Application of Artificial Intelligence as a Tool for the Continuous Improvement of Higher Education Courses

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***Abstract*—Continuous improvement strategies, informed by research-based decisions, play a pivotal role in advancing education. Nowadays, the use of artificial intelligence for data analysis offers profound insights into the perspectives of a studied population. These insights serve as critical decision support for refining improvement strategies. This study proposes employing AI such as Microsoft Azure Learning, a Microsoft Excel Add-In, and Voyant Tools 2.2, to analyze survey data from an interdisciplinary undergraduate students enrolled in a "Circular Economy" course. The analysis focuses on evaluating text answer of students to open-ended questions focused to collect students' opinions regarding course content, its relevance to their field of study, and the performance of professors. Textual responses were subjected to sentiment analysis to classify overall sentiment (positive, negative, or neutral), and complemented by generating word clouds and word linking diagrams to create a context, this analysis was eperformed by using Microsoft Excel Add-In, and Voyant Tools 2.2, for sentiment analysis and word clouds and linking diagrams respectively. Obtained results revelated a general positive perception about the course, and field of applicability. Nevertheless, a negative connotation was found for the question related to course content and professor performance, closer analysis revealed negative sentiments was focused on course organization and interdisciplinary work, rather than professor performance. In addition, these tools identified crucial concepts of Circular Economy for students and its relevance to their careers. This multi-tool approach facilitates pinpointing areas for course enhancement and provides actionable recommendations to decision-makers, aiming to improve course effectiveness and enhance student satisfaction.**

***Keywords*—artificial intelligence, continuous improvement, professional education, natural language processing systems, interdisciplinary course, educational innovation**

I. Introduction

Since the 1990s, as global development drives dynamic customer expectations, and increases competition, industries and corporations have adopted various Continuous Improvement (CI) tools and methodologies to remain strong in market [1]. In education, improvement science serves as a guide with a systematic approach directed at scholar-practitioners for CI in the field, considering three main pillars: 1) identifying a problem to solve or goal to achieve, 2) implementing strategies or changes, and 3) evaluating and measuring success [2]. The challenge of CI in education sector, lies in the fact that improvement opportunities and measures may encompass a wide range of areas, actions, and indicators [3]. Consequently, various CI projects and methodologies with different levels of participation and impacts, have been applied in the education sector. Examples include Kaizen, six sigma, DMAIC (Define-Measure-Analyze-Improve-Control), design-based school improvement, Data teams, teacher research, DBDM (Data Based Decision Making), among others [3–5]. These methodologies have been widely utilized in other industries for decades with positive results. To promote evidence-based decisions making, the DBDM methodology has gained popularity in recent years. Consequently, educators have become collaborative and active participants in data collection and interpretation. However, they face challenges in interpreting the data and the need for advanced statistical knowledge, and tools [5]. Fortunately, Artificial Intelligence (AI) now offers a fundamental driver for education development, as it has done in other industries, transitioning from AI in education to AI for education. This involves using platforms, intelligence evaluation systems, and other tools to understand, learn from, and create conducive education environments [6]. The use of AI to analyze text and perform sentiment analysis classification has emerged as commonly used technique to address the challenge of understanding students' perceptions, feelings and improve how learning occurs and how various factors can influence it. Researchers frequently turn to the use of AI, machine learning and other lexicon-based approaches for sentiment analysis [7]. Sentiment analysis examines groups of words withing a text and identifies emotions expressed with a positive or negative connotation. This analysis has garnered interest in recent years because the results are considered to provide insight into the thoughts of the studied population, which can be used as decision support in developing improvement strategies [8]. According to Zhou and Yu [9], most sentiment analysis studies in education reported in the literature have focused on higher education courses, employing a hybrid approach with machine learning and lexicon-based tools. These studies primarily focus on teachers/educators as the main stakeholders, with only 10% of studies were performed in interdisciplinary groups. Furthermore, most studies have aimed to design methods of sentiment analysis, with only 17% examining the relationship among sentiment, behavior, performance, and achievement, as well as evaluating teachers' performance [9].

