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PAPER

Prototype for Analyzing Instructor Profiles in Online Courses: A Fuzzy Logic-Based Approach

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ABSTRACT

Online education has grown exponentially in recent years, becoming the main form of education in many countries due to the global pandemic. However, evaluating the performance of online instructors can be challenging as obtaining accurate feedback from students is not always easy. This research project proposes an intelligent evaluation model for analyzing the instructor's profile in online courses using fuzzy deformable prototypes. By identifying the personality traits and emotions expressed by students in surveys, the model evaluates the instructor's personality based on the five main traits of psychology: openness to experience, conscientiousness, agreeableness, extraversion, and neuroticism. The results obtained can help instructors improve their methodologies and communication, providing better quality online education. The proposed method involves data cleaning, natural language processing, and fuzzy logic analysis, and the results are presented in a user-friendly web interface. The approach has the potential to revolutionize instructor evaluation in online education.

KEYWORDS

online education, instructor evaluation, fuzzy logic

1 INTRODUCTION

Online education has experienced significant growth in recent years, revolutionizing the way people access knowledge and develop their skills. As digital technologies advance, online education has become an increasingly popular alternative to traditional education. This approach allows students to learn at their own pace and overcome geographical barriers, providing educational opportunities to people from different places and socio-economic conditions.

Assessing teacher performance in online subjects is critical to ensuring the quality of education and effective learning of students. Although assessment of teachers in online settings presents unique challenges, there are several tools and approaches that can be used to measure their performance, and some [1] intelligent assessment methodologies based on diffuse logic and expert knowledge-based systems enable

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abstract concepts of a human experience to be converted into a numerical inference system applied to the evaluation. In essence, it seeks to replicate the cognitive processes used by evaluation experts.

Distance learning requires teachers to make innovative teaching decisions to optimize the elements of distance learning, improve the quality of teaching activity and achieve sustainable development. Existing studies tend to select distance learning schemes based on empirical knowledge, but these approaches are constrained in terms of efficiency and accuracy due to poor decision parameters and prone to human error. In order to overcome these deficiencies, Lili Zhao [2] focuses on optimizing teaching decisions using data from distance learning platforms. A hybrid neural network model is proposed that combines Bi-LSTM and CNN to capture the characteristics of teaching decisions over time and build a more expressive characteristic space. In addition, a multi-objective TDO model based on diffuse logical reasoning is developed to address the challenge of multiple combinations of decision elements in distance education, meeting the required standards.

The article titled "An Extension of Fuzzy Deformable Prototypes for predicting student performance on Web-based Tutoring Systems" [3] presents an extension of Fuzzy Deformable Prototypes (FDPs) using interval type-2 fuzzy sets, aiming to enhance the capability of FDPs in handling uncertainty and imprecision. This extension is applied to predict the academic performance of students using web-based tutoring systems. The prediction model utilizes behavioral patterns to determine the future academic performance of new students based on their similarity to previously identified prototypes. Interval type-2 fuzzy sets (IT2FS) are employed to address the imprecision in academic data caused by the overlapping between fuzzy representations of the prototypes.

Online education has been a powerful tool for expanding access to education, overcoming geographical and socioeconomic barriers. Evaluating teacher performance in online environments is crucial to ensuring educational quality, and approaches based on fuzzy logic and expert systems have been developed to measure their performance [1]. Additionally, making innovative decisions in distance education requires addressing uncertainty and imprecision. In this regard, extending Fuzzy Deformable Prototypes using interval type-2 fuzzy sets has proven to be an effective solution. This combination of techniques allows for managing imprecision and modeling uncertainty in predicting students' academic performance in online tutoring systems. These advancements in decision optimization and academic performance prediction, based on fuzzy logic, have the potential to further enhance the learning experience in virtual environments and maximize educational outcomes.

1.1 Why should we evaluate the personality of the teacher?

Personality [4] is defined as "lasting patterns of perceiving, relating, and thinking about one's environment and self". Personality traits are prominent aspects of personality that manifest themselves in a wide range of important social and personal contexts. They are tendencies to feel, think and behave in a relatively coherent way over time and in those situations in which the dominant trait could be manifested. That is, the personality influences both the vocational choice of people of teaching, and their daily work tasks.

