Contextualizable Learning Analytics Design: A Generic Model and Writing Analytics Evaluations

Antonette Shibani†
University of Technology Sydney
Sydney NSW Australia
antonette.shibani@gmail.com

Simon Knight
University of Technology Sydney
Sydney NSW Australia
simon.knight@uts.edu.au

Simon Buckingham Shum
University of Technology Sydney
Sydney NSW Australia
Simon.BuckinghamShum@uts.edu.au

ABSTRACT

A major promise of learning analytics is that through the collection of large amounts of data we can derive insights from authentic learning environments, and impact many learners at scale. However, the context in which the learning occurs is important for educational innovations to impact student learning. In particular, for student-facing learning analytics systems like feedback tools to work effectively, they have to be integrated with pedagogical approaches and the learning design. This paper proposes a conceptual model to strike a balance between the concepts of generalizable scalable support and contextualized specific support by clarifying key elements that help to contextualize student-facing learning analytics tools. We demonstrate an implementation of the model using a writing analytics example, where the features, feedback and learning activities around the automated writing feedback tool are tuned for the pedagogical context and the assessment regime in hand, by co-designing them with the subject experts. The model can be employed for learning analytics to move from generalized support to meaningful contextualized support for enhancing learning.

CCS CONCEPTS

• Applied computing ~ Computer-assisted instruction

KEYWORDS

contextualizable learning analytics, learning design, conceptual model, CLAD, writing analytics

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1 Introduction

With the growing quantity of data generated from the Internet of Things (IoT) and digitization, there is increasing interest in analytics and big data. In education, high profile initiatives like massive online courses (MOOCS), online video-based learning, educational apps, and personal and portable computing devices, have provided access to increased quantities of learner data [25]. Thus, analytics and big data in education holds the potential to develop scalable methods that can be employed widely across large numbers of students and institutions; to obtain big impact from big data [25]. While data was previously available in educational research, learning analytics holds the promise of providing insight for learning research through the longitudinal collection of data on various levels of granularity from multiple sources in authentic learning environments [28].

However, an inherent problem in the application of such technologies for education is that educational systems are contextual, meaning different factors like educators, instruction, and task design influence learning in its pedagogical setting. Thus, generalized solutions cannot cater to all learning contexts in the same way. For instance, a predictive model trained on data from one discipline may not be generalizable to another discipline if there are contextual factors that affect the model performance. The move from big data to meaningful data is important for learning analytics researchers to improve learning [11; 25]. While general productivity and management tools like writing editors, and LMSs work well in many cases, the context is particularly important for student-facing tools that provide feedback on higher-order constructs of learning. A recognized challenge in the field of learning analytics is the uncertainty around "LA's pedagogical relevance and value-add in contextualized learning and teaching settings across different disciplinary domains" [37].

In an empirical study predicting academic success in a blended learning model, it was found that granular course-specific models provided better insights to the instructors compared to the generic models. This prompted a call for predictive models in learning analytics to account for instructional conditions so that learning analytics does not promote a one-size-fits-all approach [10]. That is, even in in large scale learning environments this connection between Learning Design (LD) and Learning Analytics (LA) has been emphasized as a means for the pedagogical context to enhance our interpretation of analytics into actionable insights

and meaningful interpretations [10]. While theories connecting LA applications with pedagogy are receiving increasing attention, the challenge of developing discipline-specific and contextualized LA systems remains. Most systems are developed to be generalizable and open for wider contexts, and very few learning analytics systems can provide contextualized support [22].

Scalability and contextualization seem to contradict each other in the sense that they prioritize different objectives. This arises from the tension between quantitative approaches that often identify generalizable regularities in learning, and qualitative approaches that tend to understand the particularities tied to specific contexts [42]. When structural relations identified by computational approaches are given more importance than nuanced processes, it leads to the concern of favoring generalizability over contextualization. So how do we strike a balance between these two? This paper will examine the question of how we develop scalable learning analytics applications that can cater to large number of students, while also catering for specific contexts by considering the nuances that make them distinctive. The next section will introduce relationships between learning analytics and learning design, before we introduce a model for identifying four key elements for contextualizing LA for pedagogical contexts. An exemplar implementation is then provided from writing analytics, in which a tool is customized for specific contexts by embedding it in two different learning contexts to meet their respective pedagogical needs.

2 Learning Analytics and Learning Design

Learning analytics promises much more than scaling up using big data, because it is about meaningful data for learning [25]. While much learning analytics work has been conducted with large quantities of data in institutional contexts, for senior management, curriculum designers, and researchers, there is an increasing emphasis on using LA to directly support learners. There have been calls for developing student-facing LA solutions to encourage students towards more sophisticated metacognition about their own learning processes [17].

However, for LA to work effectively, it must be coupled with pedagogical approaches. The contextualization of LA, then, arises from its integration in pedagogical contexts to augment the learning design and provide analytics that are aligned with the intended learning outcomes [20]. This pedagogically driven approach prompts the alignment of learning analytics to learning design towards contextual frameworks that are defined for the pedagogic intent of analytics applications, such that learning analytics can provide the necessary data, methodologies and tools to test the assumptions of the learning design [23]. An understanding of the pedagogical contexts enhance our interpretation of analytics into actionable insights and meaningful interpretations [10]. This learning design approach addresses a known concern that even high-quality technologies may not be used by students if they are not embedded in the curriculum. A clearly defined learning design helps students use the tools to add value to their learning by closing the gap between the potential and actual use of technologies [35].