However, various issues are associate with sentiment analysis techniques, such as the lack in the detection of sarcasm, irony, and other language-specific challenges that AI may not identify, leading to a "false positive" or "false negative" sentiment [7, 8]. Moreover, inaccuracies in adhering to grammar rules result in a wide range of accuracy rates [10]. Another limitation in information analysis and

interpretation through sentiment analysis is the source and level of specificity of the analyzed text. Analysis can be conducted at the document or sentence level; accuracy varies when detailed information about aspects and assigned sentiment polarities is required [11]. The literature review reveals a limited number of cases in education where sentiment analysis has been used to evaluate students' perceptions. It also emphasizes the need for standardized procedures to conduct and report the results of such studies and highlights the impact of the lack of contextualization and conceptualization in sentiment analysis studies, which decrease results accuracy [12].

To address these issues, other tools such as word clouds and link diagrams could complement the information obtained from sentiment analysis. The aim of this study was to propose the use of AI sentiment analysis tools in conjunction with word clouds and word linking diagrams for analyzing survey data to identify areas of opportunity and deploy improvement strategies of a higher education course.

II. Literature Review

Sentiment analysis has been widely recognized as a valuable tool for understanding the emotions and perceptions of users and costumers across various industries. Numerous studies have assessed the effectiveness and accuracy of sentiment analysis tools in different languages including Portuguese, Italian, Spanish, and French, using the Microsoft Azure ML platform. These studies have found the platform to be effective in constructing sentiment analysis models suitable for data analytics. Despite variability in accuracy, ranging from 79% to 92% depending on the language, the data generated can be applied to a wide range of potential applications [13, 14].

Businesses can leverage sentiment analysis information to inform decisions regarding the implementation of programs aimed at promoting costumer well-being and satisfaction [15]. For instance, Powel *et al*. [15], analyzed emotional changes among costumers of an Italian restaurant before and during the COVID-19 pandemic using social media comments. They observed a shift in sentiments with a 12 % increase in negative sentiments and a 15% decrease in positive sentiments during the pandemic compared to previous periods. However, the authors caution that the absence of sarcasm evaluation limits the interpretability of the findings. Another study by Kumar and Kumar [16], compared user perceptions of two different cloud-based services, from a competitive standpoint using sentiment analysis. Such comparisons serve as indicators of market competition dynamics and can inform companies' decisions regarding marketing strategies. In realm of education, researchers from Penn University applied sentiment analysis to assess students' perceptions of learning efficacy at the university. Similarly to Powel *et al*. [15], the authors noted that while sentiment analysis provides a general overview, it may not capture nuances, necessitating the integration of additional analysis tools for a more nuanced understanding [17]. Kumar and Kumar [16], complemented sentiment analysis findings with the word clouds, offering a visual summary of the main factors identified by costumers in the analyzed text. This approach facilitates more precise conclusions regarding identified sentiments and their associated text. Word clouds have emerged as valuable data visualization tools due to their simplicity and ability to rapidly highlight relevant information in a text [18]. Additionally, they enable the synthesis of vast amounts of information, condensing it into the most prevalent or repetitive contextual words, thereby facilitating the review of only pertinent or impactful information [19]. Finally, the correct and complementary use of AI tools promises effective management of information. According to some authors, if it is correctly executed and interpreted, AI can be used not only to analyze existing data but also to identify new opportunity areas in research and future work, thereby accelerating scientific advancement and impact [20].

III. Materials and Methods

A. The Course and the Students

The study was conducted using information collected during a course titled "Circular Economy" taught in person at Tecnologico de Monterrey, located at Guadalajara, México. The course followed an intensive learning model consisting of 120 hours distributed over five weeks, during which students received theoretical, and practical information. Additionally, an industrial partner was involved to facilitate the translation of learned concepts into proposals to address real-life situations.

The participants in the study comprised an interdisciplinary group of 62 students in their eighth and final semester of bachelor programs from the Business, Engineering and Law schools at Tecnologico de Monterrey, Guadalajara, México. The students pursued various bachelor' s degrees, including Finance, Business Administration, Law, Industrial Engineering, Biotechnology Engineering, Civil Engineering, Computer Science and Technology, and Biomedical Engineering. The interdisciplinary course aimed to develop cross-cutting sub-competencies related to systemic thinking and sustainability principles. It was delivered using a team-teaching model, with contributions from three different professors from the Engineering School, three from Business School, and five professors from Law School. Furthermore, the course execution was divided into three stages; i) learning of theoretical and conceptual aspects of Circular Economy, Materials, and Sustainable Processes, taught by each of the participating schools individually from their disciplinary perspectives; ii) interdisciplinary work, and team integration involving students from all the schools, where they shared their perspectives on the subject, and initiated proposals meeting the industrial partner's requirements; and iii) integration of interdisciplinary proposals presented to the industrial partner and professors through an oral presentation.

