Automated Classification of Argumentative Components in Students' Essays

Supplementary Information

1. Prompts of the Essays Used in the Current Study

Prompt One

We value uniqueness and originality, but it seems that everywhere we turn, we are surrounded by ideas and things that are copies or even copies of copies. Writers, artists, and musicians seek new ideas for paintings, books, songs, and movies, but many sadly realize, "It's been done." The same is true for scientists, scholars, and business people. Everyone wants to create something new, but at best we can hope only to repeat or imitate what has already been done. Can people ever be truly original? Plan and write an essay in which you develop your point of view on this issue. Support your position with reasoning and examples taken from your reading, studies, experience, or observations.

Prompt Two

Having many admirers is one way to become a celebrity, but it is not the way to become a hero. Heroes are self-made. Yet in our daily lives we see no difference between "celebrities" and "heroes." For this reason, we deprive ourselves of real role models. We should admire heroes—people who are famous because they are great—but not celebrities—people who simply seem great because they are famous. Should we admire heroes but not celebrities? Plan and write an essay in which you develop your point of view on this issue. Support your position with reasoning and examples taken from your reading, studies, experience, or observations.

2. Discourse Indicators and Corresponding Relations

Discourse Relations	Typical Discourse Indicators
Sequence	above all, additionally, after, after that, another, at first, at the outset, essentially, eventually, finally, first, first of all, for a start, for one thing, fourth, further, furthermore, in addition, in the beginning, in the end, in the first, in the first place, initially, later, more importantly, moreover, most importantly, next, nth, nthly, second, second of all, secondly, subsequently, then, third, thirdly, to begin with, to start with, what is more, last, lastly, in addition, in addition to
Temporal Situation	after, as, as soon as, at the same time, before, earlier, in the meantime, meanwhile, now, now that, previously, simultaneously, since, until, when, whenever, while
Causal Relations	after all, as, as such, according to, in turn, as a consequence, as a result, because, consequently, else, given that, hence, if ever, if not, if so, in case, in that case, it follows that, let us assume, on condition that, on the assumption, on the grounds that, or , or else, otherwise, provided that, providing that, since, so, so that, suppose, supposing , supposedly, then, therefore, thus, unless, accordingly, consequently, ultimately, thereby, following, afterward, afterwards, as a matter of fact, because of, actually, in order to, in order for, so as to
Similarity Relations	again, also, as well, correspondingly, likewise, once again, once more, similarly, too
Contrast and Expectation	at any rate, admittedly, all the same, although, apart from, at the same time, but, by comparison, by contrast, despite that, despite the fact that, even if, even so, even then, even though, however, in any case, in contrast, in spite of, in spite of that, instead of, naturally, nevertheless, nonetheless, notwithstanding that, notwithstanding that, of course, on one hand, on the contrary, on the one hand, on the other hand, rather than, regardless of that, still, then again, though, to be sure, unfortunately, whereas, while, yet, otherwise, conversely, unlike, admittedly

Discourse Relations	Typical Discourse Indicators
Clarifying Statements	actually, for example, for instance, in actual fact, in fact, in other words, on the contrary, that is, that is to say, to take an example, briefly, i.e., alternatively, alternately, after all, e.g., in this case, in that case, such that, such as, about how, to some extent
Summary	all in all, altogether, essentially then, finally, in conclusion, in short, in sum, in summary, in summation, last, lastly, on the whole, overall, summarizing, summing up, to conclude, to sum up, to summarize, above all
Interruptions	anyway, by the way, in any case, in any event, incidentally, specifically, particularly
Thesis	as far as I am concerned, point of view, agree, think, don't agree, don't think, believe, don't believe, do not agree, do not think, do not believe, position that, in my opinion, clear that, seems to me, personally

3. All Retained Features for Argumentative Component Classification

Component	Number	Definition
Positionality Feature	1	The normalized location of the component in the essay
Named Entity Feature	2	The number of named entities in the component
Semantic Similarity Features	3	The semantic similarity between a component and its preceding component
	4	The semantic similarity between a component and its succeeding component
	5	The absolute value of the difference of the two values in (3) and (4)
POS Features	6	The number of plural nouns in the component
	7	The number of personal pronouns in the component
	8	The number of adverbs in the component
	9	The number of verbs (base form) in the component
	10	The number of verbs (past tense) in the component
	11	The number of verbs (gerund or present participle) in the component
	12	The number of verbs (past participle) in the component
	13	The number of verbs (non-3rd person singular present) in the component
	14	The number of verbs (3rd person singular present) in the component
	15	The number of wh-determiners in the component
	16	The number of personal wh-pronouns in the component
	17	The number of wh-adverbs in the component
Syntactic Dependency Features	18	The number of clausal modifiers of noun in the component
	19	The number of adjectival complements in the component
	20	The number of adverbial clause modifiers in the component
	21	The number of adverbial modifiers in the component
	22	The number of attributes in the component
	23	The number of clausal complements in the component
	24	The number of compound modifiers in the component
	25	The number of negation modifiers in the component
	26	The number of complements of preposition in the component
	27	The number of possession modifiers in the component

Component	Number	Definition
	28	The number of relative clause modifiers in the component
	29	The number of roots (of syntax trees) in the component
	30	The number of open clausal complements in the component
	31	The number of noun phrases as adverbial modifiers in the component
	32	The number of coordinating conjunctions in the component
	33	The number of sequence indicators in the component
Discourse Indicator Features	34	The number of temporal situation indicators in the component
	35	The percentage of contrast indicators in the component

4. Average Classification Accuracy among Different Classifiers and Feature Sets

	Feature Set	Random Forest	Logistic Regression	SVM
Accuracy	1	0.50	0.42	0.43
	2	0.56	0.47	0.51
	3	0.67	0.65	0.66
	4	0.77	0.74	0.75
	5	0.79	0.75	0.76
	6	0.79	0.75	0.75
Precision	1	0.50	0.30	0.32
	2	0.56	0.40	0.49
	3	0.66	0.64	0.66
	4	0.76	0.73	0.74
	5	0.78	0.74	0.75
	6	0.78	0.74	0.74
Recall	1	0.50	0.42	0.43
	2	0.56	0.47	0.51
	3	0.67	0.65	0.66
	4	0.77	0.74	0.75
	5	0.79	0.75	0.76
	6	0.79	0.75	0.75
F-score	1	0.50	0.34	0.35
	2	0.56	0.41	0.47
	3	0.67	0.64	0.66
	4	0.77	0.73	0.74
	5	0.78	0.74	0.75
	6	0.78	0.74	0.74

Note. Numbers indicate which feature set was used. 1 = Baseline (Positionality), 2 = Baseline + Named Entity, 3 = Baseline + Named Entity + Semantic Similarity, 4 = Baseline + Named Entity + Semantic Similarity + POS, 5 = Baseline + Named Entity + Semantic Similarity + POS + Syntactic Dependency, 6 = Baseline + Named Entity + Semantic Similarity + POS + Syntactic Dependency + Discourse Indicator

5. Results of Two-sample T-tests among Different Features Sets

Results of two-sample t-tests of accuracy extracted from all random forest models showed that the model with feature set 2 (M = 0.5, SD = 0.03) significantly outperformed feature set 1 (M = 0.56, SD = 0.03). Similarly, significant differences were also found between feature set 2 and feature set 3 (M = 0.67, SD = 0.03), feature set 3 and 4 (M = 0.77, SD = 0.02), and between feature set 4 and 5 (M = 0.79, SD = 0.03). The results indicated that adding in named entity, semantic similarity, part-of-speech, and syntactic dependency features led to significant differences in classification performance.