Learning analytics pedagogic intervention designs have been proposed for integrating LA technologies as part of a larger educational context [41]. This way, Learning Analytics can focus on 'augmenting', rather than revolutionizing existing high quality pedagogy by enhancing classroom practices [20]. By finding new methods to solve existing pedagogical issues, LA can contribute to existing good practices by improving them with insights and technical affordances, rather than analytics remaining separated from current classroom teaching and learning practices. Considering classroom-level constraints, and orchestrating LA to suit them can better aid the adoption of LA technologies [27].

To aid this LA-LD alignment, Bakharia et al, proposed a conceptual framework linking learning analytics to learning design. In this framework, the teacher plays a central role by bringing context to the analysis, making decisions on the feedback to be provided to students and in the adaptation of learning design [5]. Similarly, Alhadad and Thompson [2] propose the mediation of effective teacher inquiry processes, enhancing opportunities for genuinely evidence-informed practice by avoiding the oversimplification of learning enhancement to a data-driven process. Despite the importance of aligning LA and LD, few empirical studies demonstrate how this alignment happens in practice across pedagogical settings. A detailed systematic review of 43 studies in the current landscape connecting LA and LD can be found in [24]. Based on this review, Mangaroska and Giannakos suggest that a framework should be developed to capture and systematize learning design grounded in learning analytics, and study how learning design choices influence learning and performance over time. They also emphasize the need for educators to design for learning by making use of LA affordances as opposed to being providers of knowledge only.

An example system providing an instructor's personalized support to students at scale was E2Coach, which provided encouragement, guidance and advice to students through unique personalized web pages based on gathered student information [16]. A similar personalized feedback from the instructor was also enabled by the OnTask tool, where the instructor can define rules based on student engagement in activities to provide personalized feedback messages [22]. However, these systems provided personalized support at an operational level, and do not address details of the course content. There are few LA tools that offer contextualized support by adapting to different pedagogical settings. It is to be noted that this kind of contextualization for pedagogical settings is different from the personalization and adaptation of systems and visualizations for individual users in adaptive environments by individual user data modelling [26; 44]. The contextualization defined in our case is at the course or subject level set up by an instructor for their pedagogical contexts.

3 Conceptual model for Contextualizable Learning Analytics Design (CLAD)

The lack of explicit pedagogical theory is a challenge in the field of Learning Analytics, which can limit the potential of LA approaches and cause misaligned practice [21]. To contribute to the theory of contextualized LA and to further support theory-

guided practice, we propose a conceptual model that brings together elements of LA and LD for contextualized support for learners. Knight, Buckingham Shum, and Littleton [18] argue that the way we deploy learning analytics as forms of assessment implies particular epistemological and pedagogic assumptions. In this view, how we understand learning or 'success' is fundamentally bound up with the learning context and intended learning outcomes. Thus, learning analytics under a 'pragmatic maxim' bases the quality of analytics on its practical consequence on learning, asserting the need for contextualization of LA in a learning context [12]. Taking this perspective, we define a conceptual model for learning analytics to align with pedagogical contexts. The conceptual model builds on existing work connecting LA and LD to provide a usable model for learning analytics researchers and practitioners for implementing contextualizable learning analytics applications in their pedagogic contexts.

Contextualizable Learning Analytics in our paper is defined as "*the pairing of learning analytics and learning design that can be flexibly adapted for different learning contexts*". The core of the concept stems from the link between two types of components: *Learning Analytics* (LA) and *Learning Design* (LD), which mutually drive each other during the course of contextualization (Figure 2). LA here includes the tools and technologies to be contextualized, and LD denotes the teaching and learning context whose pedagogical intention is the context in hand. These key components come from existing work on aligning LA and LD so that the pedagogic intent of analytics applications can be maintained, interpretation of analytics enhanced, and the assumptions of the learning design tested using data and tools provided from learning analytics [10; 23; 35].

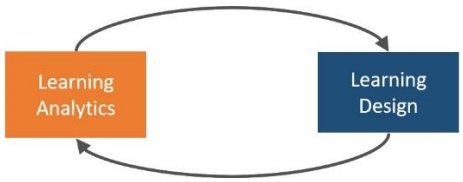


Figure 1: Link between Learning Analytics and Learning Design in Contextualization

To unpack how these components can work together in practice, we introduce a conceptual model for Contextualizable Learning Analytics Design (CLAD) (see Figure 2). The model includes elements for contextualizing learning analytics to different learning settings. Educators who are the subject experts in the context drive the contextualization process in the model. As identified by previous work, educators play a key role in contextualizing LD and teacher-inquiry processes are critical to authentically embed LA in practice [2; 5]. But in addition to the educators, the model also includes other stakeholders like LA designers who work hand in hand with the educators for effective contextualization. This communication among stakeholders bridges the knowledge gaps about the potential and trade-offs of LA innovations and manages expectations among the different stakeholders [27; 38]. The productive dialogue between stakeholders in interdisciplinary teams facilitates an improved understanding of the potentials and pitfalls of analytics, which can lead to pedagogic impact and increased adoption [38].

