Genre Analysis and the Automated Extraction of Arguments from Student Essays

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Abstract

A full understanding of text is out of reach of current human language technology. However, a shallow Natural Language Processing (NLP) approach can be used to provide automated help in the assessment of essays: our approach uses genre, cue phrases and a set of patterns. Cue phrases, with their associated semantics, are used in conjunction with patterns to identify categories of argumentation partly derived from research in metadiscourse in the academic paper genre.

In this paper, we describe an approach for automated extraction of arguments from student essays as a basis for their assessment in a formative as well as a summative sense. We introduce our own essay argumentation schema and show how we arrived at this categorisation. We also introduce “student essay viewer”, a tool that allows tutors and students to visualise argumentation in a student essay and may therefore be useful in aiding assessment and providing feedback to students.

Introduction

Extraction of arguments from documents is an interesting problem in natural language research and it has many potential applications, ranging from text classification and document summarisation to the semantic web. For instance, document summarisation could improve the performance of search engines dramatically: by allowing searching the summary of a document (rather than its full text), it would enable focusing on relevant documents and skipping the irrelevant information currently obtained by keyword-based search engines.

Previous research into identification of arguments in research papers has relied on a conceptualisation of academic paper structure. These approaches typically expect a paper to contain an introduction and a results section and employ some heuristics to identify relevant parts of a research paper, such as paper contributions and background knowledge. However, our student essays domain is presenting us with a somewhat different challenge. In fact, while containing background and approach comparisons, student essays usually do not contain original contributions to knowledge. More importantly, their structure is less predictable than that of an

academic paper and cannot therefore be totally relied upon in devising a strategy for argument extraction.

In this paper, we present a categorisation suitable for student essays. We also present the “student essay viewer”, a prototype tool for the extraction of arguments from student essays. We claim that a visualisation of the arguments presented in student essays could benefit both tutors and students. On the one hand, it would enable time-constrained tutors to easily locate the most “interesting” (argumentation-rich) parts of student essays, allowing them to determine if the essay covers the required “points” and probably spot correlations between highlighted parts. On the other hand, such a visualisation could help students “see” if their essay contains enough of the expected type of argumentation.

The main contribution of this paper is the categorisation for student essays. We analysed several essays looking for clues of important argumentation and thus derived our “first-stab” categorisation. We then reviewed this categorisation and compared it to several annotation schemes for academic research papers. The following rationalisation step (with the re-grouping or renaming of some categories) resulted in our final categorisation. Because it focuses on student essays, our categorisation omits categories that are not applicable to this domain. More details on our categorisation can be found in section 1.

The paper is organised as follows: section 1 discusses the research background on argumentation schemas in papers and argument modelling. It then introduces our own essay metadiscourse categorisation in the context of the reviewed background. Section 2 reports on our attempts at using existing annotation tools in our domain. Section 3 describes our proposed solution, illustrating the student essay viewer and its main characteristics. Section 4 analyses its potential role in assessment. Section 5 reports preliminary results and indicates future work. Finally, section 6 presents our conclusions.

1. Argument Modelling in Papers

Relevant research background spans from articles on argumentation in research papers to knowledge representation tools supporting the construction of rhetorical arguments.

An important strand of research has focused on paper structure, producing metadiscourse taxonomies applicable to research papers. In his CARS model (Table 1), Swales (Swales, 1990) synthesised his findings that papers present three moves: authors first establish a territory, then a niche and finally they occupy this niche. Although his analysis targeted only the introductory part of an academic research paper, his model has nevertheless been influential.

