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Impact assessment methods for teaching activities on sustainable development goals in higher education institutions: A case study from a Bosnian university

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Abstract
This study explores various approaches for assessing the impact of teaching activities on Sustainable Development Goals (SDGs). In addition to the well-known keyword search method, the study also introduces innovative methods utilizing text similarity algorithms, specifically Jaccard and Cosine algorithms. The performances of the traditional keyword search method and the proposed text similarity algorithms are then compared with the results obtained from a self-identification study conducted among the academic staff within the case study context. The strengths and weaknesses of each method are also discussed, aiming to contribute to a comprehensive understanding of impact assessment methodologies in the context of SDGs in education.

Keywords: Sustainable development goals, Keyword search, Text similarity, Data Mining, Higher education, Impact assessment

1. Introduction

By transferring knowledge and skills to individuals, teaching activities play a crucial influence in determining how society will develop in the future. With the increased attention being paid to sustainable development on a global scale, educators have a special opportunity to help the Sustainable Development Goals (SDGs) be achieved. The SDGs, endorsed by the United Nations (UN) in 2015, offer a thorough framework for solving urgent global concerns like eradicating poverty, environmental degradation, and social injustice.

Higher education institutions have a unique position not only for students but also for all of society, compared to other sectors, in terms of creating and disseminating knowledge. Education and research activities have a direct impact on all the SDGs, by supporting the implementation of each goal and the SDG framework as a whole. Learning and teaching activities can easily promote awareness, understanding, and engagement among students by educators by including sustainable development principles in the curricula. Additionally, educators may also disseminate the culture of sustainability outside the classroom by implementing sustainable practices in local or global projects or activities offered to the community. To secure a sustainable and prosperous future for everybody, it is critical for educators to understand their role in supporting sustainable development and to adopt new strategies.

In addition to their important impact on society, higher education institutions themselves also benefit from engaging with SDGs. The SDGs are a universally accepted framework that provides an organized structure, almost acting like guidelines for higher education institutions to become responsible institutions. By offering targets and measurable indicators, SDGs provide a new way for higher education institutions to demonstrate and communicate their impact and contribution to global and local well-being. This common framework is adopted among governments, businesses from different sectors, funders, and the community. It provides an opportunity for higher education institutions to collaborate and work together for common interests, potentially resulting in new partnerships and access to new funding streams.

Through their regular activities, without any additional effort, universities naturally contribute to the achievement of the SDGs. It is essential and valuable to adopt a well-structured approach to implementing the SDGs to ensure comprehensive engagement and maximize the impact of the university outputs. The engagement process of universities with the SDGs starts with the 'recognition'. The recognition step aims to map the ongoing activities and their contributions to SDGs. Following this step, the 'opportunities' are analyzed considering the current situation clarified by the recognition step. This step includes activities such as capacity building, creating ownership, identifying potential improvements, detecting gaps, and priorities. Finally, the 'organizing principle' focuses on the integration and implementation of identified targets. This last step is designed to monitor and evaluate the established plans to provide sustainable implementation [1].

As part of the 'recognition' step, mapping the university contributions to SDGs plays a crucial role in further discussions and ongoing efforts related to the SDGs by assessing strengths and weaknesses, building capacity, and facilitating reporting and communication. Additionally, it can contribute to forming a national or regional overview of expertise in the SDGs while identifying areas where more engagement is needed. There are three main approaches mostly implemented to measure the impact of the activities on SDGs: desktop assessment, self-identification, and keyword searches [1]. The desktop assessment approach involves a manual review of data sources and the assignment of activities to the SDGs, making it a simple but labor-intensive option that is suitable for small systems with smaller datasets. Self-identification relies on individuals identifying which SDGs their activities align with. Keyword searches use SDG-specific keywords to search through activity-related data. This method requires a technical and efficient approach to handle large datasets, and it would be better to be automated so that it will be easily reapplied when there is a change in the dataset. Here, the dataset can be the text taken from research reports, scientific articles, projects, or course descriptions, depending on the focus of the assessment process.

Several studies in the literature focus on creating an efficient tool for conducting keyword searches on university activities. In terms of research outputs, some recent studies worked on proposing keywords, tools, and different approaches [2], [3], [4]. For the teaching activities, [5] proposed methodology and tool applied to engineering degree programs as a case study. They developed an Excel tool and used an SDG keyword data set proposed by Monash University [6]. More recently, this study was extended with the introduction of a keyword scanning tool to quantify the SDG coverage for the learning outcomes (LOs) of a module in a university [7]. The researchers compared the results of the automated tool with the results of a survey they conducted among the academic staff via self-identification. They employed a Python code that scans the inputs from Microsoft Excel and matches the common keywords. However, this tool requires extensive preprocessing of the data including collecting all learning outcomes from various resources, formatting them, and creating Excel files. Considering the large database of universities with hundreds or thousands of courses, this preprocessing step can be cumbersome. Instead, in our study, an automated web scraping method was used to extract all necessary data from the university course catalog website, automatically format it, and prepare it to be used for analysis.

In this study, the primary objective is to assess the extent to which the curricula at the chosen institution, the International University of Sarajevo in Bosnia and Herzegovina, align with the principles of the UN SDGs. Recognizing the limitations of the keyword search method, which may not fully grasp the context of sentences, an alternative approach is also employed. Instead of relying solely on keywords, advanced text similarity

algorithms are implemented that consider not only the surface-level lexical matches but also the semantic understanding of the content about the UN-recommended learning objectives for the education for SDGs [8]. This alternative methodology, to the best of our knowledge, was not implemented before in this type of study and aims to provide a more comprehensive evaluation of the impact of teaching activities, marking a significant step forward in the assessment of sustainable development integration within university curricula.