The model proposes four main elements represented as gear cogs in Figure 2 for contextualizing learning analytics design, so that LA can be coherently integrated in authentic classroom settings. The learning design (dark blue) brings the educators to contextualize learning analytics through the key elements of *Assessment* and *Task Design*. The key elements of learning analytics (orange) are *Features* and *Feedback and User Interface* (UI), developed by LA designers which are adapted for the LD. *Features* refers to those attributes in the data that are considered significant enough to identify, and bring to the user's attention via the *Feedback/UI*. These LD and LA elements should synchronously align in particular contexts to support that learning, rather than being rigidly fixed. When used effectively, LA plays a supporting role in LD. When used ineffectively, the two mechanisms are either not fully engaged, or are driving in opposite directions, with LA resisting the LD, or vice-versa.

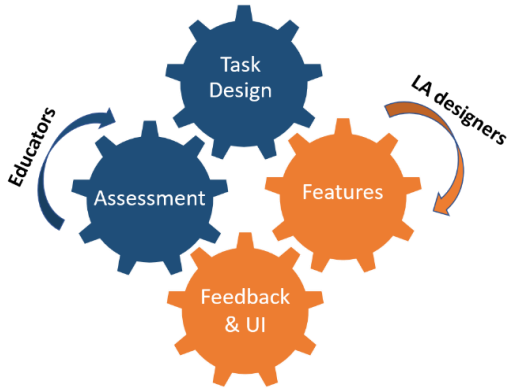


Figure 2: Conceptual model for Contextualizable Learning Analytics Design (CLAD)

Assessment plays a key role in contextualization, since it should align with the intended learning outcomes of the curriculum [6], without which the learning analytics would remain distant from the pedagogy. This is important because the uptake of LA by learners and educators depends on how well its usage is mapped to their curriculum and adds value. The *task design* ensures that the LA is relevant to the learner and is grounded by pedagogic theory [35; 41]. The construction of complex learning activities that make use of analytics to encourage further metacognition requires pedagogical expertise. Such effective implementation of LA can be supported by LD [17]. For LA to align to LD, *features* of the LA system should be adaptable to the learning context to provide useful analytics. That is, the *features* should be pedagogically salient, and not simply technical representations of low-level trace data. This modeling might require changes to the underlying technical infrastructure for introducing new features identified as a requirement for the context, or the possibility to amend existing features in order to address the LD context. The *feedback and the User Interface (UI)* that the learner ultimately interacts with also should be

contextualized for the pedagogical context, so that the relevance and usage of the technology for the context is well understood.

In addition to being tuned for the LD, LA also shapes LD. The elements of LA contribute to the LD in two ways. First, LA and the data it is based in create technical affordances for the LD. Second, LA can challenge the theoretical underpinnings of the originally designed learning activities. LA and its intervention design can help learning designers with improving the alignment of: learning tasks, *assessment* criteria, and LA data for reflective purposes; bringing these into 'constructive alignment' towards the learning outcomes [6].

The CLAD model accentuates the concept of malleable LA and LD, where the contextualization elements shape and drive each other to align in the pedagogical context. This process of developing contextualizable Learning analytics by aligning the elements of LA and LD can help spot issues and requirements to make them flexible enough to improve each other when desirable. Such alignment draws on the notion of flexibility in scripts for computer-mediated interactions so that the strict design choice does not affect the dynamics or over-constrain the pedagogic setting [9; 20]. The model emphasizes an equal contribution of LA and LD for contextualization, so that they do not crowd out each other with more weight given to one over the other. This task-oriented approach is granularized enough to study how students are using LA to study its effectiveness, in contrast to other work which focuses on LD-LA alignment at an overall course level [10].

The contextualizable LA design model may be applied both top down and bottom up. First, top down, large scale generalized LA can apply CLAD to provide support for particular learning contexts. In this way, mature LA tools that are proven to work in general settings can implement CLAD to add specificity to particular LDs, to provide contextualized support. Second, bottom up existing LA for specific learning contexts can be scaled up to other learning contexts. This transfer of design across learning contexts can be enabled by the use of abstractions like 'design patterns' that can share the general principles of task design and purpose including theoretical foundations and the practical implementation of designs for educators [13].

The following sections will discuss how CLAD was employed using a writing analytics tool in two case studies, and how we can evaluate implementations in this context. We claim that the model can be instantiated to provide contextualized support for different learning contexts and illustrate how the elements of LA and LD mutually shape each other in this process. We also claim that the transfer of contextualizable LA design works and students find it valuable by providing empirical evidence for evaluation.

4 Implementing the model

4.1 Writing analytics

Writing is a key skill in academic and professional settings, which students find challenging to learn. Writing Analytics (WA) can be thought of as a sub-domain of learning analytics that uses analytic techniques to develop a deeper understanding of writing in educational contexts [7]. It uses computational and natural language processing (NLP) techniques to study the written products and processes involved in the creation of the product, and to develop tools providing automated feedback or grading on writing. By providing a background of work done in this area, we illustrate how our writing analytics tool is distinctively designed for contextualization.

