From Text to Structure: Towards an Intelligent Framework for Evaluating Course Syllabus Completeness Leveraging NLP-Based Approach

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Abstract

A syllabus is a roadmap for instructors and students to successfully navigate and complete a course. A well-developed intelligent system for checking syllabus coherence and completeness can significantly enhance curriculum design and overall educational quality. Numerous educational research emphasize that a proper syllabus should contain several key components, including instructor contacts, course information, course description, course objectives, course outline or schedule, course requirements, alignment with program outcomes, course evaluation methods, prerequisites, required materials, grading scale, institutional policies, and additional course materials. However, despite the importance of these elements, many syllabi in practice suffer from inconsistencies, incompleteness, or a lack of alignment with institutional and accreditation standards. These shortcomings can diminish the overall quality of education and lead to disengagement among students. Based on our literature review and to the best of our knowledge, there is currently no standardized automated tool available to evaluate whether a specific course syllabus meets these essential criteria. In this study, we propose a Natural Language Processing (NLP) technique that extracts and interprets the textual content of a course syllabus, identifies key components, and compares them against standardized syllabus templates. The system calculates a completeness score for the syllabus and highlights components that are either incomplete or missing. The system is currently in development and has shown initial success in detecting structural components within sample syllabi. The goal is to establish an automated, intelligent tool that benefits educators and academic institutions by supporting optimized curriculum structuring that aligns with educational standards and learning objectives.

Keywords: course syllabus, completeness, accessibility, natural language processing, sentence embeddings, and document analysis

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Introduction

Academic instruction begins with a course syllabus that specifies learning goals, along with assessment techniques and policy requirements, as well as student expectations. When properly structured, the syllabus serves as a student's curriculum guide and remains compliant with accreditation requirements and educational standards. The strong importance of syllabi is often neglected due to poor completion standards, which also leads to misalignment with academic goals and results in weaker educational effectiveness and student engagement. Assessment of a course syllabus is required in order to have a successful outcome. It implies checking if the course syllabus fulfills all the requirements. Course syllabi are unstructured, diverse in format, and often written in natural language. Manually evaluating their completeness, coherence, and alignment with academic standards is time-consuming and error-prone. The increasing variety of academic programs and student mobility, and the emphasis on outcomes-based education, have compounded the importance of syllabus standardization and transparency. Colleges are compelled to indicate alignment of the content of their courses to program objectives. Students also need more transparency and organization in order to better manage their study tracks. Here, automation represents an efficient and data-based approach to ensuring syllabi are always of a high standard. In addition to that, the push towards digital transformation in education has brought about the need for organized education content. Syllabi, which are usually kept in disjointed forms (PDFs, Word documents, LMS text boxes), are an unrealized source of institutional information. Automation of syllabus data extraction and structuration helps facilitate better curriculum mapping, accreditation reporting, and customized learning.

This work proposes a structured, intelligent framework that evaluates course syllabi based on their content completeness and accessibility. The system leverages Natural Language Processing (NLP) techniques to transition from unstructured syllabus documents to structured evaluations, providing actionable feedback for faculty and administrators. The primary objectives of this research are:

- Evaluating academic syllabi against institutional content and accessibility standards.
- Assessing the presence and completeness of essential syllabus components.
- Identifying common accessibility issues based on best practices for digital document design.

The rest of the paper is designed as follows: description of key components in standardized syllabi, related study in the arena of employing NLP in the evaluation process of academic curriculum, the methodology of our proposed syllabus evaluation approach, results, discussion, and conclusion.

Key Components in Standardized Syllabi

Accreditation bodies and educational guidelines suggest a standardized set of syllabus components, including instructor information, course descriptions, objectives, learning outcomes, evaluation methods, course schedules, prerequisites, and institutional policies. Researchers in various educational fields show consensus in having this particular component in a syllabus in order to make it complete (Collier & Beel, 2018; Rashtian et al., 2020; Wagner et al., 2023; Wotring et al., 2021). A brief description of these components is given below.

Instructor Contact Information: This section includes the instructor's name, email address, office hours, and phone number. It is critical for establishing communication between students and faculty, helping foster a supportive learning environment.

Course Information: A standard syllabus should contain details about the course name and code and semester, and year, along with meeting time. Fundamental course information allows students to understand crucial aspects of their coursework.

Course Overview: The learning program details all important subject matter discussed throughout the curriculum extensively. Students can understand the course material better to assess if it aligns with their academic goals.