This paper aims to present the implementation of these impact assessment methods via a case study, compare their results, and provide valuable insights on the efficacy of educational strategies in supporting sustainable development by analyzing the connections between educational activities and the SDGs. It utilizes a mixed-methods approach, incorporating both qualitative and quantitative components. Qualitative analysis involves assessing the semantic understanding of educational content about UN-recommended learning objectives for SDGs. In contrast, quantitative analysis involves comparing the results obtained from different assessment methods using statistical methods. In Section 2, the methodology in detail is: the data set used, web scraping process, keyword search method, and text similarity algorithms are explained. Section 3 includes the results and comparisons and lastly, section 4 gives the concluding marks.

2. Methodology

In this paper, a methodological study was conducted to examine and quantify the impact of teaching activities on the SDGs by utilizing different approaches and comparing their performances. A diagram is provided in Figure 1 to illustrate the steps of the methodological process implemented in this study.

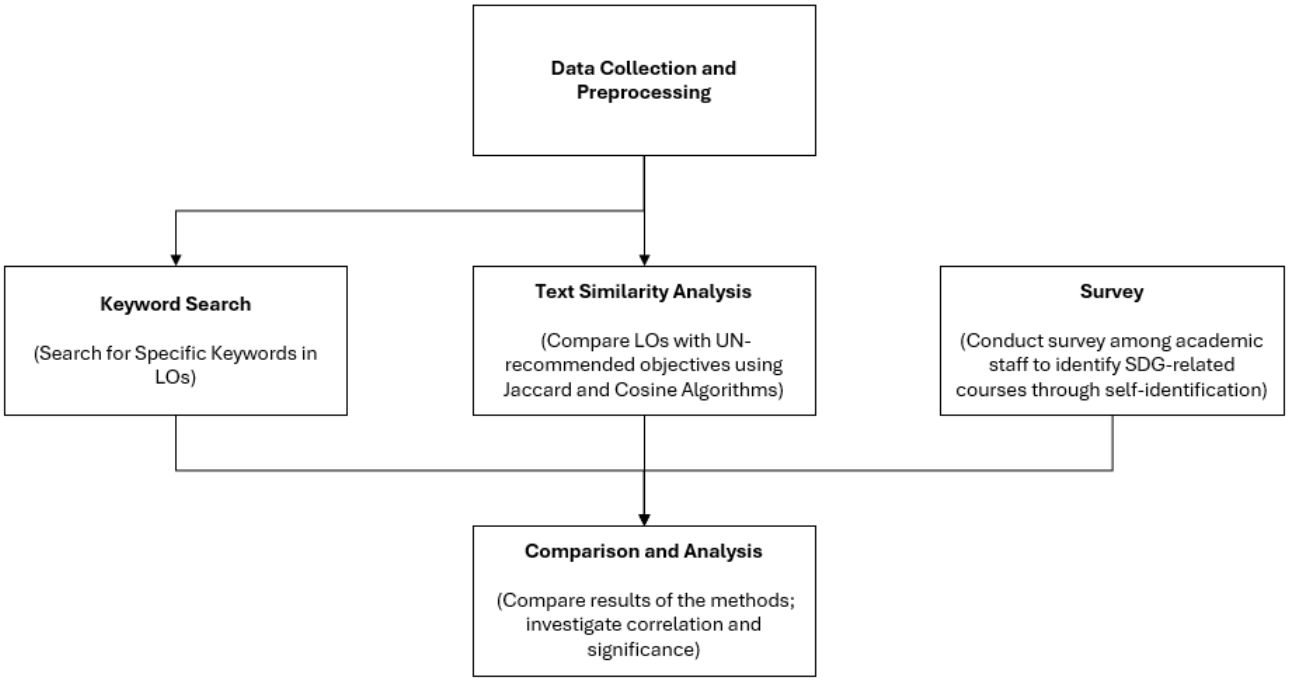

Figure 1. Methodological process

One of the most known and popular approaches is the keyword search approach which aims to search for specific keywords in activity-related texts and reports their frequency of appearance in the text. Since the primary focus of this work is teaching activities, the data set to be used contains course learning outcomes to gauge impact accurately. Learning outcomes are clear, measurable statements that define the knowledge and skills a learner will attain upon completing a learning activity. The first step is a thorough process that includes web scraping to extract learning outcomes of the courses offered by all academic programs under six faculties. After extracting the data from the web, a keyword search was implemented.

The next approach is the text similarity analysis that compares the learning outcomes of the selected university and the UN-recommended learning objectives. This approach implements two different algorithms: Jaccard and

Cosine text similarity algorithms. These algorithms consider more complex text similarities than simple keyword searches, such as the percentage of overlapping words or semantic similarities.

To compare the performances of these different assessment methods, a survey was conducted among the academic staff who are responsible for each program at IUS. Academic staff was asked to scan their curriculum and the syllabi of all courses offered and asked to report the SDG-related courses (self-identification). The results of this survey were then used for comparison, and the correlation between the results of the algorithms and the survey, along with their significance, was investigated.

2.1. Dataset

This study utilizes three separate datasets: the first comprises the learning outcomes of all courses offered by the selected university IUS, the second is a curated SDG-specific keywords dataset that will be systematically searched within the first dataset and the last dataset is the UN-recommended learning objectives for SDG education [8] which will be used for checking the text similarity with the first dataset. Figure 2 visualizes the datasets used for different models.

