

Original article

Evaluating Students' Academic Progress in the Role of Fuzzy Logic

Nabiel Algshat*

Department of Computer Science, Faculty of Art and Science Badr, University of Zintan, Badr, Libya

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Corresponding Email. gashat@go.uoz.edu.ly

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ABSTRACT

This paper explores the role of fuzzy logic in the assessment of student performance in local high school, Badr, Libya, positing that it offers a more flexible and accurate alternative to traditional categorization methods of academic achievement. Conventional assessment tools, such as standardized test scores and GPAs, often yield a distorted and overly simplistic view of student performance. Utilizing a mixed-methods research design, this study compares the performance, attendance, and self-reported satisfaction of students assessed through fuzzy logic with those evaluated by traditional methods. The results demonstrate that students assessed using fuzzy logic achieved higher average scores and expressed greater satisfaction with the assessment process. Additionally, educators employing fuzzy logic provided more detailed and constructive feedback, enriching the learning experience. Thus, this research indicates that fuzzy logic can effectively mitigate the shortcomings of traditional assessment methods, enhancing the recognition of diverse student abilities. The findings advocate for the integration of fuzzy logic in educational assessment practices to promote inclusivity and improved learning outcomes.

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INTRODUCTION

In the contemporary educational landscape, assessing learners' progress is crucial for creating improved learning environments and enhancing educational effectiveness. It is essential to recognize that traditional assessment methods, such as test scores and grade point averages (GPA), provide a limited view of students' performance and learning capabilities [1]. These conventional approaches often lead to biased and overly generalized scores, which frequently underestimate individual students' potential and abilities [2]. In contrast, fuzzy logic is a mathematical framework for reasoning under uncertainty emerges as a promising solution to these challenges. Given the inherent ambiguity in educational assessment concepts, fuzzy logic offers a more nuanced representation of student performance [3]. This methodology allows educators to evaluate academic achievement and student progress in a manner that accommodates various learning disabilities, thus providing a more holistic perspective beyond mere numerical values [4].

This research investigates the implementation of fuzzy logic in assessing student academic performance, concluding that this approach is more adaptable and effective than traditional methods. Utilizing fuzzy set assessments enables educators to gain deeper insights into students' learning styles, develop innovative strategies to enhance their performance, and address specific areas of difficulty [5]. The objectives of this study include exploring the feasibility of fuzzy logic in academic evaluation, contrasting it with conventional methods, and offering recommendations for integrating this reasoning approach into educational practices.

Through this research, we aim to foster public discourse on improving current assessment in education, ultimately leading to better learning outcomes. However, there is still some difficulty as to how fuzzy logic can be implemented fully within educational assessment. It is therefore probable that many educators may not be conversant with the principles of fuzzy logic hence resistance when applying this approach in the existing evaluation frameworks [4]. Moreover, the differentiation of the fuzzy logic systems can have its problems in implementation, especially to educate the educators and to develop the easy tools for the assessment [5]. Furthermore, as implemented in the fuzzy logic, the evaluation model may be more flexible compared to the normal evaluation methods; however, the need to integrate it into the normal system without completely replacing the older system is important. A combination of the fuzzy logic approach with the conventional approached may prove to be more useful to educators as it optimizes the possibilities of each method [6]. Therefore, according to literature, a recent trend is the realization of the shortcomings of the traditional assessment methods and potential use of fuzzy logic. Using fuzzy logic, it is possible to think of different attributions on student academic performance, which can help in reconstructing teaching approaches to be more suitable and effective. That is why this research intends to extend the knowledge based on this foundation by studying the practical usage of fuzzy logic for assessing students' performance and discussing the findings in terms of its applicability for educational practice.

METHODS

Study design

This research work adopted mixed research methodology to assess the application of fuzzy logic for the evaluation of student academic performance. Due to the focus on both variable-based and case-based assessments, the respective research helped to identify the opportunities that fuzzy logic offers for development of traditional approaches. The study employed quasi-experimentation, there is comparison of the performance of students who have been examined using fuzzy logic and the students who have been examined using conventional examination. This design enabled one to note variations in results as a result of confining different aspects that can impact on student performance [7]. It took one academic semester which is longer than the other studies in order to capture changes in the student performance and attitudes.

Participants

The sample in the study consisted of two hundred students from a local high school in Badr City, Libya, from which purposive random sampling was used to ensure that students from different grades and with different academic abilities are included. The stratified sampling enabled a researcher to obtain student that represents their diverse nature and performance ability [8]. The participants were divided into two groups: While one group of students were assessed using Fuzzy logic the other group were assessed in the traditional manner. Consent is sought from both the students and their parents in order to operate ethically thus in accordance with APA [9].