B. The Questionnaires

The professors developed a questionnaire that was administered to the students of the "Circular Economy" course at the end of the term. This questionnaire aimed to measure students' knowledge of circular economy and their personal perceptions regarding the course' s performance and application. It consisted of multiple-choice and open-ended

questions to assess knowledge and perceptions, respectively. For this study, only three open-ended perception questions were utilized: A) How did you feel about this course in terms of thematic content, environment, and teaching methods? B) What are your feelings and thoughts about the concept of circular economy in your career after receiving this course? and C) What are the most important ideas you have taken away from the course, and what would you include for future interactions? These questions aimed to gauge students' feelings along three main dimensions: A) the course content, the industrial partner, and the professors' performance, B) the perception of the concept, relevance, and application of the course in their disciplines and professional life, and C) the overall perception of the course.

C. Use of AI in the Interpretation of Results

The responses to the open-ended questions were subjected to sentiment analysis using the Microsoft Azure Machine Learning add-in for Excel (Fig. 1). Microsoft Azure sentiment analysis is an AI tool included in Microsoft Excel package, that employs natural language processing techniques to analyze a provided text and assign a score from zero to one, with zero associate with the most negative sentiment and one with the most positive.

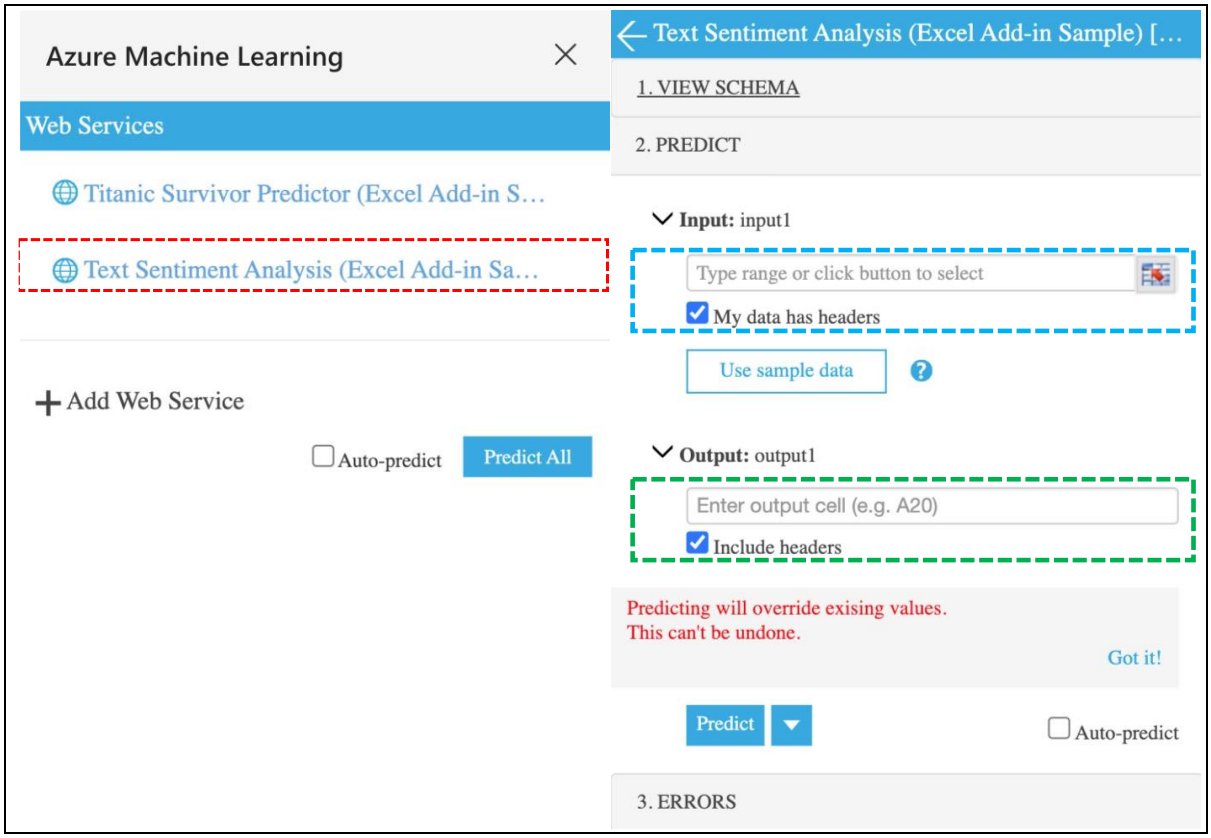

Fig. 1. Microsoft Azure Machine Learning add-in for Excel and its required parameters -Azure service; -cells that include students' responses; -cell where the results will be deployed.

