the AcaWriter CARS parser (see Table 2) to help students identify rhetorical moves in research article introductions.

AcaWriter's moves were mapped to the CARS moves by examining their communicative functions, and comparing them to the three CARS rhetorical moves. The mapping was validated by first conducting a genre analysis on various research articles annotating the CARS moves. After this, the emerging CARS parser in AcaWriter was tested to see that it identified the same moves. Next, the Elsevier STEM corpus (Elsevier, 2015) was analyzed using the parser, where sentences were checked to see which were tagged and if they corresponded with the CARS moves. Once the testing was complete, a rules-based system was employed to the CARS parser so that feedback would be generated when the moves do not follow the same order as the CARS model and if moves are missing.

To help doctoral students improve their scholarly writing, it is essential that AcaWriter's feedback is clear, specific, and actionable so that students understand what they need to do in order to revise and improve their text. The analytical report that is generated by AcaWriter highlights the moves that students have written (see Figure 12). Each AcaWriter tag is assigned to a color that corresponds to each CARS move used in the mapping. This was done so that students are able to clearly

distinguish which sentences matched back to the CARS moves. Highlighting the moves in students' texts encourages them to think critically about their writing.

Table 2. AcaWriter tags mapped to CARS moves (adapted from, Swales & Feak, 2004)

CARS Rhetorical Moves	AcaWriter Tags
Move 1 – Establishing a research territory:	
by showing that the general research area is important, central, interesting, problematic, or relevant in some way (optional)	E - Emphasis
by introducing and reviewing items of previous research in the area (obligatory)	B - Background
Move 2 - Establishing a niche:	
by indicating a gap in the previous research, raising a question about it, or extending previous knowledge in some way (obligatory)	C – Contrast & Q – Question
Move 3 - Occupying the niche:	
by outlining purposes or stating the nature of the present research(obligatory)	S – Summary
by listing research questions and hypotheses (optional)	
by announcing principle findings (optional)	
by stating the value of the present research (optional)	N – Novelty
by indicating the structure of the research paper / thesis (optional)	S – Summary

For example, if a sentence is tagged as Move 2, but the student did not intend to express move 2, it allows to them go back and see if they have expressed their meaning effectively, and in turn, revise the sentence. Students are also given clear, actionable feedback messages when their texts are missing moves and if they are in a different order to the CARS model. These feedback messages prompt students to revise their texts specifically related to each move. An explanation about each move is given, alongside guidance on language that students can use to achieve the rhetorical move (see Figure 13) with additional guidance provided in the Resources tab. AcaWriter supports students writing practice as they go through the recursive nature of writing, guided by feedback to help them achieve their communicative goals.

Pedagogic design and procedures (HDR)
A writing intervention using AcaWriter was designed to help students understand the concept of rhetorical moves and apply the moves in their writing.

NOTE: Computers don't understand writing like humans. So, AcaWriter may highlight rhetorically good sentences that actually make no sense, or leave un-highlighted a sentence that you feel is really good. It's fine to disagree with the feedback — but it's also your job to check your facts!

Analytical Report	Feedback	Resources

Move 1: Establishing a research territory

E Emphasis of a significant or an important idea
B Background information and reviewing previous work

Move 2: Establishing a Niche

C Contrasting idea, tension, disagreement or critical insight
Q Question or gap in previous knowledge

Move 3: Occupying the Niche

N Novelty and value of your research
S Summary of the author's goal or nature of the research, or structure of the paper

E **C** From a human-centred computing perspective, the end-user's interpretation of these visualisations is a critical challenge to design for, with empirical evidence already showing that 'usable' visualisations are not necessarily effective from a learning perspective. Since an educator's interpretation of visualised data is essentially the construction of a narrative about student progress, we draw on the growing body of work on Data Storytelling (DS) as the inspiration for a set of enhancements that could be applied to data visualisations to improve their communicative power. **S** We present a pilot study that explores the effectiveness of these DS elements based on educators' responses to paper prototypes. **E** **B** It is now widely accepted that timely, actionable feedback is essential for effective learning. In response to this, data science is now impacting the education sector, with a growing number of commercial products and research prototypes providing "learning dashboards", aiming to provide real time progress indicators.