Table 1 - Swales's CARS model

Move 1: Establishing a Territory		
Step 1	Claiming Centrality	*Recently, there has been wide interest in…*
Step 2	Making Topic Generalisations	*A standard procedure for assessing has been…*
Step 3	Reviewing Items of Previous Research	Verbs like *show, demonstrate, establish*
Move 2: Establishing a Niche		
Step 1a	Counter-claiming	Negative or quasi negative quantifiers (*no, little*); Lexical negation (verbs like *fail* or *lack*, adjectives like *misleading*); negation in the verb phrase, questions, expressed needs/desires/interests (*The differences need to be analysed*), logical conclusions, contrastive comments and problem-raising
Step 1b	Indicating a gap	
Step 1c	Question-raising	
Step 1d	Continuing a tradition	
Move 3: Occupying a Niche		
Step 1a	Outlining purposes	*This, the present, we, reported, here, now, I, herein*
Step 1b	Announcing present research	
Step 1c	Announcing principal findings	*The purpose of this investigation is to …*
Step 1d	Indicating RA structure	*The paper is structured as follows…*

Others (Teufel *et al*., 1999) extended Swales's *CARS* model by adding new moves to cover the other paper sections. Given their focus on automatic summarisation, their annotation schema aims to mark the main element in a research paper: its purpose in relation to past literature. They classify sentences into background, other, own, aim, textual, contrast and basic categories.

Table 2 - Teufel's Annotation Scheme - slightly modified from [2]

BACKGROUND	Statements describing some (generally-accepted) background knowledge
OTHER	Sentences presenting ideas attributed to some other specific piece of research outside the given paper
OWN	Statements presenting the author's own new contributions;
AIM	Sentences describing the main research goal of the paper;
TEXTUAL	Statements about the textual section structure of the paper;
CONTRAST	Sentences contrasting own work to other work;
BASIS	Statements to the effect that current work is based on some other work or uses some other work as its starting point;

The authors claim that this methodology could be used in text summarization, since automatic text summarization requires finding important sentences in a source text by determining their more likely argument role. However, theirs is not an implemented system. Their experiments in manual annotation showed that their annotation schema can be successfully applied by human annotators.

Hyland (Hyland, 1998) describes a metadiscourse schema that distinguishes between textual and interpersonal types in academic texts (Table 3). Textual

metadiscourse refers to devices allowing the recovery of the writer's intention by explicitly establishing preferred interpretations; they also help form a convincing and coherent text by relating individual propositions to each other and to other texts. Interpersonal metadiscourse alerts readers to the author's perspective towards both the information and the readers themselves: it therefore expresses a writer's *persona*.

Table 3 - Hyland's Taxonomy: Functions of Metadiscourse in Academic Texts

Category	***Function***	***Examples***
Textual Metadiscourse		
Logical connectives	express semantic relation between main clauses	In addition, but, therefore, thus, and
Frame markers	explicitly refer to discourse acts/text stages	Finally, to repeat, our aim here, we try
Endophoric markers	refer to information in other parts of the text	Noted above, see Fig 1, table 2, below
Evidentials	refer to source of information from other texts	According to X / Y, 1990 / Z states
Code glosses	help reader grasp meanings of ideational material	Namely / eg / in other words / such as
Interpersonal Metadiscourse		
Hedges	Withhold writer's full commitment to statements	Might, perhaps, it is possible, about
Emphatics	Emphasise force of writer's certainty in message	In fact, definitely, it is clear, obvious
Attitude markers	Express writer's attitude to prepositional content	Surprisingly, I agree, X claims
Relational markers	Explicitly refer to/build relationship with reader	Frankly, note that, you can see see
Person markers	Explicitly reference to author(s)	I, we, my, mine, our

Another strand of research has focused on supporting construction of rhetorical arguments and tools for "making thinking visible" and help with essay writing (Sharples and O'Malley, 1988). Both Belvedere (Suthers *et al*., 1995) and SenseMaker (Bell, 1996) are about the development of scientific argumentation skills in unpracticed beginners and focus on rhetorical relations between propositions. These are modelled mainly as consisting of evidence, claims and explanations. Such an approach would not be suitable in our case, since we are trying to model generic (not simply scientific) student argumentation at undergraduate and graduate level.