Therefore, it is necessary to emphasize that teachers, as educators of future professionals, have the responsibility to be examples not only in terms of their

experience, knowledge, and skills for life, but also in terms of personality traits that can be learned through observation. In this way, teachers have a social impact not only through their pedagogical work, but also as role models, which emphasizes the importance of evaluating their distinctive personality traits.

Finally, it is important to consider personal aspects of teachers that could influence the impact of psychosocial factors on their health. Psychological [5] factors, such as people's personality traits, may be related to health and disease processes. At present, there are theoretical models that explain the mechanisms by which personality characteristics are related to health. These models include the biological or constitutional predisposition model, the behavioral model associated with the disease, the stress modulation model and the behavioral model or risk/health behaviors. The personality traits most related to disease susceptibility are neuroticism and negative affectivity.

1.2 The Big Five personality factors

The dimensional model of personality, known as the Big Five, posits that there are five fundamental personality factors. These factors were derived through the factorial analysis of the words people use in everyday language to describe personality traits, employing the lexical approach to personality [6]. This line of research was initiated by Robert McCrae and Paul Costa, who identified the Big Five: neuroticism, extraversion, openness, agreeableness, and conscientiousness. Numerous studies support these five factors and their significance in understanding human personality [7].

1. **Neuroticism.** It pertains to individuals who are frequently plagued by negative emotions such as worry and insecurity. Emotionally, they are more volatile than stable [6], [7].
2. **Extraversion.** It characterizes individuals who are friendly, fun-loving, affectionate, and talkative. They often appear happy and experience positive emotions. They are likely to be biologically more sensitive to pleasure than others. What distinguishes the typical extravert is an active and energetic happiness [6], [7].
3. **Openness.** Experts provide various labels for this factor: culture, intellect, intellectual interests, intelligence, and imagination. It is described using terms like artistic, curious, imaginative, intuitive, original, and broad-minded. Individuals with openness to experience are more likely to find effective solutions to problems [6], [7].
4. **Agreeableness.** Also referred to as social adaptability or kindness, it indicates that a person is friendly and accommodating, avoids hostility, and tends to get along well with others. They are pleasant and kind, in contrast to those who are unkind, described as suspicious, insensitive, and uncooperative [6], [7], [8].
5. **Conscientiousness.** It is also identified as seriousness, impulse control, and achievement orientation; it describes differences in individuals' organization and self-discipline. Generally, they have a higher motivation for achievement in academic and work contexts [6], [7].

In the field of psychopathology, an alternative model to the traditional categorical approach of personality is proposed, known as the dimensional perspective. This perspective considers that all individuals fall on a dimensional spectrum of traits.

In other words, traits apply to everyone to varying degrees, moving away from the categorical distinction of traits as present or absent [9].

The domains of personality traits encompass a spectrum of more specific facets of personality that tend to appear together. According to the American Psychiatric Association, five specific domains have been identified [9]: negative affect, detachment, psychoticism, antagonism, and disinhibition.

1.3 Fuzzy logic

The use of fuzzy logic has gained significant acceptance in society, and fuzzy systems are increasingly being implemented in various domains. The versatility and adaptability of fuzzy logic make it a valuable tool in addressing real-world problems that involve imprecision and ambiguity. As a result, the utilization of fuzzy logic continues to expand and find relevance in a wide range of disciplines [10], [11].

Fuzzy logic has had significant applications in electronic information processing. In certain fields of knowledge, its statements are assigned truth values that represent broader degrees of truth or falsehood than just "true" or "false". In a deductive system, there are "input" statements and "output" statements. The objective of any fuzzy logic-based system is to describe the degrees of truth of the output statements based on the input statements. Furthermore, some systems can adjust the degrees of truth of the output statements as the input statements are adjusted. These properties make certain fuzzy logic systems resemble learning systems and excellent mechanisms for process control. From a technological perspective, fuzzy logics fall within the realm of so-called Artificial Intelligence and have given rise to fuzzy expert systems and automatic control systems [12].

2 METHODS AND MATERIALS

2.1 Sample

Survey responses from students provide valuable data for instructor assessment. [13]. As a result, it is critical to comprehend their thinking as well as the dynamics of the teaching-learning process throughout the semester. The collection of this data is the first step in improving teaching procedures and creating appropriate environments for learning for students [14].