Figure 12. AcaWriter's highlighting of rhetorical moves in a research abstract, colour-coded by moves from the CARS model.

Figure 13. AcaWriter's feedback on the presence, absence, and sequencing of CARS moves.

The intervention consisted of two face-to-face workshops for doctoral students on how to write an introduction and abstract using the CARS model and AcaWriter. The workshop followed the teaching and learning cycle (TLC) of deconstruction:building the field, joint construction, and independent construction (Rose & Martin, 2012; Rothery & Stenglin, 1994). The TLC was applied in the sessions as it raises student's rhetorical awareness, which is needed in HDR research writing, through a sequence of structured connected stages and learning activities. The TLC approach allows students to become independent writers as they go through the workshop stages and scaffolded activities.

The first workshop involved discussions about writing in general, writing abstracts and introductions, and writing in their disciplines. In the same workshop, a mini-lecture of the CARS model was given to students where an introduction was deconstructed according to the CARS model. Once the facilitator was confident that the students understood the model, students were then asked to annotate abstracts and introductions according to CARS where more discussion took place about the moves the students found and if they followed the CARS model. The next activity involved students critically analyzing an introduction from a sample article, they were then asked to submit this introduction to AcaWriter for feedback and reflect on whether they agreed with AcaWriter's feedback.

The second stage of this activity is where joint construction took place, as students revised the introduction according to their analysis and AcaWriter's feedback in pairs or individually. In the final activity in this session, students submitted an introduction or abstract from their discipline to AcaWriter, where

again they reflected on whether AcaWriter identified the moves or not, or if they found moves that AcaWriter did not detect. In the second workshop, students independently constructed their own abstract or introduction in AcaWriter, and requested feedback when needed.

Measures of impact (HDR)

Perceived usefulness (HDR). The researcher conducted a focus group and interviews with students who participated in the workshops, regarding their experience of using AcaWriter. The semi-structured focus group (n = 4) and interviews (n = 3) were recorded, verbatim transcribed and coded using an inductive (bottom-up) approach.

Impact on writing (HDR). From the pilot workshops described above, pre and post-tests were conducted at the start and end of the workshops to measure student understanding of the CARS rhetorical moves (a strategy also adopted by Anthony & Lashkia, 2003; and, Cotos, 2010). Both tests contained two tasks. In the first task, students received a list of 13 sentences and were asked to annotate each sentence for the CARS moves. Students were given a score of 1 if they annotated the sentence with the correct move and a score of 0 for an incorrect move. The second task asked students to read an introduction and annotate the introduction for the three CARS moves. Scores of 1 were given if they identified the move that each section belonged to correctly. If students annotated part of the section correct and the other incorrectly they were given 0.5 and if the move was completely incorrect they were given 0. In both cases different, but equivalent, sample materials (sentences, and introductions) were used pre- and post-test. Students were not provided feedback on their results in the pre-test (as the workshop directly addressed the task aims).

Results (HDR)

Perceived usefulness (HDR)

Common themes emerged from the data: thinking about writing, structure, planning, and usefulness of automated feedback. All students found the intervention and AcaWriter useful. Students stated that the automated feedback messages and highlighting helped them reflect on their writing and its rhetorical structure:

> It makes you think about if you have the moves […] it gives you some hints, a message, ok you're missing this (Participant 3)

Some students described AcaWriter as a helpful tool for planning:

> It was useful for planning, seeing if your writing is in the right order, in an understandable order, so not only like having the moves, but you have a sequence that makes sense (Participant 4)

> I think one of the main contributions of AcaWriter is to help you structure your thinking (Participant 1).

The same participant mentioned that AcaWriter helped them to critically analyze their writing

> I think it was very useful to use a piece of writing of my own and then when the software gives the feedback, maybe you think you're having the moves, you have the right structure but then it, it happened in my case the software told me ok, you're missing move 1, but I thought that it was there...I think in that sense, it challenges you in the way that you're thinking (Participant 1).