Given these premises, we decided to base our categorisation on a generic ontology for scholarly discourse. We looked at *ScholOnto*, a project aiming to model arguments in academic papers and to devise an ontology for scholarly discourse Buckingham Shum *et al.*, 2002). As part of their project, they have produced ClaiMaker, a tool to manually enter (also visualise and search for) claims found in

research papers. ClaiMaker claims are classified as general, problem-related, taxonomic, similarity or causal.

Table 4 - Rhetorical Relations Used in ClaiMaker

Link Type	Link
General various useful links	Is about, uses / applies / is enabled by, improves on, impairs, other link
Problem-related Links to connect to concepts that are research problems	Addresses Solves
Supports / Challenges Links to use for connecting evidence and arguments to concepts that are hypotheses or positions taken by the author	Proves, refutes, is evidence for, is evidence against, aggress with, disagrees with, is consistent with, is inconsistent with
Similarity Links to tie together similar concepts, or concepts to be specified as different	Is identical to, is similar to, is analogous to, shares issues with, is different to, is the opposite of, has nothing to do with, is not analogous to
Causal Links to tie up causes and effects, or indicate that certain conditions have been eliminated as possible causes	Predicts, envisages, causes, is capable of causing, is prerequisite for, is unlikely to affect, prevents

ClaiMaker is mainly meant for academic papers: it sees an academic research paper as a set of inter-linked parts; also, statements in one paper are manually linked with statements in others, leading to a network of cross-referring claims being gradually constructed. Our motivation, however, is different, because we are dealing with (mainly individual) student essays, from which we want to extract arguments in an automated way. Although automated extraction of arguments is a difficult problem, we believe that a shallow analysis of the text can still give us clues about arguments in student essays.

As a first step in our research, we identified categories of possible arguments in a student essay. Our categorisation is mainly based on a preliminary manual analysis of essay texts, with some categories derived from ClaiMaker. Some input came from the categorisations described earlier.

Our bottom-up approach initially yielded the following argumentation categories: **definition**, **comparison**, **general**, **critical thinking**, **reporting**, **viewpoint**, **problem**, **evidence, causal, taxonomic, content/expected** and **connectors.** Some categories have subcategories: e.g. *connectors* has the following subcategories: topic introduction, inference, contrast, additive, support, reformulation and summative.

A review of this categorisation prompted us to reduce the number of categories (visualisation problems, cognitive overload). We therefore grouped some related

categories and turned them into subcategories of a new category (for instance: evidence, causal and taxonomic categories became subcategories of a new "Link" category). By making them subcategories, rather than merging them, we will still be able to visualise them separately, should the need arise. Moreover, a review of cue phrases in the viewpoint category showed a clear affinity with positioning (the new name for "critical thinking"): so we placed this under "positioning". Our revised categorisation also sees comparison as a subcategory of definition (the other subcategory being "is about"), because we often define a concept by comparing and contrasting it with other items. The rationalisation process led to our final student essay categorisation: **definition, reporting, positioning, strategy, problem, link, content/expected, connectors** and **general**.

Table 5 - Our Detailed Taxonomy for Argumentation in Student Essays

Category	**Description**	**Cue phrases** (examples)
DEFINITION	Items relating to the definition of a term. Often towards the beginning. IS_ABOUT, COMPARISONS	is about, concerns, refers to, definition; is the same; is similar /analogous to;
REPORTING	Sentences describing other research in neutral way	"X discusses", "Y suggests", "Z warns"
POSITIONING	Sentences critiquing other research VIEWPOINTS	"I accept", "I am unhappy with", "personally";
STRATEGY	Explicit statements about the method or the textual section structure of the essay	"I will attempt to", "in section 2"
PROBLEM	Sentences indicating a gap or inconsistency, question-raising, counter-claiming	"There are difficulties", "is problematic", "impossible task", "limitations"
LINK	Statements indicating how categories of concepts relate to others TAXONOMIC, EVIDENCE, CAUSAL	"subclass of", "example of", "would seem to confirm", "has caused"
CONTENT/ EXPECTED	Any concept that the tutor expects students to mention in their essay. Tutor-editable	Essay-dependent
CONNECTORS	Links between propositions may serve different purposes (topic introduction, support, inference, additive, parallel, summative, contrast, reformulation)	"With regard to", "As to", "Therefore", "In fact", "In addition", "Overall", "However", "In short"
GENERAL	Generic association links	"is related to"

