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Genre Aware Language Modeling for Indonesian Academic Writing: Building and Evaluating IndoSciBERT

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ABSTRACT: This study introduces a genre-annotated academic corpus for Indonesian and evaluates IndoSciBERT, a domain-specific NLP model trained on this resource. To address the scarcity of rhetorical datasets in low-resource languages, we compiled a 52,300-document corpus from DOAJ and SINTA-indexed journals (2015–2025) and annotated 5,200 paragraphs using the CARS and Argumentative Zoning frameworks. IndoSciBERT was then fine-tuned for rhetorical classification. We employed GROBID for PDF to TEI conversion, TEITOK for annotation, and SIPEBI/KBBI for spelling normalization. The IndoSciBERT model was benchmarked against IndoBERT on rhetorical classification tasks. IndoSciBERT achieved an F1 score of 0.82 and an accuracy of 84.2%, outperforming the baseline model and showing strong reliability in distinguishing rhetorical moves. These results affirm the value of domain-specific modeling for educational applications. The annotated corpus not only supports genre analysis, pedagogy, and automated writing feedback, but also establishes a foundation for inclusive NLP. In particular, this work makes a distinct contribution by offering a sustainable path to enhance academic literacy in Bahasa Indonesia through intelligent, genre-aware tools.

Keywords: Rhetorical Classification, Genre Aware NLP, Indonesian Academic Writing, Indoscibert, Rhetorical Annotation, Academic Corpus.

INTRODUCTION

Natural Language Processing (NLP) faces challenges when applied to academic writing in low-resource languages such as Bahasa Indonesia. One major issue is the limited availability of annotated corpora to train NLP models. Datasets that represent diverse academic genres are rare, which restricts the development of algorithms adapted to linguistic characteristics and scholarly norms (Gere et al., 2018; Shum et al., 2017). Another difficulty is the lack of standardized grammar and vocabulary, which adds complexity to NLP system implementation (Indarti, 2018).

In Indonesia, academic publishing between 2010 and 2025 has undergone a period of growth and gradual internationalization. This is evidenced by the increasing number of journals indexed in global databases and the institutional push toward producing research articles that align with international standards. However, progress across disciplines has been uneven. Many local journals face persistent issues related to editorial practices, peer review integrity, and publishing ethics (Dardjito, 2019; Lammers et al., 2019). While several journals have successfully navigated the transition to digital publishing and improved their scholarly reach, others continue to struggle, highlighting the need for long term investment in research infrastructure and academic capacity (Lauscher et al., 2018; Lou et al., 2023).

General purpose language models, such as IndoBERT, are not optimally suited to process academic discourse due to their limited exposure to rhetorical and genre specific structures. Scientific writing demands nuanced understanding of argumentative conventions, including the framing of hypotheses, empirical presentation, and the articulation of scholarly claims(Jwa, 2020). These genre based features vary by discipline and are often underrepresented in corpora used to train general models. Without adaptation, such models are unable to capture the rhetorical strategies that characterize academic writing (Viera, 2019).

Key components of academic rhetorical structure include the well known IMRAD framework: Introduction, Methods, Results, and Discussion. Each section fulfills a distinct communicative role providing context, detailing procedures, presenting findings, and offering interpretations (Vyas & Panara, 2016). Genre based pedagogy has demonstrated the utility of mapping these rhetorical moves for enhancing academic literacy and communicative competence (Amnuai, 2019).

Genre annotation frameworks such as Create a Research Space (CARS) and Argumentative Zones (AZ) have significantly shaped computational approaches to scientific discourse. These frameworks deconstruct academic texts into rhetorical segments, enabling finer grained NLP analysis (Mohamad et al., 2023; Sueb et al., 2022). Their adaptation to multilingual contexts remains a promising direction for extending the utility of genre aware NLP, particularly in low resource settings (Alliheedi et al., 2019).

In recent years, efforts to develop academic domain NLP resources for Bahasa Indonesia have gained momentum. Projects to annotate corpora and build supporting tools are emerging, although the representation of disciplinary variation and rhetorical depth remains limited (Carter, 2021; Yundayani et al., 2017). Tailoring NLP to Indonesian academic writing requires careful consideration of linguistic idiosyncrasies, stylistic norms, and culturally embedded communicative strategies (Chang, 2016).