The students' responses were organized into different Excel sheets, including the responses and the students' disciplines for future analysis. The data were then manually cleaned to remove blanks, numbers, and others special characters that could interfere with the analysis. Subsequently, Azure sentiment analysis was performed by providing the necessary information to the add-in and selecting the Randomized Response Sampling (RRS) prediction model (Fig. 1). The results of the sentiment analysis were categorized by students' disciplines and analyzed to determine the distribution of positive and negative perceptions and study the relationship between students' careers and their perceptions in the different evaluated areas.

To further associate perceptions and sentiments with opportunities areas, Voyant Tools 2.2 was employed to generate Word Clouds and Word Link diagrams for each separate question. Voyand tools were configured to create 25-word clouds, using red and New Times Roman, fonts for positively categorized words and green and Comic Sans Ms for negative categorized words, respectively. Additionally, to gain a clearer understanding of the context used by the students in their responses, a link diagram of the words was obtained using a context of three.

Microsoft Azure sentiment analysis from Microsoft excel add-in and Voyand tools were chosen to conduct the study due their accessibility and intuitive use. Microsoft Azure' s offers a user-friendly platform, making it accessible to a broader range of users without requiring extensive coding or programming knowledge. Complementing this, Voyant Tools' visualization features offer dynamic and visually engaging representations of sentiment data through word clouds and word linking diagrams. These visualizations facilitate deeper insights into students' perceptions, allowing for the identification of key themes and patterns.

Overall, the accessibility of the combined use of Microsoft Azure' s Sentiment Analysis and Voyant Tools is particularly beneficial in educational settings, where researchers and

educators may not have specialized technical expertise. Additionally, both tools are freely accessible, and users do not require deep knowledge of coding or programing language to perform the necessary analysis. These characteristics made this AI tools more appealing than typical software such as R or other programing software.

D. Ethical Implications

Ensuring ethical practices in research involving participant data is paramount. In this study, strict measures were implemented to protect the personal data of participants and uphold their rights to privacy and confidentiality.

Prior to administering the questionnaire via Google Forms, participants were thoroughly informed about the purpose of the study, how their information would be used, and the measures taken to protect their privacy. They were assured that their participation was voluntary and that they had the right to withdraw at any time without consequences. To safeguard participant anonymity, the questionnaire did not collect any personal information that could directly identify individuals. Instead, responses were collected anonymously through the Google Forms platform.

Throughout the data collection process, stringent protocols were followed to ensure that all responses remained confidential and anonymous. Data were securely stored and accessed only by authorized researchers involved in the study. Any identifying information inadvertently provided by participants, such as names or email addresses included in open-text responses, was promptly removed, or anonymized to protect confidentiality.

By adhering to these ethical principles and practices, the study upheld the rights and welfare of the participants while ensuring the integrity and validity of the research findings.

IV. Result and Discussion

The data obtained for Questions A, B and C were grouped based on their sentiment -positive, negative, or neutral- and then counted to determine the overall percentage of negative, positive, and neutral responses for each question (Fig. 2). The results revealed a predominant distribution of negative sentiments in Question A (54%), while Question B received predominantly positive sentiments (57%), and Question C received predominantly positive sentiments as well (67%). In each case, the majority sentiment accounted for more than 50% of the analyzed data (Fig. 2). These findings suggest that students dissatisfied with the course performance and content, yet they express satisfaction with its relevance and application in their disciplines. Furthermore, the general perception of the course and suggestion for improvement are positive.