Compared to Teufel's annotation scheme, our schema lacks an AIM category. This is because it seems less applicable to student essays: after all – it is hoped! – all student essays aim to answer the essay question. Similarly, we do not distinguish between OTHER and OWN (in Teufel's terms): this distinction, which Teufel reports to have caused problems to human annotators of research papers, is irrelevant in our domain. On the other hand, the content/expected category has no obvious counterpart in other categorisations, since it is a student essay-specific category comprising cue phrases identifying content that the tutor expects to find in the

student essay. Overall, there are remarkable similarities across the taxonomies introduced so far (Table 6).

Table 6 - Main Relationships of Our Essay Metadiscourse Taxonomy to Other Categorisations

Category Name	***Relationship to Other Categorisations***	
DEFINITION	• ClaiMaker: is about	
COMPARISON	• Teufel's CONTRAST	
REPORTING	• Swales: Move 1, Step 3; • Teufel: OTHER; • Hyland: EVIDENTIALS	
POSITIONING	• Swales: Move 2 (Establishing a Niche); • Teufel's CONTRAST; • Hyland: Emphatics, Attitude markers, Person markers	Hyland: Interpersonal Metadiscourse
VIEWPOINT	• Hyland: Hedges	
STRATEGY	• Swales: Purpose: M3, S1a; Structure:M3, S1d • Teufel: TEXTUAL; • Hyland: Endophoric markers	
PROBLEM	• Swales: Move 2 (Establishing a Niche)	
TAXONOMIES	• ClaiMaker: Taxonomic	
EXPECTED/ CONTENT		
CONNECTORS	• Hyland: Logical Connectives, Frame Makers, Code glosses	Hyland: most of Textual Metadiscourse
GENERAL	• ClaiMaker: General link type (except is about)	

2. Analyzed Solutions / Strategy

We first analysed how natural language processing (NLP) techniques may help in automated claim extraction. We experimented with Gate (Maynard *et al*., 2002), an open architecture for language engineering providing an infrastructure for developing and deploying software components that process human language. Gate recognises entities (e.g. people, organisations, dates, money and locations) in ASCII or HTML documents through gazetteers and grammar rules written in Jape (a language for defining regular expressions). At first, we thought that Gate might be used for finding arguments in an essay. However, we found that, while a good tool for developers, Gate is too difficult for tutors to use themselves, as they are not skilled knowledge engineers. Since our aim is to provide a tool that is easy to use, we had to look for alternative solutions.

We therefore tested the suitability of information extraction tools for pattern identification in student essays. *MnM* [Vargas-Vera et al., 2002] is an in-house

annotation tool for semi-automated support in marking up webpages with semantic content. MnM integrates a web browser with an ontology editor and provides APIs to link to ontology servers and integrate with information extraction tools. MnM currently uses an information extraction plug-in, Amilcare, which learns patterns from a training corpus. During the learning phase, Amilcare preprocesses texts using Annie, a shallow information extraction system included in Gate (www.gate.ac.uk). Annie performs text tokenisation (segmenting texts into words), sentence splitting (identifying sentences), part of speech tagging (lexical disambiguation), gazetteer lookup (dictionary lookup) and named entity recognition (recognition of people/organization names, dates, etc.). Amilcare then induces rules for information extraction using a learning system based on LP^2, a covering algorithm for supervised learning of information extraction rules derived from Lazy-NLP (Ciravegna, 2001a; Ciravegna, 2001b). This is a wrapper induction methodology (Kushmerick et al. 1997) that, unlike other wrapper induction approaches, uses linguistic information in the rule generalisation process. The learning system first induces wrapper-like rules that make no use of linguistic information, where rules are sets of conjunctive conditions on adjacent words. The linguistic information provided by Annie is then used to create generalised rules: conditions on words are substituted with conditions on the linguistic information (e.g. condition matching on either the lexical category or the class provided by the gazetteer).