Impact on writing (HDR)

While most students reported that AcaWriter helped them learn the CARS rhetorical moves, some stated that they needed more time to become more familiar with AcaWriter and the CARS framework, and thus longer interventions are planned for future evaluation.

As three people left the study after the first session, only data from the remaining students (n = 8) were included in the pre and post-test. In task 1 (annotating 13 sentences), the average number of sentences correctly annotated by students increased from 8.00 (SD = 3.25) pre-test to 9.50 (SD = 3.25) post-test. In task 2 (introduction annotation), students (n = 8), improved their scores from 1.81 (SD = 0.59), to 2.00 (SD = 0.76). However, in both tasks not all students improved their performance individually. These results suggest that understanding rhetorical moves used in research writing is a challenging skill to learn and that more time is needed to learn to apply the moves, an evaluation that is underway.

5.2 Reflective writing context

While the previous sections described and evaluated the use of the analytical genre of AcaWriter, this final learning context describes and evaluates whether AcaWriter can successfully be used to provide effective feedback for the reflective writing genre.

Learning context and background (reflective writing)

Reflective practice is an important feature of lifelong learning (Ryan, 2011). As Boud, Keogh, and Walker (1985) note:

> Reflection is an important human activity in which people recapture their experience, think about it, mull over & evaluate it. It is this working with experience that is important in learning (p.43)

Thus, reflection can help learners develop an understanding of their own experience of learning (Boyd & Fales, 1983). This makes reflection a particularly important element of degree programs in which experiential components of professional practice play an important role, notably teacher education, nursing, pharmacy and allied health disciplines, engineering, and architecture. Reflective writing tasks are advocated as an effective way to assess reflective practice in tertiary contexts (Griffin Jr et al., 2010; Ryan, 1988), making them a key component of reflective practice as students document their experiences through journals, blogs, or reflective essays. Reflective writing allows students to express how they have learned from their experiences and to connect theory with practice.

However, guiding reflection is challenging, with concerns around operationalizing deep or surface reflection (Hatton & Smith, 1995; Lew & Schmidt, 2011; Sumsion & Fleet, 1996), and developing language that is shared between students and instructors across disciplines to teach and asses the writing (Ryan, 2011). Indeed, a review of reflective writing teaching across disciplines in an Australian institution (Ryan & Ryan, 2013) found that academics struggle to explain what they are looking for in quality reflections, and thus encounter issues in guiding students in completing their reflective writing tasks.

The development of the reflective writing aspect of AcaWriter was theoretically informed by the above research on the use of reflection in education, and research on the linguistic characteristics of reflective writing identified through analysis of reflections across a number of disciplines (Gibson et al., 2017). A key aim in developing the tool was that it provide pedagogic support contextualized to the disciplines into which it was applied. As such, the distillation of the theory was also contextualized by discussions through a co-design methodology with teachers with an interest in reflective writing representing a range of disciplines (e.g. Pharmacy, Accounting, Engineering). The primary pedagogical aim of providing actionable feedback to students set the direction for this work. The result generated a reflective framework that both synthesized theory in reflective writing and that took into account practical disciplinary approaches to assessing and supporting reflection.

The reflective framework (see Figure 14) visualizes five levels describing increasing reflective depth from *Impression* and *Interpretation* through *Internalisation* and *Integration*, to *Intention*. The linguistic features were also ordered from *thoughts* and *feelings* through *challenge* and *self-critique* to *potential solution* and *learning opportunity*. The framework also incorporated elements to assist with using it for actionable feedback. The linguistic features were simplified

into 3 main categories: *context* (thoughts and feelings), *challenge* (challenge and self-critique), and *change* (potential solution and learning opportunities).

Further, guiding questions were provided that aimed to shift a student from the less reflective *impression* and *thoughts* through to the more reflective *intention* and *learning opportunity*. For example, "How is this a problem that challenges me?" or "How can I learn from other perspectives?". Each element of the framework was designed to capture common aspects of respected theories in a way that was relevant to the teachers who might use it.