For this reason, the study was conducted in three stages at a private university in Ecuador and a public university in Mexico. The participating courses are listed below:

- Stage A: At the middle of spring 2022, a survey was conducted among the distance learning courses of "Advanced Artificial Intelligence" and "Hardware Fundamentals". The survey received 16 responses, which provided valuable insights for identifying areas of improvement for subsequent data collection stages.
- Stage B: Towards the end of summer 2022, adjustments were made to the survey to enhance its acceptance among students. The courses "Research Methodology and Study Techniques" and "Thesis Seminar" decided to participate, resulting in a total of 61 student responses.

- Stage C: Towards the end of autumn 2023, a new survey was distributed to courses offered in the in-person mode. The courses included in this stage were "Intelligent Systems", "Discrete Structures", "Semiotics", "Hardware Fundamentals", "Film Appreciation" and "Investigative Journalism". The survey was well-received by students, generating a total of 349 responses.

2.2 Data collection

The dataset was compiled based on what students believed to have happened during the school year, as detailed below. Data was collected from eight classes that covered a range of topics in the Advanced Artificial Intelligence and Hardware Fundamentals courses to create the initial dataset (middle of spring 2022). The length of every lesson was three hours. As a partial evaluation of the enrolled course was completed in the eighth week, the ninth week was selected as an appropriate opportunity to obtain information on how the students regarded the classes. It is crucial to remember that the goal of this dataset was to establish initial contact with the students and evaluate their responses to the survey's initial set of questions to improve it as the experiment moved closer to its conclusion. 16 students were part of the survey. Table 1 shows the specifications and instructions that were used for creating this prototype.

Table 1. Requirements and acceptance standards

Requirements	Acceptance Standards
Survey Dataset	Student responses written freely and subjectively about the enrolled courses to evaluate the instructor.
Data Cleaning	Identifying grammatical and spelling errors to ensure data coherence and consistency.
Recognition of Personalities and Emotions in Student Responses	Identifying the personality traits and emotions expressed by students when analyzing each obtained response.
Prediction of Instructor Profile	Applying fuzzy logic to predict the instructor's profile based on the personality and emotion conveyed in students' comments, generating the Big Five traits of the instructor.
Registration of Instructor Personality Information	Gathering statistical values of the instructor's personality traits for further analysis.

The second dataset (end of summer 2022) was administered during the final week of the academic period to the courses: "Advanced Artificial Intelligence", "Hardware Fundamentals", "Research Methodology and Study Techniques" and "Thesis Seminar." At this stage, students were familiar with the teaching methodology and the instructor's approach, which allowed for a more accurate evaluation of the enrolled course. A total of 61 students participated in the survey. Building upon feedback received regarding question clarity, a new survey was developed and administered for the third dataset (end of autumn 2023). This dataset received a high response rate, with 349 students completing the survey in the following courses: "Intelligent Systems", "Discrete Structures", "Semiotics", "Hardware Fundamentals", "Film Appreciation" and "Investigative Journalism." All surveys incorporated the three evaluation areas employed by the institutions: communicative ability, course content, and course evaluation. Details about the obtained datasets are presented in Table 2.

Table 2. Information regarding from surveys

Dataset	Platforms	Description
Initial dataset (spring 2022)	Google Forms	Participants: 16 Sent questions: 7 Quality of information: short responses that cannot be effectively analyzed
Second dataset (summer 2022)	Microsoft Forms	Participants: 61 Sent questions: 9 Quality of information: better responses, but with limited relevance for accurate analysis
Third dataset (autumn 2023)	Microsoft Forms	Participants: 349 Sent questions: 8 Quality of information: Long and relevant responses that were effectively analyzed

2.3 Evaluation metrics

To evaluate this prototype, heuristic evaluations were used as a valuable tool for assessing the quality of fuzzy logic, as well as ensuring data cleanliness and interface usability [15]. Experts in those fields were involved to evaluate the system based on established standards and principles. Each item was evaluated on a Likert scale from 1 to 5 to determine if the required criteria were met.

The validation of the prototype was conducted using a weighted matrix of heuristic evaluation, which involved the manual inspection of a series of parameters and assigning a measure to each of them. Experts had access to the system and performed the necessary review of the prototype to assess its behavior according to the proposed modules in the metrics, recording the obtained score for each feature in Table 3.