Although information extraction tools are intuitively very appealing for finding patterns, we found that such tools work best in narrow domains such as job listings. This is because, in narrow domains, it is easy to define in advance templates containing concepts and relations between them. For instance, in the case of a *visiting event*, we can safely assume that visitor, date of visit and place visited will be of interest. However, in our "students essay'' domain, we cannot anticipate which concepts/relations students are going to use. Thus, information extraction techniques do not seem the most appropriate solution in the student essay scenario.

3. Proposed Solution

We therefore propose to find claims in student essays by using an approach that combines cue phrases with a set of patterns. We started off by defining gazetteers of cue phases and patterns written as regular expressions. The set of patterns were organised based on our categories (Table 5).

The proposed architecture of our system comprises: interface, segmentation, categorization and annotation modules.

- The interface is a window menu interface.
- The segmentation module obtains segments of student essays by using a library of cue phrases and patterns.
- The categorisation component classifies the segments as one of our categories.
- The annotation module annotates relevant phrases as belonging to one of our defined categories. These annotations are saved as semantic tags. Future

implementation of the student viewer could use machine learning for learning cue phrases.

We have called our tool *Student Essay Viewer (SEV)*. One purpose of visualising instances of our argumentation categories within an essay is to give a visual representation of argumentation within an essay, in a shallow version of “making thinking visible”. The intuition is that essays with considerably more “highlighted text” contain considerably more argumentation – and actual “content” – and therefore attract higher grades than essays with little highlighting.

SEV represents a visual tool for tutors to use during assessment: they may refer to its automatic counts indicator, citation highlighting or simply use it to quickly gauge the amount and distribution of argumentation cues across an essay.

On the other hand, SEV can provide formative assessment to students. Thus, if students running the tool on their own essay notice that not much argumentation is found, they are well advised to “revise” their essays before submission, or they may get a low grade. Moreover, an improvement in the essay (more background and reasoned argumentation) should result in more highlighting. This may well increase motivation in some students.