For the first data set, the International University of Sarajevo (IUS) was chosen as the case study. IUS is a prestigious foundation university located in Sarajevo, Bosnia and Herzegovina. IUS is renowned for its broad range of faculties and disciplines and its varied academic programs. IUS is one of the few universities in the region, that includes the importance and prioritization of SDG activities and contributions in their strategic plan and, to the best of our knowledge, the only university in the country with an SDG executive committee that is actively working on improving the impact of the university to SDG framework. This study involved a thorough scanning of the IUS course catalog [9], which includes all academic programs provided by the six faculties. The dataset includes learning outcomes of over 500 courses from various subject areas.

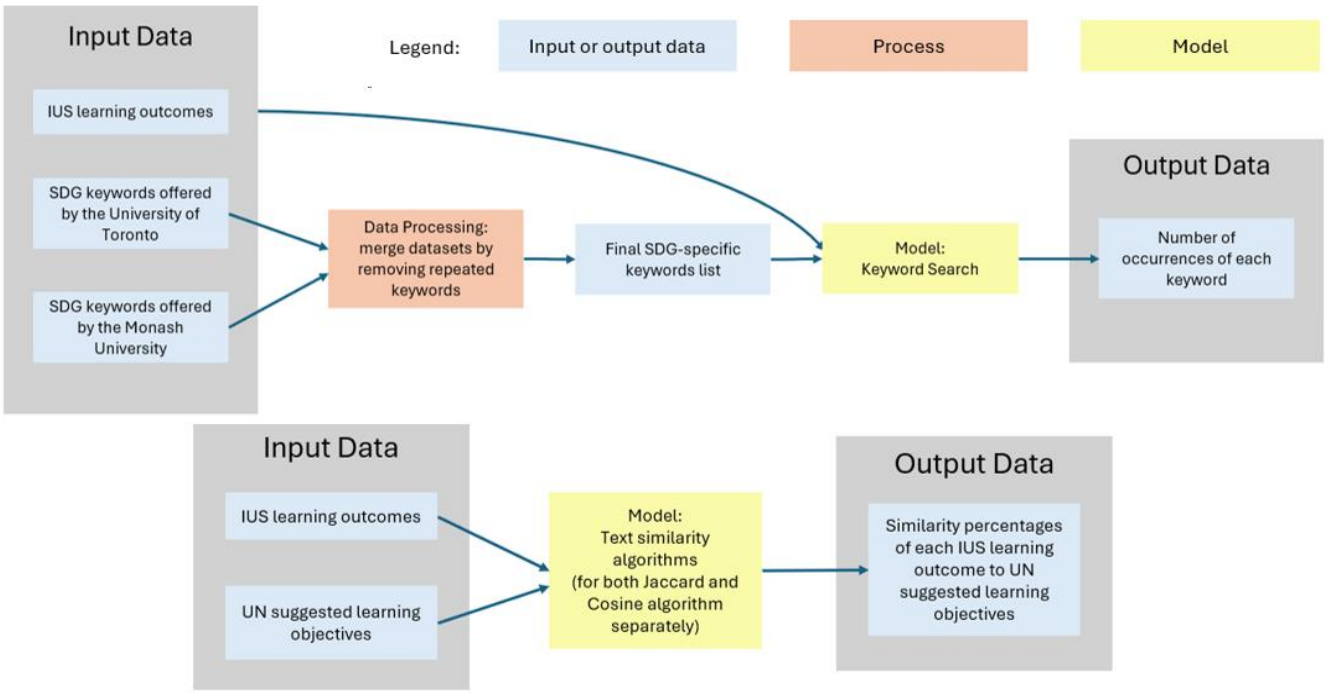

Figure 2. Datasets used for different models

The second dataset that is used in this study is a merged dataset of SDG keywords offered by the University of Toronto, The President's Advisory Committee on the Environment, Climate Change and Sustainability (CECCS) [10] and the data set proposed by Monash University [6]. The first data set was formed by CECCS using the UN Global Indicator Framework for SDG as a base, updated considering more keywords related to equity, diversity, and inclusion, and refined by removing the broad keywords to avoid false positives. This data set includes 388 keywords covering 16 SDGs. The second dataset includes the 915 SDG-related keywords

compiled by the researchers at Monash University. These two datasets are specifically designed for university activities and their combination provides a larger dataset for a more comprehensive search. For this study, these datasets were merged, and the repeated keywords were removed to create the final SDG-specific keyword list to be used in this study. In Table 1, the total number of distinct keywords resulting from the list used for this study is presented for each SDG. Note that SDG 17 was excluded from this study since it is difficult to quantify this goal and many works and datasets also did not include this goal.

Table 1. Number of distinct SDG-specific keywords offered by the University of Toronto and Monash University

	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16
# of keywords	43	69	91	82	51	75	55	76	54	82	84	72	81	61	72	92

The third dataset includes the UN-suggested learning objectives for each SDG, for the educators to improve their Education for Sustainable Development (ESD) via promoting, teaching, and learning of SDGs [8]. The document includes activities, suggested topics, and learning objectives that can be included in the courses to increase the impact. For each SDG, 15 learning objectives are suggested under three categories: cognitive, socio-emotional, and behavioral.

2.2. Web scraping

Web scraping was used to gather the learning outcomes (to form the first dataset), in which necessary information was taken from the university's web pages and combined into a structured dataset. This strategy made sure that a wide variety of courses and their associated learning objectives were included, allowing for a full examination of how the university curriculum relates to the SDGs. The data collection provides much information for analyzing the incorporation of sustainable development ideas inside the university's educational framework by utilizing web scraping techniques. This tool also helps the SDG implementers (in this case, the IUS SDG Executive Committee) to periodically conduct this analysis easily in case of an update in the learning outcomes.