Table 3. Obtained module scores

	Data Cleaning Score	Fuzzy Logic Score	Interface Usability Score
Expert Instructor	35	35	30
Expert Psychologist	35	35	30
Expert Engineer	33	35	27
Percentage score per module	98.09%	100%	96.66%

A statistical examination of reliability was performed using Cronbach's Alpha coefficient to assess the dependability and correctness of the results in an actual scenario. Cronbach's Alpha coefficient is a commonly used statistical tool to assess the reliability or internal consistency of items in a test. This tool is valuable because it measures the reliability of evaluations conducted by different assessors who objectively rate the system in question based on specified heuristic criteria [16].

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum S_i^2}{S_T^2}\right] \quad (1)$$

To calculate the coefficient, it is necessary to know the number of items (K), the sum of the item variances ($\sum S_i^2$), and the variance of the total observed items (S_T^2). This coefficient allows evaluating the consistency of the validation conducted and determining the accuracy and reliability of the assessment. A high Cronbach's Alpha

coefficient indicates that the heuristic evaluations performed by different evaluators are consistent and reliable.

If the Cronbach's alpha coefficient is high, it implies that different evaluators' heuristic evaluations are reliable and consistent. As shown in Table 5, analyzing the full sample with Cronbach's alpha yielded a value of 0.9, which, when combined with the Likert scale given in Table 4, suggests an outstanding reliability rate.

Table 4. Cronbach's Alpha rating scale

Range	Interpretation
Greater than 0.9	Excellent
Between 0.8 and 0.9	Good
Between 0.7 and 0.8	Acceptable
Between 0.6 and 0.7	Questionable
Between 0.5 and 0.6	Poor
Less than 0.5	Unacceptable

Table 5. Cronbach's Alpha results

Cronbach's Alpha	n of Elements
0.92	30

We may deduce from the results that the proposed model and graphical interface satisfy the criteria established for forecasting the teacher's profile.

2.4 Procedure

For the implementation of the prototype, the described modules were considered. As a first step, the need for data cleaning was identified, as grammatical and spelling errors were observed. For this reason, the datasets underwent data cleaning to ensure consistency and accurate prediction.

After data cleaning, the texts go through two Symanto APIs [18], which help us obtain the personalities and emotions conveyed in the texts. For personalities, the API provides two outputs: emotional or rational, while for emotions, there are seven possible responses: joy, disgust, fear, sadness, anger, surprise, and no emotion. With the responses from the two APIs, fuzzy logic is applied for predicting the instructor's profile.

The implementation of fuzzy logic requires an understanding of the antecedents (input variables) and possible consequents (output variables) to determine the potential fuzzy rules that the inference engine needs to analyze to generate the result. This will allow for the establishment of fuzzy rules that describe the logical connections and activation levels of the output variables based on the input variables. Once the fuzzy rules have been defined, the inference engine can perform the necessary calculations to obtain a fuzzy result based on the provided input information.

To determine a result using the Big Five model, rules were implemented with the assistance of a psychologist to ensure high prediction accuracy of the instructor's profile. The first two datasets were used to create a test version of the fuzzy logic and validate the behavior of the system and how the results varied with the implemented fuzzy rules. Adjustments were made to the rules to improve the accuracy probability. Finally, with the third dataset, personality predictions were made for the participating instructors, obtaining positive results and acceptance from them (see Figure 1).