Although Writing Analytics is a relatively new term, research studying writing by using computational techniques has a long history. For example, the Coh-Metrix tool analyzes texts automatically and provides 200+ measures to evaluate texts based on cohesion, language and readability [15]. Using Coh-Metrix, a number of studies have identified linguistic indices of text that correlate to high- and low-quality text ratings graded by experts. Similarly, Automated Essay Scoring (AES) systems used machine learning models trained with a large number of graded texts to predict the scores of student essays in standardized writing tests, and/or used benchmarked essays for a topic which were then used to compare and grade student essays using Latent Semantic Analysis with high reliability [30; 32].

To further provide adaptive and interactive support for learning, Intelligent Tutoring Systems (ITS) were developed to engage students in an open dialogue with an automated tutor by modelling user behavior and competencies [44]. An intelligent tutor called Writing-Pal was designed to teach writing skills to high school students providing strategy instruction, modularity, extended practice, and formative feedback using game-based and essay-writing practice [29]. A range of computer-based writing instruction tools now exists to support students in their writing learning (see review, [3]). For essay-based feedback and practice in Writing-Pal, students wrote timed persuasive essays using SAT prompts which were assessed and provided feedback based on linguistic text features. This kind of practice using pre-defined prompts or topics for providing feedback is also used in a tool called Essay Critic [4]. These are however defined for specific contexts, which inhibit their applicability to domains other than the ones they're tested for. For scaling up the usage of such tools to other learning contexts, they need to be recreated for the other domain leading to increased costs.

On the other hand, there are tools that provide generalized feedback to students based on text features in the writing including OpenEssayist [40] and Glosser [39]. This kind of generalized feedback point to students the key features and concepts in their writing for reflection but stay isolated from the pedagogical contexts. The feedback might lead to changes in their writing at surface level but might not engage students in a deeper learning for the subject. Some specialized tools use machine learning techniques to provide data-driven contextualization by making use of large text corpora with millions of examples. This includes Turnitin Revision Assistant that has a generalized set of features which are mapped to rubric elements of specific prompts to provide feedback on essays written for the prompt [43], and Research Writing Tutor which provides discipline-specific feedback by mapping the structure of other research articles from the discipline [8]. But this approach of data-driven contextualization will not work in teaching and learning contexts where there is only limited data, which is the case in most classroom contexts. Further, it does not utilize the teacher or

subject expert's pedagogic knowledge which is valuable to provide context in authentic learning settings.

Writing analytics tools can provide timely, formative feedback at scale for learners to engage with their drafts and develop their proficiency in writing. But as argued earlier in the introduction, these tools should be contextualized for and embedded in learning contexts to provide deeper reflection at the subject level. The proposed conceptual framework will be applicable for contextualizable LA design using the two approaches discussed earlier: an existing generalized WA tool to be contextualized for specific learning contexts, and an existing WA tool for a specific learning context to be scaled up to other learning contexts. We will demonstrate how both these types of contextualization were performed with our example tool *AcaWriter*.

4.2 Implementing AcaWriter

AcaWriter is a web-based tool that provides formative feedback on rhetorical moves in writing, now released under an open license[1]. AcaWriter uses a Natural Language Processing (NLP) parser, that can identify patterns of language to interpret rhetorical moves held within a modular Text Analysis Pipeline. A rhetorical move is "a discoursal or rhetorical unit that performs a coherent communicative function in a written or spoken discourse" [36]. The parser identifies rhetorically salient sentences using NLP rules based on the concept matching discourse analysis framework [31]. It does this using syntactic relationships between words, broadly by extracting a list of constituent concepts from the text, assigning the constituent concepts to a list of words or phrases with a particular function, and mapping these to defined rhetorical function (see [31] for details). The key rhetorical moves that AcaWriter can detect in academic texts are shown in Table 1, while Figure 4 shows highlighted moves identified in a sample text.

Table 1: Rhetorical moves identified by AcaWriter

Move	Description
Summary	**S**ummarizing the text's aim, goals and conclusions
Background (B)	Referring to **B**ackground or prior work done in the area
Contrast (C)	Pointing to **C**ontrasting ideas, issues and disagreements
Emphasis (E)	**E**mphasizing and ringing attention to important ideas in the text
Perspective (P)	**P**erspective or Stance from a piece of work
Novelty (N)	Mentioning **N**ovel and innovative ideas
Question (Q)	Highlighting an open **Q**uestion or insufficient knowledge in the area
Surprise (S)	Pointing to **S**urprising facts or unexpected findings
Trend (T)	Recognizing **T**rends in research and drifts over time

[1] https://utscic.edu.au/open-source-writing-analytics/

The typology of rhetorical moves has been developed based on recurrent discourse patterns from peer-reviewed journal articles from various fields. These rhetorical moves can be used to provide generalized feedback to all analytical writing, which include concepts and arguments supported by pieces of information. However, there are certain rhetorical moves that are more significant than others for some contexts, including pedagogic contexts that have particular learning foci; which will be illustrated in our examples later. It is in identifying these contexts that an expert's subject knowledge provides contextualized support for the LA design.