A variety of technical instruments and techniques are used in this study project. For example, we employ multiple Python tools for text similarity analysis and Scrapy for web scraping. We can collect, handle, and analyze data from the IUS courses with the aid of these tools. We explore the technical details of our methodology, such as text comparison and web scraping methods, further in this work. In particular, we will go over how to use Signals, Spiders, CrawlSpider, LinkExtractors, Rules, and several Python functions like Choice and Random. These elements are necessary for data extraction, web page navigation, and data structuring for additional analysis.

To ensure that our readers have a thorough knowledge, we will go into great detail in the following sections about each software component and how it fits into our study methodology.

Python provides the foundation for statistical analysis and data manipulation since it is a flexible computer language. While Spyder offers an integrated development environment specifically designed for data science, Anaconda offers a comprehensive platform for scientific computing. Web scraping and data extraction are made possible by Scrapy and its related components, which are essential for obtaining pertinent information from internet sources. In web scraping, Signals are frequently used to produce personalized signals for various events that occur during the process. This enables specific particular actions to be taken when predetermined criteria are satisfied. The basic components of web scraping are Spiders. They are in charge of specifying how to click on links and get information from websites. Every Spider is customized for a particular website or collection of websites. CrawlSpider is a specific type of Spider class used to follow links on websites to gather data according to pre-established guidelines. It's especially helpful for more intricate and sizable websites. LinkExtractors are

tools that Spiders employ to find and retrieve links on webpages so they can visit other pages inside the website, which has been of great help while retrieving links of all the IUS syllabi. LinkExtractor is a particular implementation of a LinkExtractor that provides instructions on how to pull links using CSS selectors or XPath criteria, and for this study, links were pulled using CSS selector. CrawlSpiders use Rules to specify which callback methods to call when they come across particular links and how to follow them. They aid in giving the crawling process structure. Python's Random and Choice functions are commonly employed for producing arbitrary values or selecting options at random. They could be used to add variation to the web scraping process, like randomly generating user-agent strings to evade being identified as bots. Structured data is frequently stored in files with the extension CSV (Comma-Separated Values). CSV is frequently used in web scraping to store data that has been scraped in an organized manner for further analysis. The components ItemAdapter and Is_Item are commonly utilized in Scrapy to specify and modify the structure of data that has been scraped. While Is_Item is a function used to determine whether an object is an instance of a Scrapy Item, ItemAdapter assists in adjusting data to be compatible with Scrapy's Item classes.

Together, these elements define how to traverse webpages, gather data, and organize it for further analysis, so facilitating web scraping. When it comes to text similarity, information retrieved using these components can be further processed and examined to determine how similar textual content is across various sources. This can be useful in determining how instructional activities affect the SDGs through textual analysis. With the use of these instruments, we hope to successfully gather, handle, and evaluate data to assess how educational initiatives affect the Sustainable Development Goals.

2.3. Keyword search

This study uses keywords derived from reliable sources centered around the Sustainable Development Goals (SDGs). These sources' extensive inventory presents a strong framework that covers a broad range of keywords carefully selected for mapping and comprehending the many aspects of the SDGs. Through the incorporation of SDG-specific keywords derived from these credible sources, this study guarantees a thorough examination of ideas and themes associated with sustainable development, supporting its content with credible and internationally accepted terminology following the guidelines set forth by these respected organizations.

The extraction of learning outcomes from IUS syllabi has been made possible using Python web scraping, which has been important in facilitating the automated and methodical gathering of this educational data. After obtaining the learning outcomes, a methodical procedure is implemented in which every keyword from the SDG-specific keywords list linked to the SDGs is carefully reviewed. Using a case-insensitive method, the script carefully verifies if every keyword appears in the cleaned learning outcomes. When a match is found, indicating that the learning outcome and the specific SDG-related idea are in alignment, the script gathers these matches in lists by labeling them with corresponding SDG numbers. This systematic methodology facilitates a thorough evaluation of the syllabi's alignment with the SDGs while also streamlining the identification process and ensuring that learning results are accurately attributed to the relevant SDGs. The steps of the algorithm are presented below:

1. Initialize an empty list to store SDG-related matches.
2. Obtain the learning outcomes from syllabi.
3. Clean the learning outcomes (remove any irrelevant information).
4. Create a list of SDG-specific keywords.
5. For each keyword in the SDG-specific keywords list:
   a. Convert both the keyword and the cleaned learning outcomes to lowercase.
   b. Check if the keyword appears in the cleaned learning outcomes.
   c. If a match is found, label it with the corresponding SDG number and add it to the list of matches.
6. Evaluate the syllabi's alignment with the SDGs by analyzing the collected matches.
7. Streamline the identification process by organizing the matches.
8. End the algorithm.

In Table 2, two examples of the matching keywords and learning outcomes are presented. In the first row, ARCH355 has multiple matches for SDG11, which is an accurate matching also in terms of the meaning of the keywords under this SDG. However, in the second row, another example is listed where the word 'class' has an exact match in terms of the letters, but the word 'class' is used with a different meaning in the learning outcome. The SDG1 keyword 'class' aims to represent societal classes. Conversely, the Advanced Programming course offered by the Computer Sciences and Engineering department uses the term 'class' to refer to a fundamental technical concept in programming. This is one of the biggest weaknesses of the keyword search method and the practitioners need to implement additional fine-tuning steps manually to detect and remove these incorrect matches due to irrelevancy, as implemented in some studies in the literature [5].