Depth							
Intention							What change is likely to lead to future benefits?
Integration			What impact on my goals/aspirations?	What other ideas could I use to change myself?	How do others address these challenges?	How can I learn from other perspectives?
Internalisation		What do these feeling say about me?	How is this a problem that challenges me?	Why do I need to change?	How can I change?	
Interpretation	What does it mean for me?	Why do I feel this way?				
Impression	What do I notice about my situation?					
	Thoughts	Feelings	Challenge	Self critique	Potential solution	Learning opportunity
	CONTEXT		CHALLENGE		CHANGE	
	Narrative					

Figure 14. Reflective Writing Framework, from Gibson et al., (2017, p. 3).

Methods (reflective writing)

Implementation site and participants (reflective writing)

Pharmacy students are required to reflect on their clinical practice in relation to their academic learning. As part of the course requirements, students are required to keep a reflective e-portfolio and document weekly reflections derived from their weekly clinical placement experiences. Data comes from 59 Master of pharmacy students who participated in a one and a half hour AcaWriter workshop.

Implementation and materials (reflective writing)

The implementation involved assessing how key linguistic features of the narrative could be identified in students' written reflections. A two-pronged approach was adopted. First, reflective rhetorical moves were developed to map the reflective writing framework of Gibson et al., (2017), in a process similar to the analytical parser of AcaWriter (described above). Secondly, expression analysis derived from earlier analysis (Gibson et al., 2016) was used to capture key features of reflection such as the use of affective vocabulary, and first-person personal pronoun centric expressions of knowledge and belief or self-critique.

The detection of reflective rhetorical moves was based on the concept matching analysis framework described in the introduction, developed to directly relate sentences to the three categories (context, challenge, and change). Matching sentences were annotated in AcaWriter with a blue square (context), pink circle (challenge) and green triangle (change). A fourth component highlighted sentences that referred specifically to the author (i.e., the self). If these self-references co-occurred with one of the 3 categories, the sentence was emboldened. Figure *15* illustrates this visual grammar in AcaWriter, along with some sample feedback statements.

Expressions were identified using rules, based on finding groups of words that involved first-person personal pronouns (i.e., I, me, my) and then looking for additional epistemic verbs (think, believe, wonder, guess) or modals (could, should, would). Additionally, words with affective strength were also identified. These expressions and/or words were annotated in the text via styles of underlining: plain represented expressions indicating belief, learning or knowledge; dotted represented expressions of self-critique; and dashed represented words associated with strong feelings.

Pedagogic design and procedures (reflective writing)
The purpose of the 1.5-hour AcaWriter workshop was four fold: (i) to provide exemplars of reflective writing at different levels; (ii) introduce students to the capabilities of AcaWriter for immediate formative feedback on their writing tasks; (iii) facilitate self and peer reflection; and (iv) introduce a validated reflective rubric (Lucas, Smith, et al., 2019) which aligned to the elements of reflection such as those derived from the AcaWriter parser output.

In the Masters, students were asked to document in an e-portfolio their experiences from their weekly clinical placements that included one critical incident (interaction with patient, carer, family member, another healthcare provider and/or a situation that has arisen as a response to a patient enquiry) from the clinical environment and reflect on the impact this has had on their learning. They were asked to draw from their previous personal and/or professional experiences with special attention to how this learning may have challenged their own personal beliefs. Prior to the AcaWriter workshop, students were asked to bring along one or two reflective statements derived from their e-portfolios for use during the interactive workshop.

During the workshop, students were first provided with exemplars of poor and high-quality reflections. These were discussed as a class, following which students were asked to identify aspects of the reflections that address the rubric criteria. The students then viewed AcaWriter feedback for these exemplars, before working individually to view feedback on their own writing. They then engaged in peer review of their reflections with the AcaWriter feedback.