Table 2 shows the distribution of scores obtained for each question, categorized by students' disciplines, with zero representing the most negative and one representing the most positive. The grand total values, representing the mean of all positive, neutral, and negative individual scores, reveal insights into student perceptions across disciplines. For "Question A" which assesses students' perceptions about the course content, industrial partner, and professor's performance, a negative perception was observed among all the students, irrespective of their discipline. However, it is noteworthy that negative scores where more pronounced among engineering students (0.32326), followed by business students (0.40301), while law students demonstrated a score (0.47765) close to neutral sentiment. This could be attributed to the notably high positive score (0.723739) exhibited by the law school, the highest among the various disciplines. In contrast, the grand total values for "Question B", which gauges the general perception of the concept' s relevance and application in students' disciplines and professional lives, varied across disciplines. While business students exhibited a positive sentiment (0.59706), engineers expressed neutrality (0.50013) and lawyers leaned slightly towards negativity (0.48338). Notably, and intriguing pattern emerged for this question, as both business and law students demonstrated a lack of neutral perceptions. Instead, their scores indicated a firm stance on the subject' s utility, with the most negative and the most positive scores of 0.051265 to 0.74258, respectively. Regarding the overall perception of the course, grand total scores reflected a positivity across all disciplines, with engineers registering the highest score (0.644339), followed law students (0.61510) and business students (0.53800).

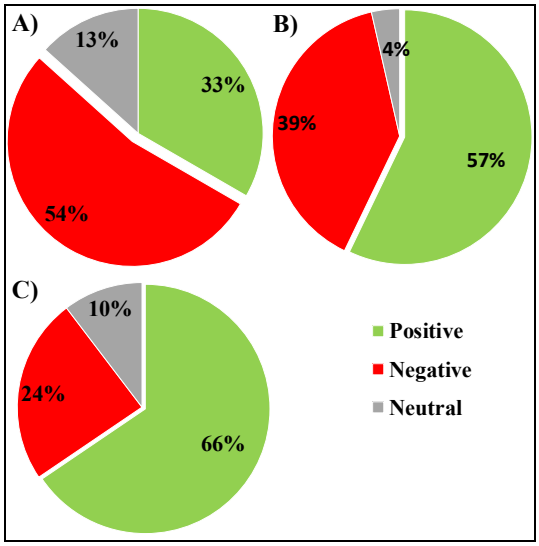

Fig. 2. Distribution of the student' s perception about: A) The course content, and performance B) Circular economy relevance and application in their disciplines; C) General perception of the course.

Table 2. Sentiments distributions categorized by students' disciplines and questions

Question	Students discipline	Sentiment score			
		Positive	Neutral	Negative	Grand Total
A	Business	0.72379	0.59402	0.20824	0.47765
	Lawyers	0.66170	0.48739	0.18790	0.40301
	Engineers	0.68072	0.53262	0.16131	0.32326
B	Business	0.74258	NR	0.20901	0.59706
	Lawyers	0.74242	NR	0.05165	0.48338
	Engineer	0.69633	0.54885	0.21571	0.50013
C	Business	0.66974	0.54649	0.33826	0.53800
	Lawyers	0.72245	0.51547	0.33826	0.61510
	Engineers	0.77215	0.54658	0.29370	0.64439

A) The course content, and performance B) Circular economy relevance and application in their disciplines; C) General perception of the course. NR: No Reported.

The Azure sentiment analysis data revealed that the primary opportunity area for the improvement in this course lies in the course content, industrial partner collaboration, and professors' performance (Question A). However, since this question encompasses multiple aspects, determining the specific improvement measures required remains unclear. This ambiguity arises from the fact that Question A cover various dimensions, such as course content and industrial partnerships, each presenting distinct levels of difficulty and potential transformation for the course. Similarly, while the overall perception of the course is positive, there is no clear delineation of the specific aspect contributing to this positivity. Although the data indicate that students have had a positive experience, pinpointing the exact elements of the course responsible for this sentiment is challenging. Consequently, identifying which existing practices should be retained to sustain this positive experience becomes difficult. To address these challenges, word clouds and link diagrams were generated to establish connections between the identified sentiments and the most frequently occurring words withing their respective contexts (Fig. 3). The word clouds display the 25 most frequently used words for each question, with negative-scored words highlighted in red and positive-scored words highlighted green.