Table 2. Example of matching keywords

Course Code and Title	Learning Outcome	Matching SDG keyword	Matching SDG
ARCH355 Advanced Urban Design	Enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management in all countries	sustainable, urban	SDG11 Sustainable cities and communities
CS105 Advanced Programming	Define, explain, and use the various data structures discussed in class	class	SDG1 No poverty

2.4. Text similarity algorithms

In the previous section, the keyword search study is explained. However, there is a weakness of this known keyword search method: it is not as strong for being able to catch the context of the sentence by only using keywords. An alternative approach would be to implement text similarity algorithms that consider semantic understanding. To our knowledge, in the literature, there is no similar work implemented for the teaching activities and SDGs mapping studies. To be able to implement these algorithms, as the reference text, the UN recommended learning objectives [8] are used and compared with the existing learning outcomes of IUS. Jaccard and Cosine text similarity algorithms are selected for this case study.

Jaccard Similarity is a straightforward algorithm to comprehend. It is intuitive because it computes similarity using set intersection and union. Results of Jaccard Similarity can be simply interpreted as percentages. It measures how much a set of words overlaps with another set. The Jaccard similarity coefficient (J) is calculated as:

$$J(A,B) = |A \cap B| / |A \cup B|$$

where |A ∩ B| represents the number of common elements (namely, words) in the sets A and B, and |A ∪ B| represents the total number of elements in the union of sets A and B. However, Jaccard Similarity does not consider the semantic ties between words; it just considers word overlap. There may be little Jaccard Similarity between two statements that have the same meaning but different wording. Still, it offers a more sophisticated scan than the keyword search method by potentially grouping more than one keyword which increases the chance to capture the context of the text.

Cosine Similarity uses Term Frequency - Inverse Document Frequency (TF-IDF) vectorization and considers the semantic connections between words. The Cosine similarity coefficient of two vectors A and B (the vectors A and B represent TF-IDF representations of the texts) is calculated as:

$$C(A,B) = (A \bullet B) / (||A|| * ||B||)$$

where (A • B) represents the dot product of vectors A and B and ||A|| and ||B|| represent the Euclidean norms (lengths) of vectors A and B, respectively.

In this method, similarity ratings may become more significant as a result. It is a flexible similarity metric that is frequently utilized in a variety of natural language processing (NLP) activities, including text categorization and document retrieval. Since each text document requires a different vector to be created and TF-IDF vectorization, the method utilizing Cosine Similarity is more complicated. For best outcomes, TF-IDF parameters (such as tokenization and weighting algorithms) may need to be adjusted depending on the application.

In some tasks, Jaccard Similarity is more suitable and straightforward, particularly when the emphasis is on the set overlap. Conversely, Cosine Similarity provides a more advanced method that takes semantic meaning into account and may be better appropriate for situations where the context and substance of the text are important. On the other hand, greater processing power and tweaking of the parameters might be needed. In this study, these two methods are implemented to capture the similarities between IUS's existing learning outcomes and UN-recommended learning objectives. The pseudo-code for the implementation process of both algorithms is given below:

1. Initialize necessary data structures and import required modules.
2. Define a function for text preparation that:
   - Tokenizes input text.
   - Removes English stopwords.
   - Lemmatizes words.
   - Returns processed text.
3. Obtain the learning outcomes from syllabi.
4. Create a list of UN-recommended learning objectives.
5. Apply text preparation function to both datasets
6. Loop through each LO and each UN objectives
   - Calculate the Jaccard/Cosine similarity between two input texts.
   - Convert the similarity coefficient to a percentage.
   - Print and save results if similarity $\geq$ 20%.
7. End the algorithm.

3. Results and discussion

This section provides the results obtained from the three methods implemented in all courses offered at IUS. The aim is to compare the results and to see if these three methods provide consistent results. Later their results were compared with the survey (self-identification) results. The first implemented method is the traditional keyword search as described in section 2.3. Using the combined dataset described in section 2.1, the learning outcomes of all courses offered in IUS are scanned and keyword frequencies are reported. In Figure 3, the total number of keywords that occurred in the set of all learning outcomes for each SDG is presented. Note that the number of unique keywords for each SDG is different (see Table 1). This can lead to misinterpretation of the presented results. For example, the number of keywords defined for SDG 10 is almost double the number of keywords that exist for SDG 1 in the keyword datasets. To avoid this situation, the total number of keywords in the keyword datasets should also be considered.

SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16
137	103	25	210	28	35	23	237	196	291	70	66	31	10	8	114

Figure 3. Frequency of keywords for each SDG

An adjusted frequency index is defined to better report the keyword search results. This new index simply considers the occurred keyword per the suggested keyword from the dataset. It is calculated by taking the ratio

of the number of occurred keywords and the number of total SDG-specific keywords in the dataset for that SDG. For example, for SDG 1, there are 43 distinct keywords suggested by [6] and [10], and the number of keywords found in the IUS learning outcomes dataset is 137. So, the adjusted frequency index can be calculated as 137/43, which results in 3.19. Namely, 3.19 keywords occurred per keyword in the suggested keyword dataset. Figure 4 shows the adjusted frequency index for each SDG. Notice that, even though the general pattern is kept, there are differences especially in SDG 1 and SDG 9, since their number of suggested keywords for the keyword search is relatively less than the other SDGs.