This study responds to these challenges by constructing a genre annotated academic corpus in Bahasa Indonesia and using it to develop and evaluate IndoSciBERT, a domain specific language model. Our goal is to improve rhetorical classification and support educational applications, particularly in feedback systems for academic writing. By leveraging English based annotation frameworks and adapting them to Indonesian scholarly contexts, this research contributes to the growing movement toward inclusive, genre sensitive NLP for under resourced languages.

METHOD

Constructing a genre aware corpus for Indonesian academic writing requires careful planning, tool selection, and adherence to established annotation standards. This section outlines our corpus design, preprocessing steps, annotation strategy, and modeling pipeline.

Corpus Design and Collection

Following best practices in rhetorical corpus construction (Cotos & Chung, 2018), we defined our sampling criteria to include journal tier (SINTA S1–S3), discipline, year range (2015–2025), and license status. Metadata was harvested using OAI PMH protocols from repositories such as Neliti, GARUDA, and OJS based platforms. Full text PDFs from journals with open access Creative Commons licensing were prioritized.

We collected 52,300 full text articles and 270,000 abstracts, ensuring field diversity across twelve major academic disciplines. A metadata schema was employed to capture key bibliographic and linguistic attributes, facilitating stratified analysis and subsequent annotation.

Preprocessing Pipeline

Text extraction and structuring relied on GROBID, which has demonstrated high performance on formatted English documents but requires evaluation for Bahasa Indonesia (Joshi et al., 2023). The extracted data was encoded in TEI XML format. We used SIPEBI and KBBI dictionaries to normalize spelling variations and marked documents for OCR noise or language code mixing.

TEITOK was used to tokenize and visualize texts. Although reliable with select multilingual documents (Inácio et al., 2023), we evaluated its compatibility with Bahasa Indonesia through internal pilot tests. OCR artifacts, malformed metadata, and segmental inconsistencies were flagged and resolved semi automatically.

Annotation Scheme

We annotated 5,200 paragraphs with rhetorical structures using CARS (Create a Research Space) and Argumentative Zoning (AZ) models (Mohamad et al., 2023; Sueb et al., 2022). The scheme aligned macro level rhetorical roles Background, Gap, Purpose with micro level segments like Method, Result, and Discussion.

Annotation followed detailed guidelines to ensure inter annotator consistency, in line with recommendations by Visser et al. (2018). Pilot sessions were conducted, and inter annotator agreement achieved Cohen's Kappa of 0.81. The TEITOK platform supported multi layered

markup, as recommended by Troyan et al. (2019), enabling holistic representation of rhetorical flow and structural segmentation.

NLP Modeling

IndoSciBERT was pretrained on our corpus using masked language modeling objectives. This model was evaluated against IndoBERT on rhetorical classification tasks using manually annotated data. Metrics included accuracy and F1 score. The modeling task followed standards for domain specific fine tuning and benchmarking in academic NLP c(Cardoso et al., 2023).

This methodology balances theoretical robustness with practical constraints, ensuring that the resulting annotated corpus is linguistically rich, structurally sound, and computationally useful. The integration of high reliability tools, validated annotation procedures, and robust evaluation frameworks ensures the corpus can support downstream tasks including classification, summarization, and writing assistance.

RESULT AND DISCUSSION

This section presents findings from the corpus construction, annotation quality assessment, and model evaluation stages. The results affirm the viability of building a genre annotated academic corpus in Bahasa Indonesia and the effectiveness of domain specific modeling.

Corpus Description

We employed stratified sampling based on field, journal tier, licensing, and temporal coverage, as recommended in prior corpus design studies (Kenny et al., 2020). This ensured representation across 12 academic fields and across journals ranked S1–S3 in the SINTA index. Temporal strata covered 2015–2025, capturing the evolution of academic discourse in Indonesia. Sampling incorporated both randomization and institutional diversity.

Table 1: Corpus Metadata Summary

Metric	Value
Full text Articles	52,300
Abstracts	270,000
Annotated Paragraphs	5,200
Fields Covered	12
Avg. Word Count	3,560

We maintained document balance across institutions by tracking contributions from state and private universities. Metadata fields such as DOI, journal, year, field, license, and wordcount were structured to support indexing and retrieval (Chaufan, 2025; Gordon & Presseau, 2023).