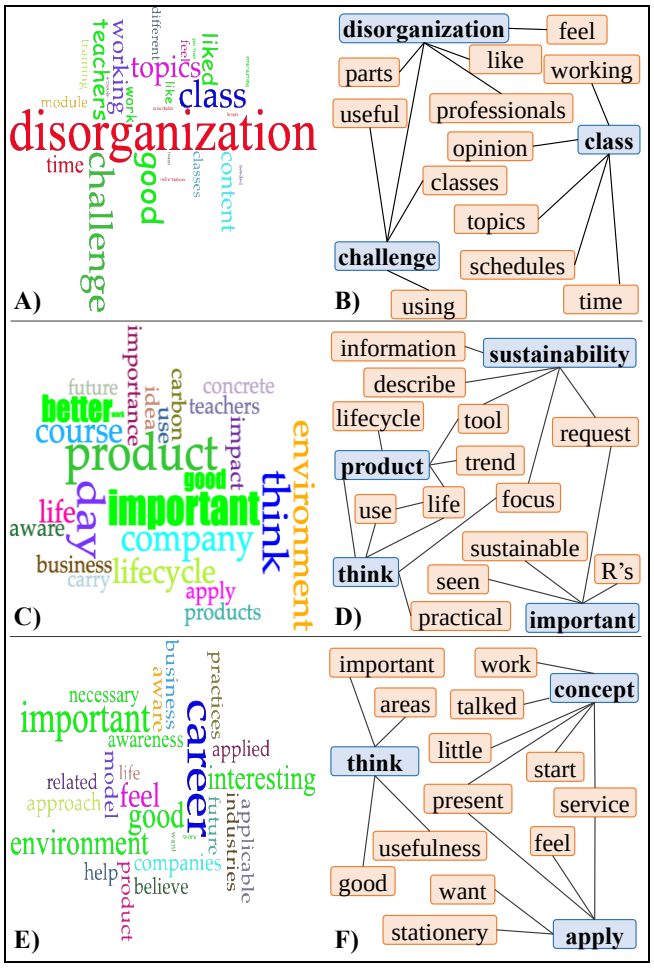

Fig. 3. Distribution of the student' s perception as the most mentioned words in form of word clouds and how these words relate between them by the construction of word linking diagrams. A-B): The course content, and performance C-D) Circular economy relevance and application in their disciplines; E-F) General perception of the course.

Regarding Question A, the word cloud (Fig. 3A) reveals "disorganization" as the most frequently occurring word with a negative score, along with other negative words such as "time", "hours", "schedules" and "information", this suggest that negative sentiments are primarily related to organizational issues and the duration of the course, which was an intensive with sessions lasting 4 to 6 hours. Conversely, some positively scored words observed in green include "teachers", "challenge" and "partner", indicating that students are satisfied with the instructors, the industrial partner, and the challenge (interdisciplinary proposals made to the industrial partner). The link diagram of this question (Fig. 3B) illustrates that "disorganization" is linked to words such as "professionals", "challenge", "parts", "like" and "feel". This context implies that students feel a lack of organization when collaborating with other professionals in the challenge. Notably, this was an interdisciplinary class where the main interaction among students from different disciplines occurred during the resolution of the challenge. On the positive side, the link diagram shows that the concept of the challenge is associate with words like "classes", "topics", "useful", and "using", indicating that students perceive the challenge as valuable and applicable to their learning from classes and topics.

For Question B most of the words revelated in the word cloud (Fig. 3C) are shown in green as positively scored words. Despite individual analysis showing negative perceptions among lawyers, no relevant red words are observed. Words such as "Important", "product" and "good" are the most frequently repeated, and all scoring positively. The link diagram (Fig. 3D) demonstrates that students associate "importance" with "sustainability", and "product" with "lifecycle", suggesting that students perceive the relevance of circular economy concepts in their disciplines through the lenses of sustainability and product lifecycle (Fig. 3D).

Finally, in Question C, the general positive perception is reflected in the word cloud (Fig. 3E), with words such as "important", "awareness", interesting", "necessary", and "environment" being the most repeated, all with a positive score (Fig. 3E). The link diagram (Fig. 3F) shows the connection of "think" to "important", "usefulness", and "good", summarizing the final thoughts of the students, indicating their commitment to the importance and applicability of the course.

After complementing sentiment analysis with word clouds and link diagrams, several suggestions can be made to enhance students' positive perception of the course:

- Organization: professors should pay more attention to organizing the courses and facilitating collaboration among students.
- Course duration: consideration should be given to reevaluating and possibly adjusting the duration of the course to address students' perceptions about time and schedules.
- Content and professors: while no general changes in the course content of professors are required, some adjustments may be necessary for law students, who do not perceive the course as relevant to their careers.

The results underscore the benefits of using AI-based technological tools for analyzing qualitative information and

translating it into continuous improvement suggestions. Based on these findings, the authors propose a general data analysis strategy for identifying areas of opportunity and developing strategies to improve courses and enhance students' experiences, as shown in Fig. 4.