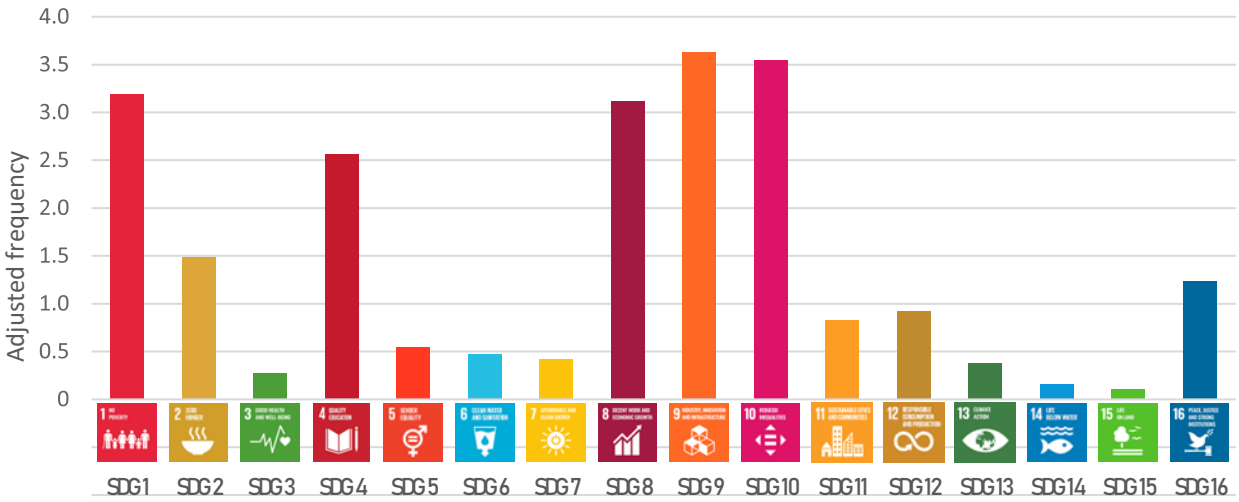

Figure 4. Adjusted frequency of keywords for each SDG

The second method implemented to assess the impact of teaching activities on SDGs is the text similarity algorithms. Here, instead of single keyword searches, the learning outcomes as a whole sentence are scanned for similarity to the recommended SDG-related learning objectives. These algorithms give percentages to represent the similarities between two sentences, in this case, each learning outcome and each recommended learning objective. In this study, the threshold for reporting similarities is chosen as 20%. The total number of learning outcomes which has a similarity of more than 20% for the learning objectives under each SDG is reported. This method, as expected, resulted in a lower number of matching courses with SDGs. Also, it is important to note that the number of suggested learning objectives under each SDG is a fixed number, namely 15, therefore, there is no need for normalization or calculating another indicator to report these results as we required for the first method, keyword search.

Table 3. Example results of Jaccard similarity

Course Code and Title	Learning Outcome	Suggested learning objectives and similarity	Matching SDG
MAN352 Consumer Behavior	Identify the dynamics of human behavior and the basic factors that influence the consumer's decision process.	The learner can participate in and influence decision processes about their community. (SDG11-LO12) Similarity: 26%	SDG 11 Sustainable Cities and Communities
ME411 Renewable Energy Technology	Compare different renewable energy technologies, choosing the most appropriate one, based on local conditions at the given site.	The learner can apply basic principles to determine the most appropriate renewable energy strategy in a given situation. (SDG7-LO12) Similarity: 21%	SDG 7 Affordable and Clean Energy

First, the Jaccard text similarity algorithm is implemented. In Table 3, two learning outcomes from two different courses, and their matched (more than 20% similar) learning objectives are presented. Note that, the Jaccard

algorithm measures the overlap of a set of words with another set, therefore it does not consider the semantic relations between words.

Figure 5 visualizes the distribution of matched learning outcomes over SDGs. It is interesting to observe that SDG 9, which has the highest adjusted frequency value (see Figure 4), has the lowest similarity matches in the Jaccard algorithm method.

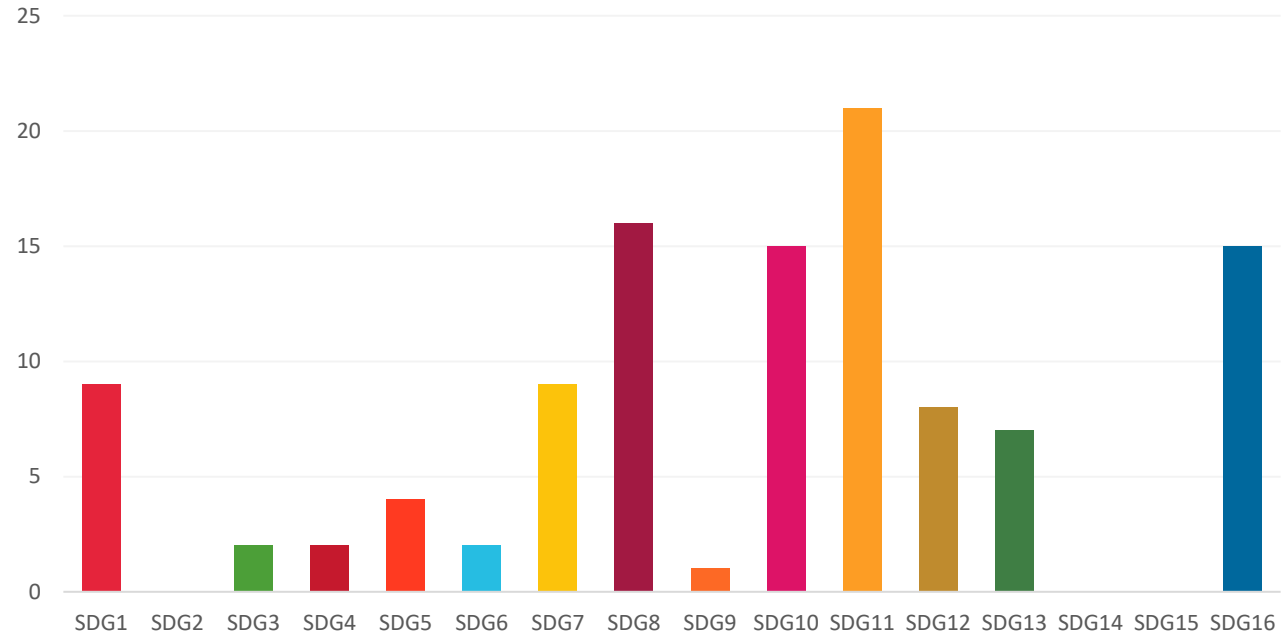

Figure 5. Number of learning outcomes with similarity greater than 20% for Jaccard algorithm