Course Objectives: The coursework should outline the achievements of students using the curriculum experience. One of the main advantages of well-stated learning objectives is the possibility of relating the assessment strategies to the learning needs of students.

Course Schedule or Outline: A week-by-week topic outline, reading lists, and due dates of assignments and examinations must also be provided. Having a proper outline will assist students in developing efficient time management systems.

Course Requirements: The document provides not only the requirements in terms of attendance but also the general code of conduct on the part of the students, along with the specifications of various assignments, presentations, tests, and projects. Clarity of requirements definition will enhance understanding of what is expected, besides treating students fairly.

Alignment to Program Outcomes: The course will be linked to its allied programming outcomes through this section, which indicates the course's relevance in attaining broader program objectives. The process also makes it possible to ascertain whether the whole curriculum is meeting and complying with the university standards and the requirements of accreditation, and would make the curriculum easy to trace.

Course Assessment Techniques: Records how the performance of the students will be evaluated. It can include the grading of assignments, assessments, and participation, as well as other marked activities to enhance transparency.

Prerequisites: Describes requirements on prior knowledge or classes that have to be passed to be enrolled. It gives the student a background of the essentials needed to carry out the course.

Required Materials: The course uses a list of required textbooks, articles, and software, among other learning materials, which the students are required to get for the course. The listed course materials ensure that learners possess the required tools to communicate instructions.

Grading Scale: A standard Syllabus should contain the grading system that determines the correspondence between percentage grades and the letter grades in order to determine the academic progress made, as well as the grades that will be attained.

Institutional Guidelines: Transmits academic honesty standards, disability accommodations, attendance policy, and other information required by the university.

Additional Course Materials: These are extra reading, tools, etc. that support students' learning experience and diverse learning approaches.

According to Rashtian et al. (2020), the absence or inconsistency of these components often compromises educational coherence. Automating the identification and verification of these elements is, therefore, a logical step in optimizing curriculum design.

Related Works

Previous assessment systems employed hard-coded templates as well as keyword checks to verify key syllabus elements through their rule-based system (Delialioglu & Yildirim, 2008). Although these systems provided deterministic responses and were comparatively simple to implement, these systems were not flexible to various formats and vocabularies and hence proved to be domain-dependent. Progressing to the next level, ontology-based systems brought structured semantic representations that facilitated mapping of course elements to defined curricular ontologies (Sabri, 2016). Ontologies facilitated interoperability, alignment to accreditation standards, and machine reasoning about the content of the courses. Despite the above developments, the construction and maintenance of domain-specific ontologies are still labor-intensive and need expertise. Knowledge graph-based models have also recently been suggested to model syllabi as nodes connected through semantic relationships. Dietze et al. (2012) showed how linked educational data and semantic graphs can connect syllabus items with broader learning resources. Such models support querying, personalization, and integration with institutional data systems—but demand rigorous preprocessing and a shared semantic backbone across departments. Institutes must perform substantial data standardization and preprocessing before they can use these systems, but few institutions maintain this capacity.

Natural Language Processing (NLP) stands today as a central element for syllabus automation initiatives. Free-text documents (Fiallos, 2018) can yield key syllabus components by employing NLP techniques that include Named Entity Recognition (NER) and topic modeling, as well as dependency parsing and transformer models (e.g., BERT, GPT). Numerous recent studies and pilot systems have explored the use of NLP for automated analysis and evaluation of educational and curriculum documents, including course syllabi. Rashtian et al. (2020) provide an overview of CRAgent, a tool built to demonstrate the possibilities of using NLP to assist in automated curriculum analysis. The computer program CRAgent allows one to quickly search and map course and program text against stated learning objectives, and more systematically and with greater specificity and scope than a manual review. The paper shows that NLP-driven instruments can help automatically identify and confirm or deny the existence of major syllabus items and the alignment with program results. Various articles have put forward the automatic mechanisms of NLP and Optical Character Recognition (OCR) in the process of grading written educational texts, e.g., answer scripts and essays. These systems apply techniques like tokenization, text similarity metrics (cosine similarity, Jaccard, and semantic matching), and machine learning (including neural models such as LSTMs) to automate evaluation and scoring tasks, demonstrating effectiveness in reducing the manual burden of assessment (Deepak et al., 2024). The adoption of structured rubrics and alignment to answer keys or official frameworks—paralleling syllabus analysis—has enabled high levels of automation,