Because of the importance of this contextualization, students are rarely directed to use the tool without further support, instead being asked to use it in the context of a wider learning design. Thus, AcaWriter contextualization is implemented at the subject level and can be drilled further to assignment levels to provide contextualized automated feedback on writing. This is done by LA designers working as a team with instructors and subject experts for the context to align analytics from the open source tool with the learning design. Elements of the proposed conceptual model that are involved in such contextualization for subjects are illustrated in detail in the following sections. They explain how the different learning contexts shape the use of the tool in different contexts.

4.3 Context 1 – Law essay writing

Analytical Writing is a key disciplinary skill for law students as they are required to effectively argue their position and clearly communicate their ideas in legal practice. In the subject Civil Practice taught for undergraduate law students in our university, students are expected to write academic essays that discuss an assigned topic, clearly outlining the legal arguments with appropriate referencing to prior cases. They should provide their perspective on the issue in formal academic writing format making it clear and engaging. While the students admitted to the degree generally tended to have strong writing skills, they were also found to overrate their writing skills and unable to assess their own work meaningfully using the assessment criteria [19]. To help students self-assess their essays based on the assessment criteria and write better essays for this subject, AcaWriter was contextualized for the subject. This is the type of contextualization where we contextualize an existing generalized LA tool to cater for a specific learning context using elements proposed in the conceptual model.

4.3.1 CLAD elements implemented in context 1. The first step to contextualize AcaWriter for this learning context was to start with the *assessment*. Rubric elements from the assessment criteria were mapped to AcaWriter's rhetorical moves to ensure that the LA tool feedback is congruent to the assessment regime. This led to identification of *features* that were useful for the context at the tool level, while also feeding back to the LD where the assessment criteria needed to be better defined to capture the intended learning outcomes, so LA and LD both shaped each other in this process. The features for the LA tool might also need to be freshly

created for the learning context if desired, or tuned at the system architecture level to modify existing features for the context as demonstrated in an earlier example [19]. Sample sentences of this mapping of rhetorical moves to elements of the assessment criteria provided to students as examples in AcaWriter are in Figure 3.

Sample Sentence	Essay Assessment Rubric Element	AcaWriter Move
The concept of good faith **has previously been thought** to be a work in progress in Australia.	Engagement with the law and scholarly literature	Background
This article will trace the origins of good faith and its development in the common law. **This essay contains three parts. The first part will talk about** the origins of good faith.	Statement of thesis, Essay plan	Summary
However, where the obligations are found in statute and they conflict with contractual obligations, **it is important to note that** the former must prevail.	Identification of relevant issues, Critical analysis and original insight	Contrast,Emphasis

Figure 3: Assessment criteria from the law essay writing context mapped to rhetorical moves from AcaWriter

In this learning context, the analytical report highlighted all the rhetorical moves identified in the students' text (Figure 4), and the feedback messages prompted reflection for students to focus on the key moves that should ideally be present in their writing. Based on the alignment to assessment, *feedback* from AcaWriter was tuned for the context to provide feedback messages on missing key rhetorical moves, and suggesting sample phrases to use as shown in Figure 5. While these samples were provided as exemplars from which students can learn how to express the important points in their essay better, it was by no means a concrete rule that prompted a fixed style of writing for all students. There are many ways which in which the moves could be expressed and students were explicitly prompted in the feedback to use their human judgement when it comes to evaluating the automated feedback and structuring their own writing.

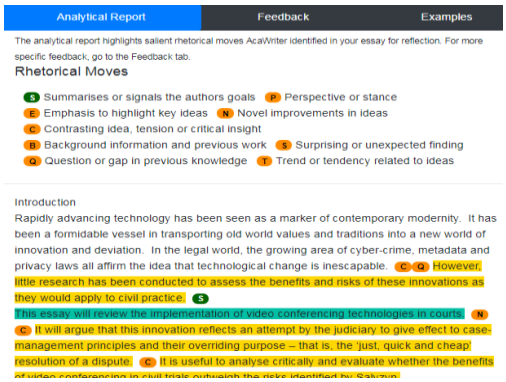


Figure 4: Report highlighting rhetorical moves automatically identified by AcaWriter

To introduce the AcaWriter tool to students in a way that they can make sense of it in its pedagogical context, a *task design* was developed to coherently integrate the LA tool into the curriculum. A stable version of the design was developed using a few iterations over the semesters, applying a design-based research approach. This task was implemented as a pedagogic intervention that included a number of online and in-class tasks for students to write better essays for the subject and use AcaWriter to get feedback on their drafts. All of these elements were co-designed by LA researchers with the instructors who were the subject experts familiar with the learning contexts working directly with students.