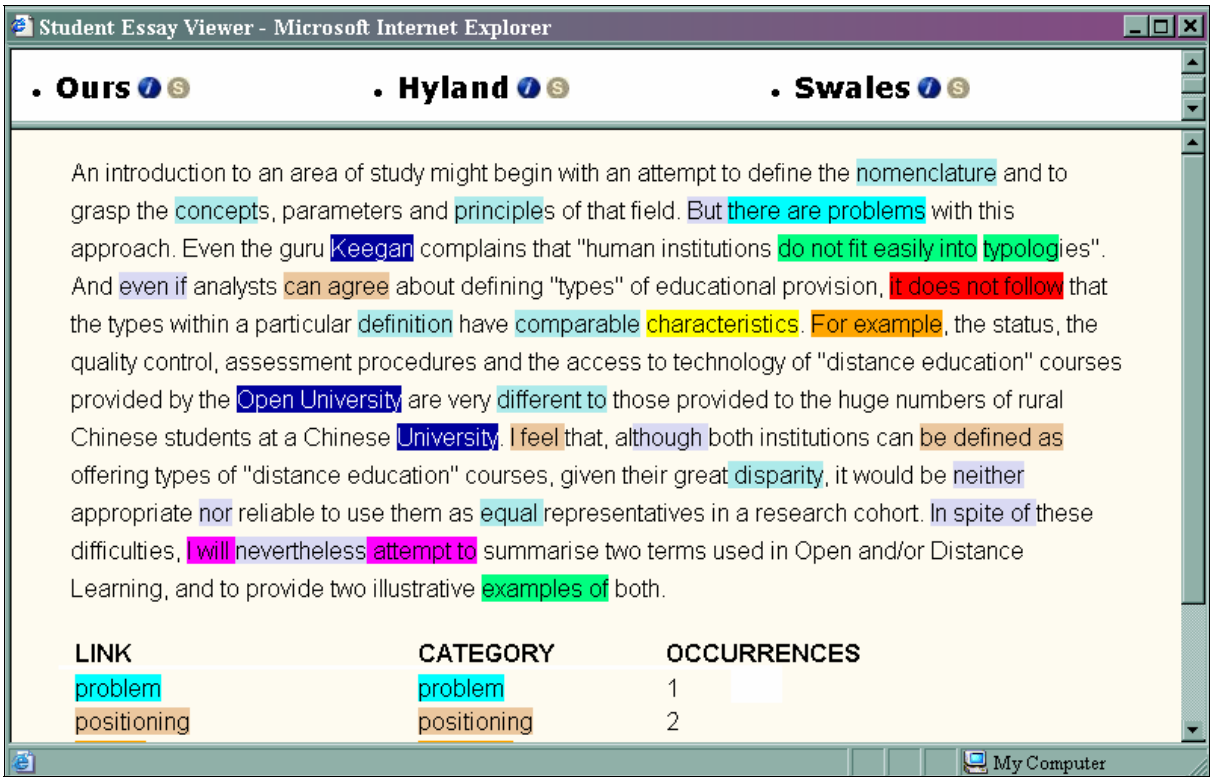

Figure 1 - Student Essay Viewer: displays all annotations in "Ours" categorisation (middle). Bottom: Automatic count indicator for each link type; Top: categorisation can be browsed

SEV can visualise different argumentation categorisations. Currently, these are: our own categorisation, Hyland's and one derived from Swales. Categorisations can easily be extended.

SEV appears to the user as a simple "webpage". In its top part, the available argumentation categorisations can be explored. The bottom (main) part contains the essay: this is initially displayed without any annotations. However, when a category is selected, the annotations relating to this category are displayed. Selecting a whole categorisation causes annotations relating to all its categories to be displayed (each colour corresponding to a different category, Figure 1). Also, a count of links of each type is displayed for reference.

4. Student Essay Viewer and Assessment

While SEV is not a standard marking tool, it can aid assessment by helping tutors quickly visualise the type (and amount) of argumentation it contains. Tutors are "essay experts": given an essay question, they approach the marking of an essay with a clear idea of what it should contain. SEV helps them quickly ascertain to what extent that essay matches their expectations. Also, SEV helps essay comparison in terms of argumentation (links), making marking less time-consuming.

SEV is based on some assumptions concerning the relationship between annotations and scores:

1) "Bad essays" generally have a lower number of annotations than better essays (i.e. are less "content-rich");
2) Critical analysis and background reviews are two essential elements in most essays. These annotations are expected to be the most important in terms of association with the essay score;
3) The relative importance of annotation categories within an essay may vary across essays types.

We decided to test our hypotheses by analysing a set of postgraduate essays from a previous computer-based assessment project at our university. We developed an annotation script and ran it over the set of essays: its output was used as data for our statistical investigation. Given time constraints (and the need to manually check over the annotations), we only analysed a first batch of 12 essays, belonging to 4 different assignments.

4.1 Link Count and Score

A correlation ($r = 0.878$; $N=12$; $p<0.01$) was found between total link count and score. The ANOVA F-statistic confirmed this link in the sample set: $F(1,10)=33.501; p<0.01$. While the evidence is not conclusive, it does point in the general direction we had hypothesised (assumption 1).