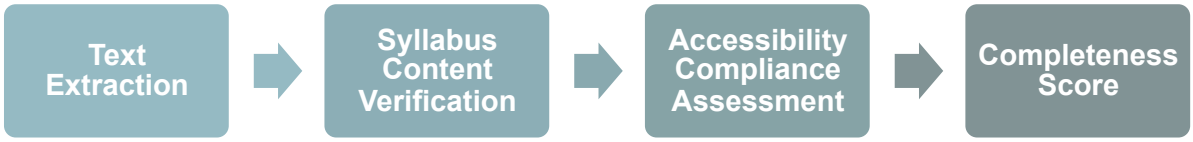
improving both speed and consistency (Gao et al., 2024). Lang et al. (2018) introduced an automatic framework that extracts learning goals and objectives based on their syllabus and uses a hybrid data mining technique that involves the utilization of Latent Dirichlet Allocation (LDA) and neural networks. Based on their system, they were able to process 70 syllabi to identify topic clusters of the syllabi and associate them with Bloom's taxonomy through topic modeling. A neural net was subsequently trained to project the discovered textual patterns to learning objective frameworks and provides a scalable way to create structured learning outcomes out of unstructured text. Parhizkar et al. (2010) presented a novel online course feedback mechanism possessing NLP and text mining capabilities that parse open-ended answers given by students. Although focused on post-course feedback rather than syllabus design, the system illustrates the potential of NLP in structuring educational feedback and documents.

The studies increase the existing body of knowledge, in that they show how NLP and AI methods can extract structured meaning from an unstructured text in education, be it to identify the learning objectives or carry out synthesis evaluation. Our proposed approach builds upon these foundations by combining component verification and accessibility analysis into a unified framework for syllabus evaluation.

Methodology

The proposed framework follows a structured pipeline that converts course syllabus documents into a standardized, machine-interpretable representation and conducts completeness assessment and accessibility compliance checking in an automated fashion. Figure 1 conceptually depicts the workflow, which is divided into four main stages: (1) text extraction and preprocessing, (2) content verification, (3) accessibility compliance assessment, and (4) scoring and report generation.

Figure 1
Workflow of the Syllabus Evaluation System



Text Extraction: Our initial dataset consisted of 36 syllabi from courses in the Information Science (IST) and Computer Science (CS) categories. One of the main input forms we chose is the .docx file format since it is common in schools, colleges, and universities, allows structural metadata to be embedded (such as headings, table components), and is simpler to process compared to PDFs or scanned documents. The syllabi were analyzed with the Python-docx library. Under this methodology, we extract:

- Paragraph Text: Course instructional data, policies, and descriptions.
- Table Content: Table structures are maintained and are often utilized in course schedules and grading distributions.
- Document Metadata: These would consist of heading styles, list markers, as well as inline formatting indicators, which are helpful in accessibility testing.

Verification of Syllabus Content: We developed a required component checklist. To detect the components that we have discussed in the previous sections of this paper, we implemented two detection approaches:

Baseline (Keyword Search): Each component was associated with a set of keywords (e.g., "objectives", "outcomes", "goals" for learning outcomes). A syllabus was marked as containing the component if any keyword was present.

Proposed (Semantic Embedding Matching): Using the all-MiniLM-L6-v2 sentence transformer, each sentence in the syllabus was embedded into a 384-dimensional vector space. Canonical descriptions of every mandatory component were also embedded. Cosine similarity was calculated between syllabus sentences and component vectors to define the presence of a component. Therefore, the detection was possible even in cases when the non-standard phrasing was used.

Accessibility Compliance Assessment: Along with the completeness of the content, we approach the question of accessibility, analyzing compliance with the accessibility requirements, paying attention to the 3 most important aspects:

1. Heading Structure: Confirms that headings are used with the semantic styles of the document and not the visual styles only. This is vital for screen reader navigation.
2. Alternative Text for Images: Checks to ensure that every embedded image has an alternative (alt) text attribute.
3. Table Header Tags: Checks that tables contain marked out header rows, without which users who use assistive technology will not be able to read the table.

These checks were applied directly on the document object model (DOM) parsed from .docx files, and we correctly identified formatting capabilities without using heuristic-based inspection of the text.

Scoring Completeness: We designed a two-tier scoring system:

- Component Score: The required syllabus items will each offer up to 1.0 points as long as they are present. The total number of components is used to bring the score to a standard level. The score is normalized by the total number of components.
- Accessibility Score: A maximum of 1.0 point is awarded for accessibility compliance, depending on accessibility compliance and fractional deductions given to each violation.