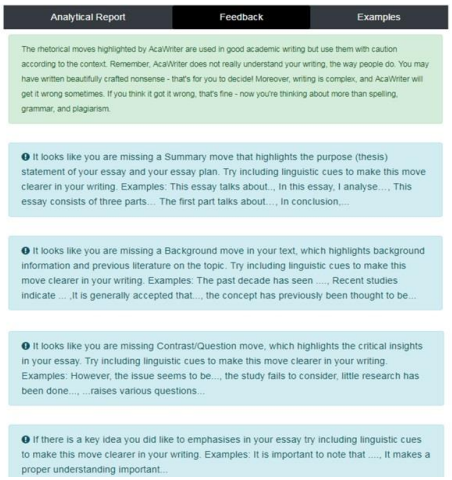


Figure 5: Feedback messages from AcaWriter tuned for the law essay writing context

The writing intervention developed for students in the Civil Practice subject cohort was a one-time activity that was facilitated in class in a tutorial session in authentic settings. Students were divided into two groups for us to evaluate the use of contextualized tool in this scenario: AcaWriter feedback group, No feedback group. The design of the task is shown in Figure 6. First, an induction was provided to the task using an introductory reading or video which was created by the instructor to explain the goals of the activity. Then students logged in to an online platform which facilitates the writing tasks online, and collects activity data [34]. The first task was a matching exercise where students were asked to identify sample sentences from an essay that would match elements of the instructor's marking rubric so they have a better understanding of the rubric facets in the assessment criteria by learning from exemplars. In the next task, students were provided with a sample improved essay pdf where the instructor highlights what changes can be made to the text and rhetorical moves can be added to improve the structure and clarity of the essay and its concepts. Then students had to assess the given sample essay by applying the assessment criteria, to enhance their ability to self-regulate their work by practicing the skill of self-assessment.

The main task followed next, where students were asked to revise this given essay which they assessed earlier, to improve its quality. For this activity, students in the AcaWriter feedback group used AcaWriter to receive automated feedback to revise and improve the given essay, while students in the No feedback group did not get access to AcaWriter and revised the essay based on the guidance provided in the previous tasks only. Then

students had a discussion with their peers on the changes they made on their improved essay and provided further feedback. Peer feedback has been seen to be effective in writing instruction since students learn from each other, and by providing feedback they become better judges of their own work. For groups receiving automated feedback for revision, this peer feedback provided additional contextual feedback and sense-making to interpret and augment the feedback from AcaWriter [33]. Except for this revision task where the AcaWriter feedback group students were provided additional access to AcaWriter feedback, the two groups were involved in the same activities for comparing their effectiveness. Finally, students completed the feedback survey where they answered questions on the usefulness of the intervention. For future use of AcaWriter for their own draft essays, a guide was provided. An earlier iteration explains rationale behind the tasks designed, and preliminary results (see [35] for details). In that intervention however, students only received a generalized analytical report with the identified rhetorical moves highlighted in the text with no contextualized feedback.

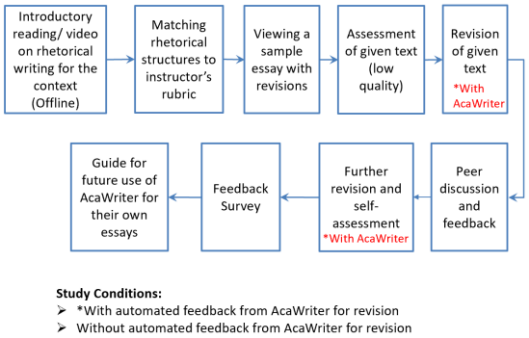


Figure 6: Writing task design for law context

4.3.2 Evaluation. To evaluate this approach and the use of LA tool to provide contextualized support for learners, the pedagogic intervention was implemented in authentic classroom settings. Students who participated in the activity were asked to answer survey questions on how useful the activity was for them to improve their essay writing on a scale of 1 (not useful at all) to 5 (very useful) and explain why they thought so. The results discussed next are based on responses from 90 students who completed all parts of the activity in this learning context and did not face technical issues. This cleaned data included 44 from the no feedback group and 46 from the AcaWriter feedback group.

The mean perceived usefulness score for students who received AcaWriter feedback (M=3.67, SD=0.79) was higher than those who did not receive AcaWriter feedback (M=2.95, SD=0.96) during the revision task (see Figure 9). The effect of AcaWriter feedback in the activity was found to be significant, $t(83) = 3.9$, $p = 0.0002$. This result was in contrast to results from the earlier intervention with generalized feedback, where no significant difference was found between the control groups [35]. While there are different elements that play a role in the contextualization, the contextualized application of the LA tool by tuning the feedback seems to have an impact on students' perception of the activity due to its direct interaction with the students.

Students from the AcaWriter feedback group also introduced a higher number of rhetorical moves (M=3.67, SD=2.83) than students from the no feedback group (M=1.14, SD=1.02) in their improved essays. The effect of AcaWriter feedback here was significant with $t(57) = 5.7$ and $p < 0.0001$. This shows that using the automated feedback from AcaWriter helped students produce better improved essays by making use of rhetorical moves mapped to their assessment criteria. Qualitative responses from students also showed that many students found the activity useful to learn skills that can help them self-assess and improve their writing by making them self-aware of their writing.

"When you're editing your own writing, you automatically think that your work sounds good and that all your ideas and views have been clearly conveyed. This exercise was useful in the sense that it indicated areas where I needed to be more explicit, which on my own I would not have noticed."

"allowed me to understand how to clear up writing style and language in providing a more succinct and cohesive argument, especially in the introduction, which reverberates throughout the essay in aiding structure and clarity of argument"

"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."

"Made me think about the structure of an essay more and how to make the essay more persuasive."