Measures of impact (reflective writing)

Perceived usefulness (reflective writing). An earlier version of the reflective genre of AcaWriter provided a prompt to users after each prompt, with the question: "Did

Figure 15. The visual grammar of reflective feedback and sample feedback.

you find the feedback on your writing helpful?" on a 1-7 scale, where 1 is low and 7 high, alongside a comment box for written feedback.

Impact on writing (reflective writing). To analyze the impact on writing, a surface-level content analysis of revisions made between feedback requests was conducted to investigate the number of reflections submitted to AcaWriter, and where the same reflection was revised and resubmitted, what the nature of those revisions was.

Results (reflective writing)

Evaluation of the reflective writing parser deployed in an pharmacy context (reported in, Gibson et al., 2017; Lucas, Gibson, et al., 2019), indicated that generally students responded positively, with some evidence of impact on writing.

Perceived usefulness (reflective writing)

As reported in Gibson et al., (2017), of 59 students, 30 used the tool to support their writing. Of this thirty, 18 (60%) posted more than once, making a total of 120 posts to the tool. Each post was prompted to provide student feedback to the question "Did you find the feedback on your writing helpful?" on a 1-7 scale; 63 posts were responded to, with 54 (85.7%) on the 5-7 (positive) range of responses.

As reported in Gibson et al. (2017), qualitative responses to the tool were also largely positive, noting:

> I was fascinated by how it works and can see its implication in future, to determine which phrases need more work/ which can be improved. (Student A)

> It details where I've made reflective statements and shows where I can improve as well as add to and fill in aspects to which I have not confirmed. (Student B)

> Prompted me to follow through with the refection to the last step of the process - I had written about my thoughts and feelings, discussed challenges, but had not followed through with reflecting on how this can lead to change…. The reports also direct me to write more personally, using language that evokes emotion, and less descriptively (Student C)

A comment by one student indicated that they saw the potential for AcaWriter to assist them in improving their grade, and even suggested that it should provide a grade (a strategy we have not focused on, instead providing formative feedback):

> This system has allowed me to identify the strengths and weaknesses of my reflection, highlighting on what criteria I have addressed and which ones I haven't. I wish there was feedback on how I could improve to get full marks and wish this reflection gave a mark at the end. (Student D)

No Pharmacy students left clearly negative comments. However, some early use of the software by students from other subjects highlighted a theme in their more negative comments: criticism either at what the software did not do or towards a lack of clarity in what needed to change. These are comments that we have sought to address by creating rule-based actionable feedback statements based on the presence and absence of rhetorical moves. For example "Doesn't elaborate on the features that are lacking and often they appear there but are not recognized. Good way of highlighting other points." (Student E). "it's not clear what needs improving" (Student F) and "comments are not clear enough" (Student G). "I don't understand what [AcaWriter] reproach to my work. It is said that there isn't a good balance but in the text I can't see how… not clear" (Student H).

Thus, while students were generally positive about the tool, this data indicates that they wanted more actionable feedback; subsequent versions have introduced such formative feedback. A later pilot reported similarly positive results (reported in, Lucas, Gibson, et al., 2019), with students indicating on a scale that the tool supported their self-directed learning, was relevant to pharmacy professional practice and enhanced their confidence in their ability to write their submissions.

Impact on writing (reflective writing)

Further analysis of the actionability of the feedback investigated the revisions made between feedback requests to identify how the feedback provided might be influencing the revisions made. Five of the 18 repeat posters appeared to modify drafts, with two of these submitting multiple versions of the same draft text. The remainder (13 users) submitted different reflections for each of their posts, which aligns with the needs of the assignment for which they were working.

With the exception of addition of new information, most draft modifications appeared to improve the quality of the reflection. For example:

> I made sure to be understanding and not force the customer to purchase just for the sake of receiving a sale (ethics, social responsibility).

was changed to:

> Initially I was confused as to why this would be an issue like isn't it exactly the same thing? But for good pharmacy practice, I decided to be understanding and not force the customer to purchase a product just for the sake of receiving a sale (ethics, social responsibility).