Secondly, the Cosine text similarity algorithm is used to detect the similarities between IUS learning outcomes and UN-recommended learning objectives. This algorithm considers the semantic ties between words, this is why the similarity ratings are expected to be more significant. In Table 4, two examples are presented which were detected to be similar to more than 20% of the recommended learning objectives. Also, in Figure 6, a bar chart is given to present the number of learning outcomes with similarity greater than 20%, detected by the Cosine algorithm.

Table 4. Example results of Cosine similarity

Course Code and Title	Learning Outcome	Suggested learning objectives and similarity	Matching SDG
IR467 Energy Security	Demonstrate an understanding of the key issues and challenges related to energy security from national and global perspectives	The learner knows about different energy resources – renewable and non-renewable and their respective advantages and disadvantages including environmental impacts, health issues, usage, safety, and energy security, and their share in the energy mix at the local, national, and global level. (SDG7-LO1) Similarity: 22%	SDG 7 Affordable and Clean Energy
LAW307 Tax Law	Appraise tax justice in Bosnia and Herzegovina and the use of the tax system to promote equality in the country	The learner can compare their system of justice with those of other countries. (SDG16-LO3) Similarity: 22%	SDG 16 Peace, Justice, and Strong Institutions

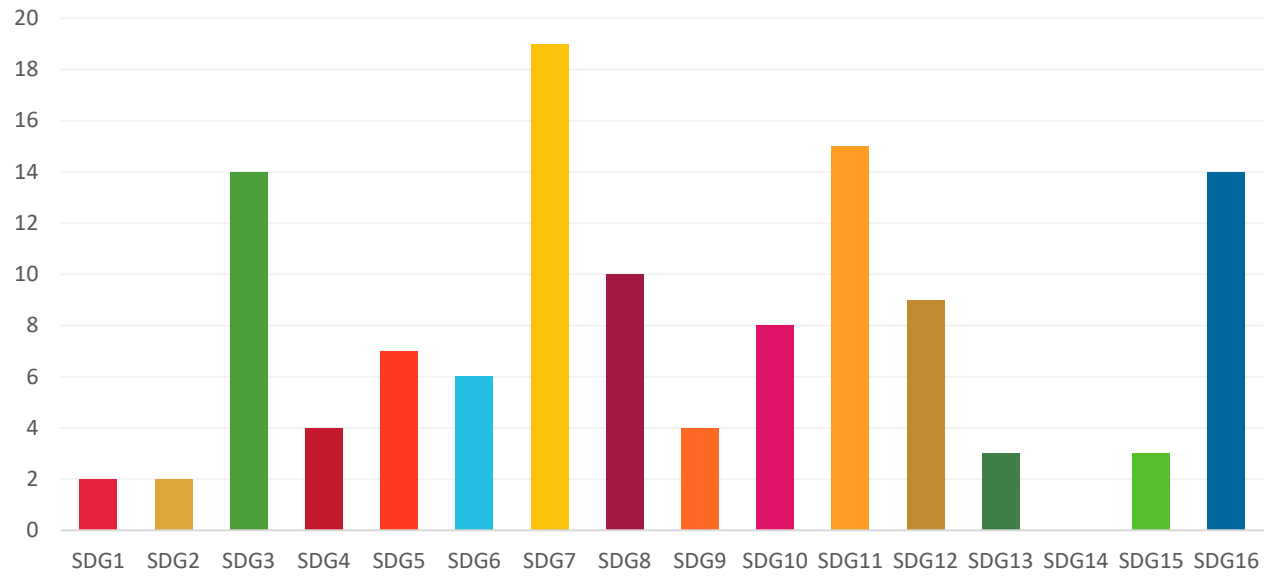

Figure 6. Number of learning outcomes with similarity greater than 20% for the Cosine algorithm

In addition to the automated approaches, a survey was also utilized to collect input from the academic staff at IUS. The program coordinators were contacted and asked to check their existing curriculum and report back relevant courses that can be related to specific SDG goals. The survey resulted in low attendance, but eventually, 33 courses were reported to be strongly related to a specific SDG. Figure 7 presents the distribution of these courses over SDGs. Even though it is a small dataset, it can give an idea of the strongly and weakly impacted SDGs for the implementers and it can serve as a useful indicator for reporting and decision-making processes. This manually collected data is used as reference data for statistical analyses detailed below, to compare the performances of the applied algorithms.

Statistical analyses help to evaluate the effectiveness and efficiency of traditional keyword searches versus innovative text similarity algorithms and self-identification studies. Statistical tests help us to determine the significance of differences in results obtained from each method, providing valuable insights into the strengths and weaknesses of each approach.