There was also some skepticism regarding the extent to which artificial intelligence can help in a nuanced language understanding problem, especially when the right terms are not explicitly used in the writing.

"A good reminder of important elements of essay writing. However, I am not sure how useful AcaWriter actually is other than providing some general feedback."

"It made me think about the importance of having clear writing with a clear stance and structure. The technology helped somewhat with this, but I found it was limited to recognised extremely plain language. Language which was more complex but accomplished the same thing was not picked up on."

The writing task embedded the learning analytics tool in the curriculum, by closely aligning it to the learning design. It helped students understand the usage of rhetorical moves, and the usage of AcaWriter feedback to write better essays for their subject and improve their writing skills. AcaWriter capabilities are seen to augment the design with better results, suggesting the appropriateness of large-scale deployment of the tool for all students in future implementations. However, since the activity is embedded in the learning context, the technological tools are an addition to the design, even without which the pedagogical design of the writing activity stays sound. The design of this task is also significantly influenced by the instructors, so parts of the design

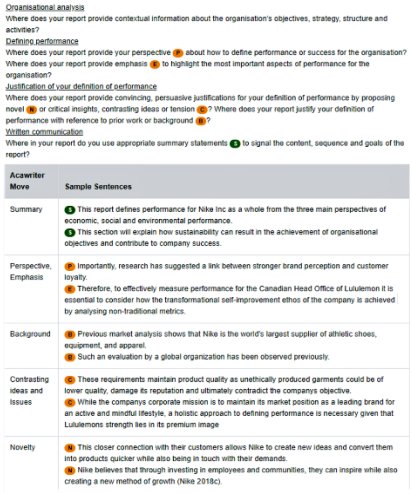
can be modified easily to suit their needs. A later iteration of this design for Civil Practice law students has been recently implemented as a completely online, individual homework activity, with all students (without control groups) getting to use the AcaWriter tool. The design can also be transferred to other disciplines my making use of shared design patterns, which we will explain in the next learning context. It evaluates the CLAD model by transferring an existing tool for a specific learning context to other learning contexts to provide context.

4.4 Context 2 – Business report writing:

Learning context 2 provides an example of transferring a design that worked well in one context to another, using the CLAD contextualization elements. The new pedagogic context here is an Accounting subject, where students are required to write business reports as part of an assignment. While accountants mainly deal with numbers, they also have to create and communicate information to aid decision-making, and their main form of communication is a business report. Some key rhetorical moves were identified as important constituents in good business reports by instructors, which could be taught with the help of AcaWriter. The pedagogical activity design from the law essay context discussed earlier was held as a baseline with few design elements tuned for contextualizing it to this business report writing context.

4.4.1 CLAD elements implemented in context 2. Here AcaWriter rhetorical moves were first mapped to rubric elements of the business report's assessment criteria. From this mapping, several AcaWriter features were identified as important for the context which shaped the tool feedback and made the assessment criteria more robust. The assessment criteria for the report's content mapped to AcaWriter rhetorical moves are shown with examples in Figure 7. Only the relevant rhetorical moves were highlighted in the analytical report in this context, and similar to the law context, the feedback messages were tuned in AcaWriter based on the missing key moves for this context.

To design the pedagogically grounded learning activity, design patterns from the existing law design were transferred to this context. The learning design spread over several weeks co-designed with the instructors is shown in Figure 8. The core of the writing activity involving introduction to rhetorical moves and AcaWriter, self-assessment and revision tasks remained the same, with few modifications done for the context. The online writing activity was designed for Week 1 as a homework activity, so students can learn from past examples and practice revision on the given sample writing in their own time. In week 2, they continue this writing activity in class with peer discussion, where students can interpret, clarify, and learn from each other. In the following weeks, students use AcaWriter for their own draft reports which they submit for assessment. The design hence involves both a practice with given samples on AcaWriter to learn writing skills, and its application for their own written reports. All students completed the same writing activity with access to AcaWriter, as no variable study conditions were defined.



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 7: Assessment criteria mapped to AcaWriter moves in accounting context

Figure 8: Writing task design integrating AcaWriter for accounting

4.4.2 Evaluation. To evaluate how the transfer of pedagogic intervention with AcaWriter worked in a different learning context, student responses for the survey questions were analyzed from the online task. Data from 302 students who completed the activity showed that students generally perceived the task to be useful to improve their report writing (M= 3.8, SD=0.9), with 66% of students selecting 4 or 5 (highest) in relation to the perceived usefulness score. The results are shown in Figure 9 along with results from the previous law learning context.

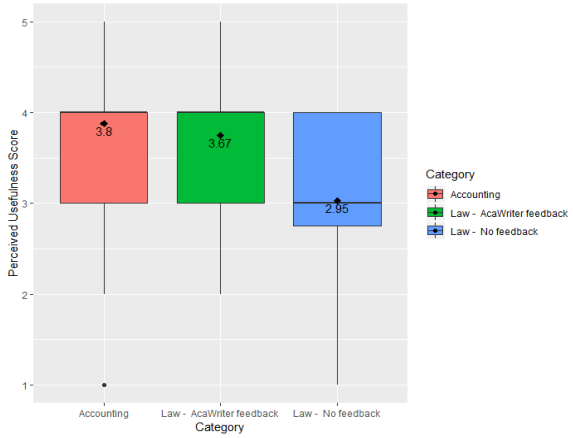


Figure 9: Students' perceived usefulness of the intervention across learning contexts and feedback conditions

Further qualitative responses showed that many students found the activity and AcaWriter useful to improve their writing, while few others believing that human feedback would be more effective compared to the automated feedback.