The first of these had no sentence tagging, whereas the second was tagged with a pink circle (Challenge). Students also changed their writing to introduce how they felt about a situation. For example, "This situation didn't sit well with me." was changed to "This situation didn't sit well with me, I felt as it these patients didn't receive the best care possible."

6. Discussion and Future Directions

Across the contexts that AcaWriter has been deployed, we have co-designed learning tasks that integrate the tool into meaningful teaching and learning activities to provide formative feedback to students specifically targeting their discipline. The sections above describe these integrations and implementations, and the evidence of impact thus far. There is some evidence of impact – most notably in the law and accounting contexts – which suggests that students who receive feedback from AcaWriter are more likely to improve draft texts and to incorporate rhetorical moves into their writing. Automated writing feedback tools like AcaWriter can thus provide additional writing support to students within and outside the classrooms in ad-hoc ways. However, further work is required to understand how the tool supports learning and how it might be developed further. In particular, impact on writing is assessed by investigating changes in a confined text-revision task (law, accounting) or on a single task (reflection), that in the legal and accounting context was assessed by tutors using their established rubric, rather than a psychometrically validated measure. Further work is also required to understand how learning from a single task and intervention transfers to other contexts (and writing tasks). Other changes, including the incorporation of rhetorical moves, are measured using the automated tool; while such measurement provides useful insight, further work should be conducted to ensure (1) that the moves added are appropriate, and (2) to understand other changes made by students, including the addition of rhetorical structures that may not be automatically detected.

In the HDR context, measurement of improvement is challenging given the distinct nature of each student research project. In this work a measure of how well students could identify and annotate rhetorical moves was piloted, however further work is required to validate this evaluation at larger scales and using a set of test samples that would allow for random selection of items, counterbalancing, and so on. Further work to establish robust tasks and reliable assessment, both of which should be authentic to the classroom context, would strengthen this evaluation.

While the perceived usefulness data indicate positive responses to both the task design and tool, and is supported by a comparison between groups who used the tool and those who did not (in law), there is potential for response bias in the use of such self-report instruments. Finally, although there seems to be a relationship between engagement with the tool and tasks, and subsequent scores, motivation is

a confounding factor in such analysis; students who complete the learning tasks may simply be more motivated to work on their assignments.

Both students and instructors recognize the imperfect nature of the feedback provided, but feedback (within 'perceived usefulness sections') indicates that they nonetheless believe it supports reflection on writing, revision, and attention to important details, including through disagreement with the tool; they thus might be said to 'embrace imperfection' (Kitto et al., 2018). The design approach we adopt supports this iterative work, through supporting stakeholder engagement, and ensuring that use of the tool can align closely with existing good practices to support learning.

In the following, we summarize the impact of the AcaWriter tool, highlighting future directions, and in particular making explicit recommendations for the community.

Recommendation 1: Develop shared corpora for testing writing analytics models

The AcaWriter tool provides formative feedback to students engaged in scholarly analytic and reflective genres of writing. The rhetorical expressions identified by the tool are well established in the literature as communicative acts that are important across a range of scholarly writing. In our development of the AcaWriter tool and underlying parsers, we have evidence that these moves feature in both published academic works (e.g. through analysis of open access corpora of writing), and student writing. Analysis of student writing has included both the British Academic Written English (BAWE) corpus (Nesi et al., 2004) and student writing at our own institution. However, the former consists only of work of relatively high quality, while the latter cannot be made public. Work to investigate relationships between rhetorical features, other features of the text, and outcome variables (notably criterion-referenced grades), is hampered by the lack of established graded corpora of student writing of varying qualities, across established tasks (see recommendations 2 and 4). Sharing such a corpus will foster collaboration in tackling the development of writing analytics to provide formative feedback to students.