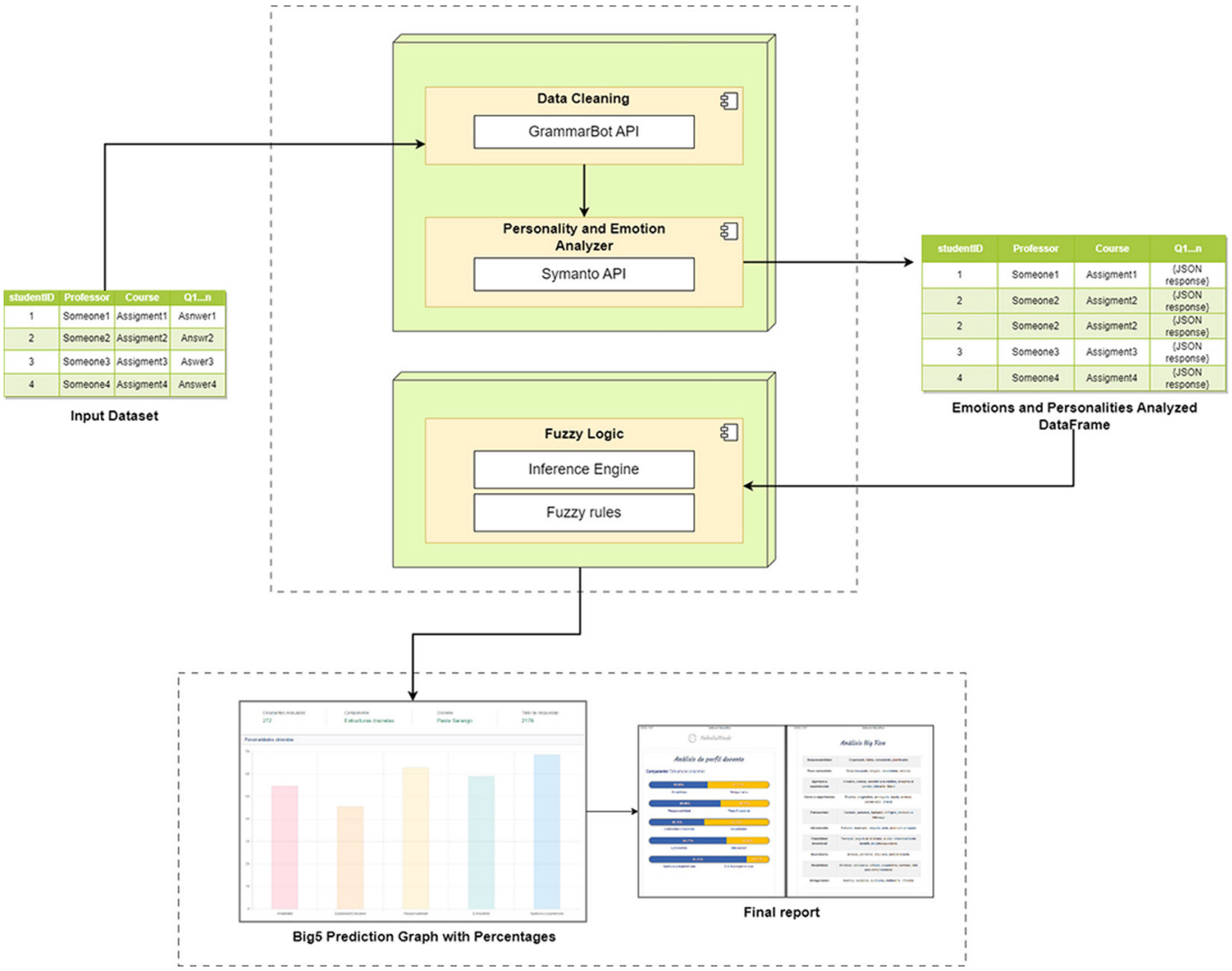

Fig. 1. General flowchart for Big5-based instructor profile prediction

- *Input Dataset:* The dataset generated from Microsoft Forms, which contains student's responses is exported and then uploaded to the prototype in a dataframe format.
- Data Cleaning: A thorough analysis is performed on each value in the dataframe to identify and correct any inconsistencies or errors. This ensures that the dataset is reliable and suitable for accurate predictions by Symanto.
- Symanto API: Once the text has undergone the data cleaning process, each value in the dataframe is sent to Symanto for natural language processing. Symanto's advanced algorithms and endpoints are utilized to predict personality traits and emotions based on the provided text.
- Fuzzy Logic: The processed dataframe, containing Symanto's predictions, is then fed into the inference engine along with the proposed fuzzy rules. The inference engine evaluates the data based on the defined rules and generates resulting personality profiles. These profiles are recorded in a new dataframe, ready to be displayed in a user-friendly dashboard.
- Dashboard: The dashboard interface allows users to conveniently filter and analyze the data by components and instructors. It also offers the option to download a comprehensive report that showcases the results generated by the Big5 model, including detailed characteristics of each personality dimension.

3 RESULTS

After the completion of the development and implementation process of a graphical interface, different reports were generated solving the personalities of the instructors who participated in data gathering to determine their personality features. A heuristic validation was also carried out to evaluate the usability and efficacy of the user interface. In this regard, the findings were excellent since a high accuracy in predicting the teacher's profile was reached, and several parts of the interface that may be modified to increase user-friendliness were discovered. The results achieved in these aspects will be summarized in the next section.