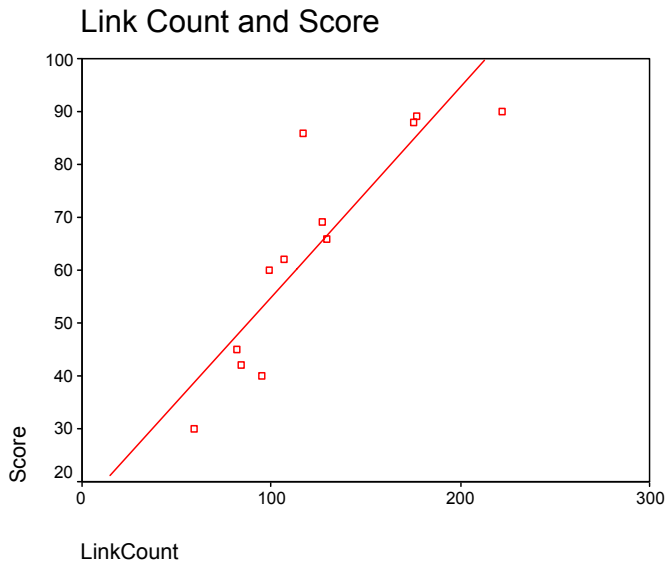

Figure 1 - Correlation between Link Count and Score

4.2 Link Categories and Score

We then set out to determine the most important types of links for the “determination” of score. We ran a multiple regression analysis on the sample set, using the main annotation categories as independent variables and score as the dependent variable. “Positioning” was found to have the highest correlation with score ($r=0.753;N=12;p<0.01$). Not surprisingly, multiple stepwise regression found positioning and background (expected + reporting) to be the variables with greatest relative importance($F(1,10)= 18.462; p<0.01$).

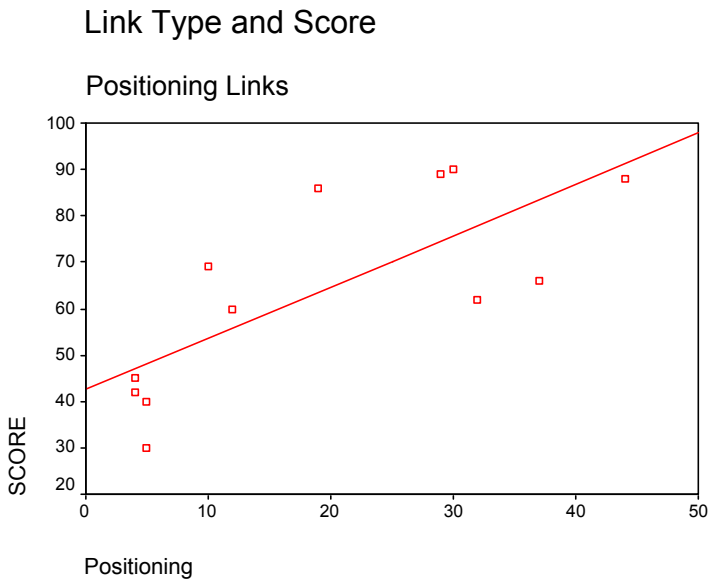

Figure 2 - Correlation between number of "Positioning" links and score

4.3 Annotation Categories and Essay Questions

We have so far applied SEV to four different assignments. An analysis of the essay questions (Table 7) showed that they were answered by essays with different "link profiles" (Table 8).

Table 7 - Examples of Essay Questions

Question Asks…	*Assignment*	*Example*
1. Summary + How and Why	Ass 1, part 2	"In the light of Otto Peter's ideas… say how each type can or cannot serve these ideas and why"
2. Opinion about X	Ass 2, part 1	- "Who do you think should define the learners' needs in distance education?"
	Ass 4, part 3	- "State and define your views on the questions of whether the research is adequately addressing what you regard to be the important questions or debates"
3. Describe + Discuss	Ass 2, part 2	"Imagine you are student and your teacher has a strong leaning towards the technical-vocational orientation. Describe and discuss your experiences, using concepts and examples from text book 1."
	Ass 4, part 2	"Define and discuss any cultural factors you observe in relation to each of these questions"
3. Give example of X and Critique X	Ass 4, part 1	Provide examples of web links covering a wide range of choose aspects of open and distance education and write a short critique of each.