Recommendation 2: Develop a set of established shared tasks for evaluating writing analytics interventions

While identifying predictive relationships between text features and outcomes is one significant method for evaluation, a – perhaps clearer – approach is through identifying change associated with direct interventions. Across the implementation contexts described above, there is clear evidence of impact, although further evaluation is required in each case. Implementing and integrating for impact in authentic learning contexts, rather than in lab-based studies, has been a significant contribution of the AcaWriter program of work, demonstrating the potential of co-

design and augmentation of existing practices in tool development. In our discussion, we highlight a number of approaches we have taken to a task-oriented evaluation, including asking students to revise a text that they are provided. These approaches allow ready comparison of conditions, as well as holding a pedagogic benefit in their own right. We thus see significant potential in developing a shared library of such evaluation tasks. Further work is required to evaluate the impact of AcaWriter across deployment contexts and tasks, and to design evaluation tasks appropriate to the learning context, particularly in a country without widespread adoption of standardized college writing assessments (Knight et al., in press).

Recommendation 3: The community should work together to develop shared open-source writing analytics systems, where relations between textual features and feedback can be mapped, and adopted or adapted to particular assessment tasks

The open-source and modular nature of the AcaWriter tool have been a significant asset to us in developing and implementing the tool across contexts. Because of this open-source nature, elements of the AcaWriter suite have been adopted at other institutions, as well as being used in tutorials designed to teach academics – both more and less technical – about the potential of writing analytics, using Jupyter notebooks that display code blocks alongside explanatory rich text and the outputs of the code (Knight et al., 2017; Shibani et al., 2018)[6]. There is significant potential for this approach to develop capacity across institutions, using an extensible and modifiable system. However, the current feature set is limited in scope, largely based on rhetorical moves, and thus work is needed to build a shared library of feature-feedback relationships that can be adopted and adapted for particular assessment tasks and wider learning designs.

Recommendation 4: A shared library of learning designs should be developed to provide patterns for the adoption and adaption of writing tools

Underpinning all of our work has been a learning design approach, in which we have augmented existing successful practices of formative assessment to contextualize the AcaWriter tool to particular assessment tasks by mapping textual features to feedback structures. This has had an impact, and instructors are positive about this approach to integrating writing analytics in practice. To scale this approach to further contexts, we intend to develop a user interface for the middleware component of the AcaWriter system that more readily allows end-users to map features to feedback. However, in doing this, further research on the user experience and learning design concerns of such an approach will be required; the success of implementing AcaWriter is in its integration with learning design.

As already described, we have begun to develop a library of open access (Creative Commons licensed) learning designs, which demonstrate to educators how AcaWriter can be aligned with different kinds of student writing tasks and

assessment criteria. This is how we conceive 'contextualized scalability' (Shibani, Knight, et al., 2019). As with other design pattern approaches, by providing 'templates' for educators to adopt or adapt, we propose that a learning design exchange will help accelerate the rate at which the community can develop and refine effective uses of the tool.

In conclusion, the AcaWriter project has taken a holistic approach to co-designing formative feedback for students, using NLP technologies and learning design to do so. We have detailed how we are assessing the impact of the tool once it is integrated into a well-designed writing activity and aligned with assessment criteria. To move research and impact forward in this space, we derive four key recommendations from our own work, including the need for shared datasets, evaluation tasks, technical approaches, and learning designs.

Acknowledgements

Notes

1. Academic Writing Analytics project: https://cic.uts.edu.au/tools/awa
   Open-source release: https://cic.uts.edu.au/open-source-writing-analytics
   Educator resources: http://heta.io/resources and illustrative Jupyter notebook https://github.com/uts-cic/ALASI2018-WritingAnalyticWorkshop

2. For Athanor technical tutorials, see http://heta.io/online-training-in-rhetorical-parsing

3. At present, this requires work on the underlying code. However, developing a tool that interacts with this middleware layer to support end-users (such as academic staff) to create such mappings is on the AcaWriter roadmap.

4. Higher Education Text Analytics project resources: http://heta.io/resources

5. AcaWriter information portal for university staff and students: https://uts.edu.au/ acawriter

6. See, particularly, https://github.com/uts-cic/ALASI2018-WritingAnalyticWorkshop

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