"By doing this exercise, it shows me a clear idea on how we could approach in 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."

"It's like having a tutor or another person check and give constructive feedback on your work."

"I have always been quite good at writing i think, however, i never approached it in this way and i have found it quite helpful."

"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."

"I believe this exercise may be of better use to some than others, and that it offers good information that could be of use, for me personally, the program would need to be able to help me to better understand what I'm doing incorrectly than correctly, and as such, I believe that a human reading through it is still more effective in that regard."

Overall, the intervention contextualized for the subject was found to be helpful for students to improve their writing skills, with the transfer of design patterns successfully implemented and tested. However, the impact of this activity on the writing of their own needs to be studied to see if students apply the skills they learnt from the activities onto their own writing to reap long term benefits.

5. Discussion and conclusion

This paper proposes a *Contextualizable Learning Analytics Design* (CLAD) model for developing learning analytics at scale that are aligned with the learning design. The contextualization elements of the model include learning design aspects (assessment and task design), and learning analytics aspects (features and feedback of the tool). The model highlights the possible dynamics that can arise: the cogs metaphor was chosen since these elements can be synchronized or desynchronized, and engaged or disengaged. The adaptation of LA technologies provides technological affordances like automated feedback, that can be contextualized to provide relevant feedback, and the implementation of the intervention informs LA research and the learning design. The model was demonstrated and evaluated using pragmatic implementations and transfer in two different authentic learning contexts using the student-facing writing analytics tool AcaWriter. Subject matter experts and instructors who teach the subject to students played a major role in co-designing elements of the contextualization, so that the LA augmented existing good practices in the LD.

The results of the empirical studies show that students found the activities and feedback useful to improve their subject-related writing skills. Long term studies still need to be conducted to evaluate the impact on writing improvements over time. We found an increased understanding and perceived usefulness in students' perceptions of the intervention and automated feedback, when compared to findings from an earlier version of the AcaWriter tool which provided only generalized feedback. The contextualization of different elements, particularly tuning the writing analytics tool to fit the context, seemed to have an impact on student perceptions and uptake of the application. We attribute this to the closer meshing of the 'cogs' — the alignment between learning analytics and learning design fosters pedagogically grounded activities for students, which do not alienate LA systems from their subject contexts. More work needs to be done to explore the instructor/subject expert's perspectives on how the contextualization was implemented and conceived from their end.

Our findings add weight to the argument that Learning Analytics applications are more useful once educators can contextualize them to particular learning contexts. Features, feedback and the user interface change users' interaction with tools. A design implication is that these should be designed to be configurable: we need systems that are malleable to the needs of the educator, considering the learning goals. The model thus intends to help learning analytics designers contextualize student-facing tools for learners. It encourages developers of LA tools to keep their systems more flexible and design tunable elements for different contexts by instructors, even if their source code is not open-access. This work also helps to identify where poor practice exists, for instance an inappropriate use of analytics, or a misalignment of assessment and learning outcomes. Providing a level of control for educators also ensures transparency around the systems, so that the models do not act as a black box for human interpretation. This is in line with the ethical discussions around machine learning to cater for an interaction with AI and human intelligence for trustworthiness of AI [14]. Increasing malleability, and reducing opacity, have implications for the architecture of software systems, the skillsets of analytics team, and how they are introduced to learning contexts.

The co-design methodology also implies that both sides of LA and LD should be configurable. From the educator's side, this requires willingness to change their task design and assessment if required to provide meaningful LA. The synchronized application of the contextualization elements at the LA and LD levels will provide effective contextualized LA design. The dialogue provides agency to the educators who bring in the learning context to LA technologies by providing orchestration to the educators, and would improve adoption of LA [2; 27; 38], but does require more work on standardizing communication around the stakeholders. Future work in the AcaWriter tool for scaling up contextualization could involve more instructor-centered interfaces which allow instructors to create their own rules to provide relevant feedback. This method of giving the power to the educators can help scale up to a greater number of contexts, but also raises issues about the capability and data literacy of the educators to do complex thinking around such systems, which should be thought through.

Although the initial set up required for such contextualizable learning analytics designs might be slow, it works over time for relevant application of LA in many different learning contexts. In our example, the cost involved in contextualizing the learning analytics design in the first law context was high due to the effort

required in the co-design process with the instructor. However, when the design was stabilized with resources, it was easier to be transferred to the new accounting context. A third context where AcaWriter was tuned to cater to research student writing also exists (see [1] for details). This way of catering for the context ensures that LA contributes to the learning in authentic practice for pragmatic real-life usage. It introduces a potential path for mature learning analytics systems to be deployed in contexts other than the ones they were originally developed for, to still fit in the context. The use of design patterns can help transfer existing good designs to other learning contexts without reinventing the wheel. Future work around contextualization may find further levels and elements for contextualizing LA in other authentic learning scenarios.

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