The Final Completeness Score is an explainable metric (0–100%) that can be compared across syllabi, which is computed as:

$$\textit{Final Completeness Score} = (\textit{Component Score} + \textit{Accessibility Score}) / 2 \times 100\% \quad (1)$$

The system produces three outputs for each syllabus:

- A dictionary-style report that lists the status of each required component (Present/Missing) as shown in Figure 2.
- A detailed list of accessibility violations and compliance checks, an example is shown in Figure 3.
- The Final Completeness Score.

Figure 2
Syllabus Evaluation System Output (List of Missing/Present Components)

Standard Syllabus Template

	Component	Status
0	Course Information	Present
1	Instructor Info	Present
2	Course Description	Present
3	Learning Objectives	Missing
4	Course Outline	Present
5	Course Requirements	Present
6	Textbooks	Missing
7	Grading Policy	Present
8	Attendance Policy	Missing
9	Academic Integrity	Missing

Figure 3
Syllabus Evaluation System Output (Accessibility Issues)

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Accessibility Issues:

Course Schedule Table Not Detected.
Heading Styles Found.
No Poor Link Text Found.
Images Found.
Image 1:Has alt text | Text: Illustration of a machine learning concept graph
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This multi-layer output design ensures that results can be used both for quantitative benchmarking and qualitative improvement.

Evaluation

We tested using a set of original course syllabi to assess the system to determine the accuracy of our proposed framework. The section presents the description of the dataset, the experimental design, performance measures, and the gained results.

Dataset: The evaluation dataset comprised 36 course syllabi, including courses from the Information Science (IST) and Computer Science (CS) subjects. The syllabi had all been converted into a .docx format so they were fully compatible with our text extraction and accessibility checking modules. The collected syllabi contain specific characteristics such as:

- Style of writing: from formal policy-oriented language to informal instructor-prepared notes.
- Structural organization: certain syllabi walked through templates established by an institution, whereas some were free form.

- Terminology: alternative wording of a similar element (e.g., learning goals vs. course outcomes).

Such differences offered a pragmatic testing platform to measure the strength of both the keyword as well as the semantic methods.

Experimental Setup: We compared two content verification methods:

1. Keyword Search (Baseline): A rule-based system where a list of keywords is maintained per component.
2. Sentence Embedding Matching (Proposed): We utilized the all-MiniLM-L6-v2 transformer to calculate semantic similarity between syllabus sentences and reference component descriptions.

We manually highlighted the availability or absence of the mandatory items in each of the syllabuses. The ground truth basis of such evaluation was provided through these annotations. All syllabi were subjected to accessibility checks, and the data were used to form the accessibility value in the final metric of evaluation.

Performance Metrics: We applied the metrics below to test the performance of the system with the ground truth:

- Precision – The proportion of detected components that were correct.
- Recall – The proportion of actual components correctly detected.
- F1 Score – The precision and recall in combined through a harmonic mean.
- RMSE (Root Mean Square Error) – This is to quantify the difference between the scores assigned by the system and the actual score.

Table 1

Comparative Performance of Baseline and Proposed Approaches

Detection Method	Precision	Recall	F1 Score
Keyword Search (Baseline)	0.22	0.20	**0.21**
Sentence Embedding (Proposed)	0.50	0.45	**0.47**

Result: Table 1 shows the performance of the keyword searching model and the NLP-based embedding approach. Semantic embedding method performed better in all the metrics when compared to the keyword search method, with the greatest part being achieved on the recall performance measure, i.e., the method is more robust toward the changes in phrase. Regarding the completeness score prediction, RMSE 1.74 implies a moderate difference between the human scoring and the model.

The comparison shows that the proposed NLP-based semantic matching method is significantly more useful than the keyword search in the detection of components of a syllabus.

Discussion

Evaluation results reaffirm that the semantic embedding technique produces a significant improvement of the traditional keyword-based method when it comes to synthesis-based detection of syllabus completeness. The F1 score is higher when using semantic matching (0.47) as compared to keyword search (0.21), which reflects the usefulness of the contextual understanding aspect of natural language processing. It is especially significant to the

academic environment, as course documents can be immensely different in their languages, manners, and shapes even when describing similar components.