The basic idea is that, depending on the essay question, we expect to find a different "distribution" of links in the essay themselves. For instance, a question asking for a "summary" is usually answered by an essay containing many "reporting" links. Table 8 matches essay questions with our essay metadiscourse categories (Table 8).

Table 8 – Examples of Essay Questions and Expected Links

Example of Question	*Links Expected to be Important*
1. Summary of X + How and Why	Essays answering such questions have a high number of the following link types: reporting, positioning, expected, is about, part and contrast.
2. Opinion about X	Essay has a high number of background, expected names, positioning. However part link it does not seems very relevant
3. Describe and Discuss	Describe and Discuss essays feature a high number of support and positioning links. In the case of assignment 2, part 2, there was a low number of reporting links, as students were asked to describe a hypothetical situation; however, this may not always be the case.
4. Give an example of X and Critique X	In these essays, analysis and summative connector links are higher than "is about" and "contrast" links.

We found stronger correlations for assignment 1 than, say, for assignment 4. This is because the former is a “standard” essay requiring background “reporting” and reasoning on it, while assignment 4 is less traditional and more difficult to “gauge” (as it was based on a required detailed web search)

4.4 Student Essay Viewer and Feedback

The main functionality of SEV, providing a quick visualisation of the type and amount of argumentation in an essay, is probably enough help for tutors, as they already know what they would like the essay to contain.

However, unlike tutors, students are often unclear about what exactly should go into a particular essay or might get “side-tracked” and use too many words covering one aspect of the essay (e.g. background) at the expense of others (e.g. positioning). By allowing visualisation of argumentation types, SEV could alert the student to a lack of certain types of argumentation. Such a warning should be linked to an analysis of the essay question like the one provided in section 4.3. For instance, if the question requires justifications or asks “why” and “how” questions, this suggests that the essay is expected to contain considerable “positioning” argumentation and that, in this case, lots of background material simply will not be sufficient.

5. Results and Future Work

The main contribution of this paper is our student essay metadiscourse schema, which we have compared and contrasted with categorisations in the research essay domain (Section 1).

We have analysed links between argumentation extraction in essays and score for the purposes of aiding assessment (Section 4). We found that the total number of links seems to be correlated with score, that positioning and background (expected + reporting) are the variables that generally contribute the most to score prediction and that the essay question is associated with the relative importance of different link types in an essay.

We have implemented an easy-to-use tool to visualise the highlighted categories used in an essay and shown how the essay viewer can be helpful to both tutors and students. The main benefit for tutors is quick visualisation of the type of argumentation and concentration of links, while students can use the essay viewer to get feedback about their essay, particularly about lacking categories.

In our investigation, we have used real data, actual essays written by postgraduate students as part of their course. We believe that the results reported here are encouraging in terms of the quality and robustness of our current implementation. However, there is clearly a lot more work needed to make this technology easy enough to use for tutors and students (who are neither experts in language technologies nor 'power knowledge engineers') to use. Future implementations of the

student essay viewer could categorise longer linguistic units (e.g. sentences or paragraphs) and explain the reasons why a specific categorisation is assigned to them. These explanations might be displayed in pseudo-natural language.

As mentioned above, the inclusion of an "essay question analysis" tool – currently being implemented – will be particularly beneficial for students. In fact, the feedback component should use the essay question to determine what categories are expected to be prominent in an essay and alert the user if a relevant category is missing or underrepresented. This will give students valuable clues as to whether they are answering the question correctly.

6. Conclusion

This paper has presented a generic metadiscourse annotation schema for student essays and highlighted its links to other schemas relating to academic papers. It has also described an argument visualisation tool for student essays that uses our essay annotation schema and a cue-based approach to detect argumentation.
We also explored some hypotheses as to how the student essay viewer may assist assessment and give formative feedback to students in their essay writing efforts.

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