The generated reports provide detailed information about the personality of the evaluated teachers, displaying the percentage of each of the five factors of the Big Five model along with their respective poles and characteristics. It is important to note that the poles do not have a negative or positive connotation; they simply describe the opposite ends of each dimension. Furthermore, the generated report presents a table with the typical characteristics associated with each personality, as named by [17]. This allows teachers to gain a more comprehensive understanding of their profile and, in turn, improve their relationship with students and the classroom environment.

As can be observed in Figure 2, in the "Discrete Structures" course, it was observed that students have a high perception of the instructors as being highly extroverted, responsible, and open-minded. This indicates that during their classes, the instructor is seen as highly creative, friendly, energetic, organized, and reliable.

Fig. 2. Report generated by the web prototype of the Discrete Structures course

In Figure 3, in the "Hardware Fundamentals" course, students perceive the teacher to have stability in all dimensions, with percentages close to 50% in each of them, showing a greater tendency towards a closure of experiences, resulting in a realistic, pragmatic, and rational profile. These are characteristics that the teacher was described as having when verifying the evaluation results.

Fig. 3. Report generated by the web prototype of the Hardware Fundamentals course

In Figure 4, in the "Semiotics" course, students perceive the teacher to have an inclination toward responsibility, extroversion, and openness to experiences, with percentages exceeding 55% in each of these traits. These characteristics have been validated with the teacher and are consistent with the type of teaching they provide to their students during their sessions.

Fig. 4. Report generated by the web prototype of the Semiotics course

Once all the results of the teacher personalities were obtained, they were averaged to gain a general understanding of the teachers who chose to participate in predicting their personality. The results obtained are presented in Table 6. Additionally, another table (Table 7) is provided to show the standard deviation among each of the dimensions.

Table 6. Average of personalities obtained for each Big Five dimension of the instructor

	Openness to Experience	Conscientiousness	Extraversion	Agreeableness	Neurotism
Discrete Structures "A"	68.71	63.02	59.17	54.84	54.33
Hardware Fundamentals	43.74	56.31	49.36	49.54	51.02
Semiotics	67.45	59.35	59.63	53.92	48.85
Intelligent Systems	63.26	58.23	54.97	50.05	49.58
Discrete Structures "B"	81.31	59.56	64.71	48.99	53.85
Film Appreciation	67.03	61.17	60.18	54.66	45.29
Average	**65.25**	**59.60**	**58.00**	**52.00**	**50.49**

Table 7. Standard deviation among each of the dimensions

Id	Course	Average %	Standard Deviation
O	Openness to Experience	62.25	8.48
C	Conscientiousness	59.60	0.15
E	Extraversion	58.00	7.83
A	Agreeableness	52.00	4.60
N	Neurotism	50.49	8.87

Based on the obtained results and the identified characteristics in the evaluated teachers (Table 7), it is confirmed that they have a positive profile for higher education. The analyzed dimensions, such as openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability, are desirable traits in an educational environment.

Teachers who scored higher in these dimensions demonstrate being organized, creative, responsible, and friendly, which is essential for creating a conducive atmosphere during the educational process with students. These characteristics are beneficial for fostering a positive and constructive relationship between teachers and students, which can improve the quality of teaching and promote effective learning.

4 CONCLUSIONS

Difficulties were encountered in spelling and grammar correction in Spanish because many of the evaluated libraries were originally developed for English and

not for Spanish. Additionally, some libraries do not recognize the context in which words are used. The greater variety of verb tenses, pronouns, and objects in Spanish can lead to inaccurate or incomplete correction of grammatical errors [18].

Understanding the teacher's personality through student comments is a valuable tool for improving the work environment and student performance. By having a clear idea of the teacher's personality, it becomes possible to identify areas where teaching style can be improved and tailored to the needs of the students. This can enhance the quality of teaching and foster a more positive relationship between the teacher and students.

The information presented in this document has been the result of exhaustive research, during which not only the effect of fuzzy logic but also that of other resources supporting the education process has been explored, as well as the way in which each of them employs different techniques and methods of artificial intelligence to achieve the established objectives. It is worth noting that the development of this prototype fulfills certain aspects of "Intelligent Tutoring Systems" that can be adapted to the student's characteristics and improve the pedagogical strategy [19].

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