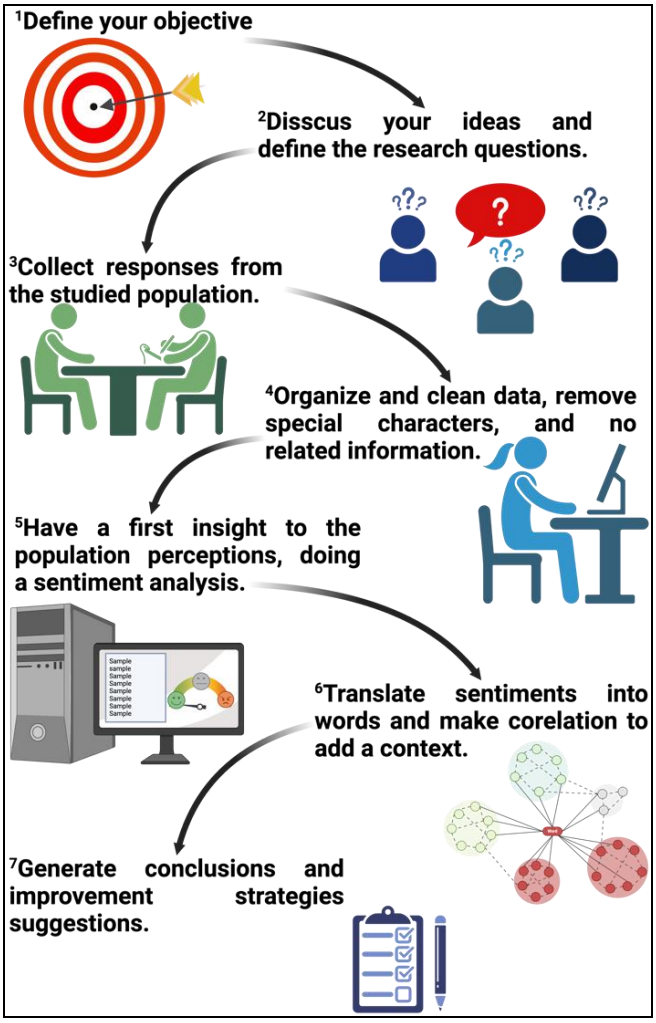

Fig. 4 General strategy of analysis of data for the identification of opportunities areas and development of strategies to continuous improvement.

V. Conclusion

The present studio showed the combination of an easy-to-use AI tools for the analysis of the answers received in a questionary applied to students of an interdisciplinary course called Circular economy, to interpretate the students' responses and suggest course improvement strategies.

The used AI tools were Microsoft Azure sentiment analysis for the determination of the general perception of the students classifying the answers as positive, negative, and neutral; and Voyant Tools 2.2 where the students' answers were used to create word clouds and word linking diagrams to interpretate the previously determinate sentiment translating it into words.

The questionaries were designed to explore three areas of interest i) the course content and performance ii) the relevance and application of Circular Economy in students' disciplines, and iii) the general perception of the course. While sentiment analysis results indicate a positive overall perception of the course among students, a closer examination of individual questions reveals negative sentiments regarding about the course content and performance. However, further analysis using word clouds and word link diagrams revealed that these negative sentiments were primarily related to course duration and organizational issues, while the professors' performance elicited positive sentiments. Another important finding facilitated by the combination of these tools was the identification of key concepts withing Circular Economy relevant to students' careers.

Overall, the use of AI tools enabled the qualitative analysis of data to identify opportunities for improving an interdisciplinary course in Circular Economy. Sentiment analysis provided insights into student satisfaction levels, while word clouds and link diagrams offered context to the sentiments expressed, facilitating the identification of specific areas for improvement and the development of focused strategies. The versatility, availability, and ease of use of these tools make them suitable for application in various academic and professional settings.

Future research could focus on using these tools to monitor changes in student perceptions over time, across modules, and during interactions, providing insights into the effectiveness of intervention strategies.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

K.G.C.A. Made the application of surveys, data analysis and conceptualization and writing of the paper; E.R.V: Made the design of the surveys and support the paper conceptualization and reviewing; L.V.N: Made the design of the surveys and support the paper conceptualization and reviewing; M.M.G.P: Made the design of the surveys and application, and support the paper conceptualization and reviewing; all authors had approved the final version.

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