The fact that the embedding model obtained a higher recall rate proves that it can recognize the elements of the syllabus presented in non-standard or subject-specific language. An example is the successful mapping of the embedded approach of associating the skills to be acquired and the learning outcomes component, but which failed in the keyword-based system. Such flexibility is needed to scale the framework to a wide variety of disciplines without exhaustive lists of keywords. An RSME of 1.74 about the completeness scoring indicates that, though the system is, overall, in agreement with human raters, there are some edge cases that the system is unable to work out. These consist of syllabi that partially cover a component but in an unusual format, so that the detection is less precise. The accessibility results also point to a notable gap: even well-designed syllabi commonly do not meet the bare minimum of satisfying digital accessibility requirements.

- More than half of the syllabi did not contain an adequate heading style, which restricts their usage by students who use screen readers.
- Almost 50 percent of them failed to provide alternative text to images, which puts learners with visual impairment at a disadvantage.
- Violation in the table header is less common, but it still applies to almost one-third of the sampled syllabi.

Figure 4

A List of the Syllabus Evaluation System's Output for Selected Syllabi

Filename	Completeness Score	Missing Elements	Accessibility Issues
CGDD422_SL.docx	89.60%	Textbooks	Images Missing Alt Text, Tables Without Headers
CGDD303 Advanced Game Networking.docx	91.70%	Textbooks	None
CGDD271Syllabus.docx	100.00%	None	Tables Without Headers
CGDD214_SL.docx	89.60%	Textbooks	Images Missing Alt Text, Tables Without Headers
CGDD213 Roleplay Realms.docx	91.70%	Textbooks	None
CGDD212_Deal, Dice, and Strategy.docx	91.70%	Textbooks	None
CGDD203 Intro to Networking.docx	91.70%	Textbooks	None
CGDD109jg_SL.docx	89.60%	Textbooks	Images Missing Alt Text, Tables Without Headers
CGDD101jg_SL_v2.docx	89.60%	Textbooks	Images Missing Alt Text, Tables Without Headers
AMUS_383-Syllabus[59].docx	97.90%	None	No Heading Styles, Tables Without Headers
AMUS201_Syllabus.docx	97.90%	None	No Heading Styles, Tables Without Headers
AMUS_382_Syllabus[82].docx	97.90%	None	No Heading Styles, Tables Without Headers
AMUS_381_Syllabus[5].docx	97.90%	None	No Heading Styles, Tables Without Headers
AMUS_337_Syllabus.docx	97.90%	None	No Heading Styles, Tables Without Headers
CGDD100 LevelUp Intro.docx	97.90%	None	No Heading Styles

These certainly provide an outline of how accessibility assessment must be integrated into any syllabus assessment scheme. Although outcomes are encouraging, a number of limitations should be noted in the current version of the proposed system:

1. Disciplinary Scope: The review focused on IST and CS syllabi. Fields that employ more narrowly focused terminology (ex., humanities, fine arts) may need extra adjustment of the system.
2. Format Limitations: The existing implementation accepts only .docx formats of files. The widespread use of PDFs in academic distribution poses problems in the verification of accessibility issues.
3. Fine-tuned Model: The all-MiniLM-L6-v2 embedding is a general-purpose model, which makes it effective. Corpus-level fine-tuning can be used to improve precision and recall on a corpus of syllabus documents.

Despite those limitations, it is evident that the proposed tool can reduce the time to review curriculum committees, assist instructors in adhering to requirements challenged by institutions.

Conclusion

The objective of this work is to propose a framework that uses state-of-the-art NLP methods to automatically determine the quality of completeness and the accessibility of course syllabi. Transforming free-form text into structured evaluations, the system helps identify missing elements and the existing accessibility gaps. Experiments with actual syllabi revealed that the model observes course elements more than a course content keyword search and provides conclusive, demonstrative feedback to educators and administrators. It is also scalable so that institutions can apply it to a large variety of courses without any extensive manual review. The current version has been tested with Syllabi in limited disciplines; however, expanding the database, checking the format support, and utilizing fine-tuned language models have the potential to improve the accuracy. The framework can develop into an effective instrument for enhancing the quality of the syllabus and inclusive practice with these additions.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The writers state that the manuscript's language was proofread and improved using AI-assisted writing tools, including Grammarly and QuillBot. The use was restricted to fixing spelling and grammar mistakes and rewording sentences to make them more precise and understandable. The author additionally states that no other AI or AI-assisted technologies were employed to generate material for the paper, except for Grammarly and QuillBot. The original writings of the methodology, findings, analyses, and discussion are the result of meticulous and methodical investigation.

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