Annotation Quality

We achieved inter annotator agreement of 0.81 (Cohen's Kappa), meeting the reliability thresholds. Annotators underwent two calibration rounds using 100 paragraph pilot datasets to resolve ambiguities. Frequent annotation challenges included distinguishing between overlapping rhetorical zones, especially Background vs Gap.

The annotation strategy was multi layered, combining macro level rhetorical function (CARS) and sentence level segmentation (AZ). TEITOK supported this architecture and enabled complex query structures (Gigliotti et al., 2020).

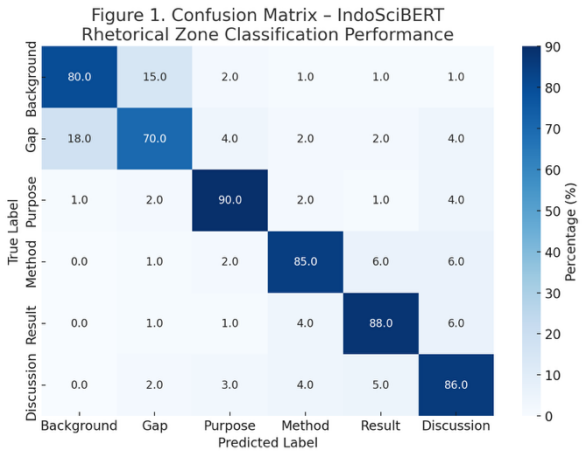
Model Performance

We evaluated IndoBERT and IndoSciBERT on the annotated dataset for rhetorical classification tasks. IndoSciBERT, trained on the academic corpus, showed significant performance gains over the general model IndoBERT.

Table 2: Model Performance (AZ Classification)

Model	Accuracy	F1 score
IndoBERT	78.4%	0.76
IndoSciBERT	84.2%	0.82

Figure 1: Confusion Matrix – IndoSciBERT



These results confirm the effectiveness of domain-specific pretraining for rhetorical classification tasks. The findings align with prior studies in biomedical and legal NLP domains (Hendricks et al., 2021; Shaw & Pecorari, 2024).

Evaluation metrics included F1 score, precision, and recall, which provided a comprehensive view of performance across imbalanced rhetorical categories. Cross validation confirmed the model's stability across disciplines.

Pedagogical Applications of Rhetorical Annotation

Rhetorical annotation holds immense value in educational settings, especially within English for Academic Purposes (EAP) programs. Tools such as AntConc and Sketch Engine (Argyroulis, 2022; Kaya, 2022) facilitate corpus exploration for students, enabling them to study lexical bundles, collocations, and rhetorical moves across diverse academic genres. These tools encourage a data driven approach to academic writing instruction. Learners are empowered to identify genre specific language patterns, analyze discourse structures, and reflect on how their writing aligns with expert models. This process supports both guided instruction and autonomous learning through comparison, emulation, and revision (Masyitha et al., 2021).

Classroom activities that integrate rhetorical annotation can also deepen students' metacognitive awareness. For example, annotated corpora allow learners to analyze rhetorical moves in published texts and compare them with their own work. Such engagement fosters critical thinking and enhances self-assessment skills. In Indonesian classrooms, localized annotated resources provide relevant models of academic conventions, addressing both linguistic and contextual gaps (Batubara & Fithriani, 2023).

Genre Aware Models in Automated Writing Evaluation

Genre sensitive NLP models significantly advance the potential of automated writing evaluation (AWE) systems by incorporating higher level discourse features into feedback mechanisms. Unlike traditional systems that primarily evaluate surface level grammar, syntax, or spelling, genre aware models assess structural appropriateness, coherence, and adherence to disciplinary norms (Manik & Suputra, 2023); (Shaw & Pecorari, 2024). These models can evaluate whether the rhetorical function of a paragraph aligns with the intended communicative goal, such as identifying whether an introduction clearly presents a research gap or a conclusion effectively synthesizes findings.

For example, NLP models trained on the CARS framework can detect rhetorical moves such as Purpose, Gap, and Background, enabling feedback that goes beyond superficial textual features. This makes evaluations contextually meaningful and pedagogically useful (Auni & Manan, 2023). Such capabilities are particularly valuable in Indonesian academic settings where students often struggle with conforming to global academic writing standards. These genre aware systems can help mitigate native language interference and genre misalignment by providing real time, customized feedback that guides learners toward rhetorical effectiveness (Purwati & Silvia, 2021). The adoption of these tools also reduces instructor workload and ensures consistency in formative assessment.