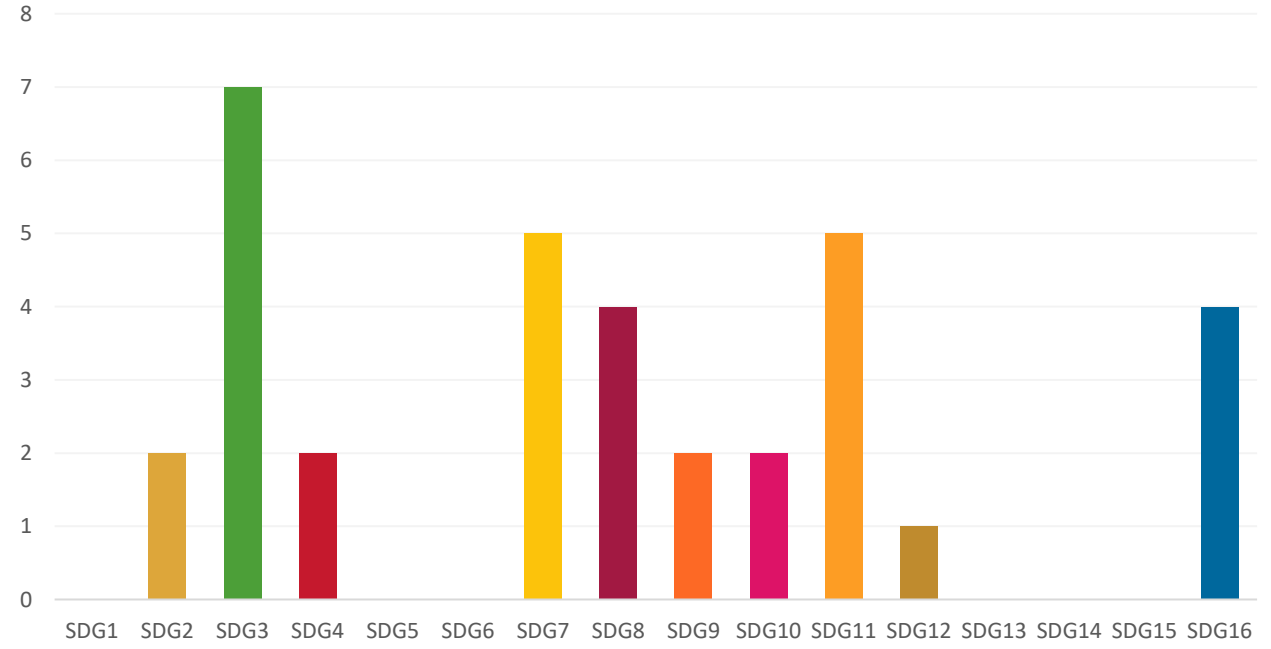

Figure 7. Number of courses matched by the teaching staff manually (self-identification)

For the statistical analysis, we define our hypothesis for methods, Keyword Search, Jaccard Similarity, and Cosine Similarity as follows:

where $i \in \{KS, JS, CS\}$, for methods, Keyword Search, Jaccard Similarity, and Cosine Similarity, respectively.

H_{i_0}: There is no significant linear relationship between the values generated by $method\ i$ and observed data (generated by the teaching staff manually),

H_{i_1}: There is a significant linear relationship between the values generated by method i and observed data (generated by the teaching staff manually)

Table 5 summarizes the results of the Pearson correlation coefficient and p-values for these 3 methods highlighting the statistically significant results ($p < 0.05$).

Table 5. Pearson correlation coefficients and p-values for 3 methods

Method i	Pearson correlation coefficient	p-value
Keyword Search (KS)	0.164	0.529
Jaccard Similarity (JS)	0.441	0.076
Cosine Similarity (CS)	0.792	0.000

The only method with a statistically significant relationship with the reference values, namely the number of manually matched courses for each SDG, is the Cosine Similarity method. The Pearson correlation coefficient for the CS method is 0.792 which indicates a strong positive linear relationship. This suggests that the Cosine Similarity method is quite effective in aligning courses with the SDGs. The datasets used in this study were not large enough to conclude precise results. However, it is important to see the potential of the Cosine text similarity algorithm to be used in automatically detecting the impact distribution of teaching activities over SDGs. Using these text similarity algorithms, the practitioners can quickly scan the courses and see the potential areas of improvement and the strengths of the existing system. One of the drawbacks of these algorithms is the requirement of a reference dataset, such as UN learning objectives for this case. For the keyword search method, there is also a requirement for a set of keywords, but these datasets can be used from different resources offered by different institutions. For the suggested learning outcomes, that text similarities require, datasets are more limited compared to keyword sets. With the introduction of more enhanced and comprehensive learning outcome datasets, the performance of these similarity algorithms can be further improved.

4. Conclusions

Including the SDGs in education is essential for raising responsible, knowledgeable, and empowered people who can actively contribute to sustainable development. Higher education institutions have the chance to mold future generations by embracing the SDGs, preparing them with the values, knowledge, and skills required to tackle global issues and build a more sustainable and inclusive society for all.

To be able to improve any process, one should be able to measure it first. For this reason, mapping the impact of activities on SDGs is essential for the implementation of SDGs in any institution. This paper proposes a successful implementation of different automated approaches for the assessment of the impact of teaching activities on SDGs and provides discussions on the weaknesses and strengths of each method.

A careful self-identification study can yield more accurate results than some algorithms. However, the labor-intensive nature of this method makes this approach nearly infeasible for implementation in large systems. Other approaches that have the opportunity to be automated, such as keyword searches and text similarity algorithms, offer a powerful tool for practitioners of their quick applicability, even with large datasets. One possible strategy is to employ these methods as supportive tools in addition to self-identification. Another advantage of these

approaches is the flexibility. With an enhanced input dataset, there is potential for an improvement in their performance. The use of AI tools to generate these initial datasets can serve as an effective implementation to improve the performance of these text similarity algorithms.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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