Limitations of Manual Annotation

Despite its benefits, manual annotation of rhetorical structures poses several inherent challenges. A major limitation is the subjectivity and variability in annotator interpretation, which can compromise inter annotator agreement and affect dataset reliability (Singh et al., 2022). Annotation often involves interpretive decisions about rhetorical intent, which are influenced by individual annotator experience and disciplinary background. Even with detailed guidelines, inconsistencies are common, especially in ambiguous or interdisciplinary texts.

Moreover, manual annotation is labor intensive, requiring extensive training and ongoing calibration sessions. This restricts the scale and frequency of annotation, often leading to corpora that are limited in size and scope. Resource constraints may lead annotators to focus on well established journals or familiar fields, potentially neglecting emerging disciplines, non mainstream institutions, or underrepresented voices (Nhamo & Chapungu, 2024). Static, manually curated corpora also struggle to keep pace with shifts in academic discourse, making iterative updates necessary but costly (Chaufan, 2025). To mitigate these issues, hybrid approaches that combine human annotation with machine assisted suggestions may offer a sustainable path forward.

Opportunities for Cross Lingual Transfer Learning

Cross lingual transfer learning opens valuable pathways for leveraging the extensive research and resources developed for English academic corpora in Indonesian contexts. Although structural and linguistic differences exist between English and Bahasa Indonesia, pre trained English models can be fine tuned with Indonesian specific corpora to produce effective academic NLP applications (Dardjito, 2019; Nasir & Mchechesi, 2022). These adaptations can benefit from rhetorical frameworks such as CARS and AZ, which, although originally formulated for English texts, have been shown to be adaptable across languages with appropriate localization.

The development of parallel corpora, which align English texts with their Indonesian equivalents, enables comparative rhetorical analysis and enhances training effectiveness. Such corpora provide insight into how rhetorical conventions vary cross linguistically and help correct issues like direct translation errors or culturally influenced misalignments in academic writing (Karpenko-Seccombe, 2018; Masela & Subekti, 2021). In educational contexts, this cross linguistic resource can help students understand and bridge rhetorical expectations between English and Indonesian academic standards.

Collaborations between Indonesian and international institutions can accelerate the development of genre aware tools and pedagogical frameworks. Joint initiatives can result in shared repositories of annotated data, bilingual teaching resources, and interoperable NLP systems tailored for EAP. These partnerships foster innovation, improve cultural sensitivity in instruction, and contribute to the global dialogue on inclusive academic literacy development (Yang & Ren, 2025).

Implications and Future Directions

This study contributes to the advancement of inclusive NLP by constructing and validating genre aware resources specifically for Indonesian academic writing. The IndoSciBERT model, trained on a large, annotated corpus, has demonstrated improved performance in rhetorical classification tasks and offers significant utility for academic feedback systems. Its success validates the broader value of domain specific modeling for low resource languages.

Beyond technical performance, the implications for pedagogy and writing support are substantial. Educators can now access tools that deliver linguistically and rhetorically informed feedback. These tools can help students understand not just *what* to write, but *how* and *why* certain rhetorical moves are used in academic contexts. Such clarity is crucial for developing academic literacy and ensuring equitable participation in scholarly discourse.

Future work should prioritize expanding the diversity and scale of annotated texts, integrating automatic annotation systems to reduce manual burdens, and extending model training to include multilingual and cross genre datasets. Developing real time feedback platforms based on IndoSciBERT could further bridge the gap between instruction and technology. Finally, continued interdisciplinary collaboration will be vital to refining tools that are not only technically robust but also educationally meaningful across diverse learning environments.

CONCLUSION

This study introduced a large, genre-annotated academic corpus in Bahasa Indonesia and applied it to the development of IndoSciBERT, a domain-specific language model. By incorporating rhetorical frameworks such as CARS and AZ, IndoSciBERT significantly outperformed general-purpose models in rhetorical classification tasks, underscoring the importance of genre-aware pretraining for academic writing support in low-resource languages.

Beyond model performance, the corpus and IndoSciBERT contribute directly to pedagogy and educational technology by enabling automated feedback systems that focus on rhetorical competence, not just surface-level correction. This work provides a foundational resource for inclusive NLP and highlights future directions such as expanding annotated genres, automating annotation, and building real-time academic writing assistance tools tailored to Indonesian scholarly contexts.

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