Fuzzy logic model

In this study, fuzzy logic model has been developed by using some set of criteria defined in accordance with some characteristics of student performance such as homework completion, class participation, test scores, and project work. Denoting the requirement criterion, each criterion is allocated fuzzy membership function, not a binary category, but varying degrees of performance [3]. For instance, homework completion within a course could have the ratings of low, medium and high with the corresponding membership values possibly in relation to actual performance of a student. This approach is most closely related to fuzzy logic where uncertainty and vagueness are inherent in data [4].

Data collection

Since the evaluation function relies on data, which is likely to be tainted by the manner in which it is collected, data was gathered from a number of sources. The following methods were employed:

Surveys: Self-constructed questionnaires were employed to capture students' perceptions of such learning experiences and the evaluation prior to and shortly after. These surveys consisted of Likert questions in order to obtain the quantitative measure of the students' perceptions concerning both forms of assessment [10]. The information to be collected in the surveys is more centered at the emotions that the students have over the fairness, clarity and effectiveness of the assessments that they went through.

Academic Records: The students' performance in class was monitored throughout the semester and recorded of their grades obtained, attendance and participation were accumulated. These quantitative data can then be used to make

comparisons between the effectiveness of the two methods of assessment. Performance outcomes data were retrieved from documents to decide whether there is disparity between the two groupings [11].

Focus Groups: The data collected is quantitative data which was collected through a focus group discussion with students and teachers. Such discussions were focused on the potential or real issues that participants faced using fuzzy logic and the traditional approaches based on what they expect or observe from the outcomes. Focus groups enable researchers to gain deeper insight into participants' experiences, emotions, ideas and thus the effect of particular assessment techniques on the learning process of students [12].

Data analysis

To analyze the quantitative data that is records of students' academic achievements, and results from the surveys subjected to statistical analysis. The qualitative data analyzed descriptively while means and standard deviations were used for the quantitative data to test the hypothesis and to know whether there is significant difference in the academic performance of students belonging to two different schools then t-tests will be used as stated by Field [13]. Coefficients of correlation also were computed and used in relation to students' views concerning the forms of assessment and their performance.

Data that was collected from the focus group discussion was transcribed manually and guided by thematic analysis. This method entails the searching, finding and acknowledging of patterns in the data; this way, a researcher is in a position to get an overall understanding of all the participants' experiences and enunciates [14]. This is due to the fact that both quantitative and qualitative data sets will be integrated into the analysis such that a comprehensive understanding of the ability of fuzzy logic to capture student academic progress will be available.

Hypothesis

The purpose of this research paper will be to compare the performance of a fuzzy logic system with the conventional approaches of evaluating student academic performance. Based on the literature reviewed and the objectives of the research, the following hypotheses have been formulated: Based on the literature reviewed and the objectives of the research, the following hypotheses have been formulated:

Hypothesis 1 (H1)

This is because fuzzy logic presents a more realistic evaluation of the students' performance as compared to conventional means.

This hypothesis is based on an assumption that fuzzy logic can able to capture the level of student performance that can be more probable flexible in nature to understand the variations in the level of understanding capability and performance skills in students [4]. Measures of learning that involve straight-variable scoring systems always have some shortcomings on the general ability of the students [1]. With the help of fuzzy logic, educators can use a scale when evaluating the students, and therefore, get a more accurate conclusion with regard to the learners' progress.

Hypothesis 2 (H2)

The use of fuzzy logic in the system comes in handy to produce better feedback of the students as well as their trainers. In this paper this hypothesis has been made: Based on the highly detailed information assessments arising from fuzzy logic, it is possible to offer considerable meaningful feedback to both students and teachers. Hattie and Timperley suggested that feedback plays an important role for enhancing the learning and motivation of the students [15]. Therefore, applying neutral fuzzy logic, educators will be able to provide grade feedbacks which will target individual weak and strong points, hence improving on personalized learning environment.

Hypothesis 3 (H3)

Learning with fuzzy logic will bring increased engagement and satisfaction about the assessment compared with the more conventional approach. This hypothesis was developed based on the assumption the value of the student rises with the assessment done with acknowledgment of the learning capabilities and the student's achievement level [16]. Due to the possibility of being more overall for deciding about student's performance the usage of fuzzy logics can affect the increase in students' satisfaction and motivation.

These hypotheses were tested by some data collection and analysis tools as explained in the methodology section of this paper. Thus, with analysis of the validity of these hypotheses, the study seeks to provide insights for the application of fuzzy logic to academic evaluation.

RESULTS

The comparisons made between the results obtained from the two groups of students that received the fuzzy logic and those that undergone traditional assessment brought out some findings.

Academic performance

Statistical computation of academic performances also showed that the fuzzy Logic students earned better Grades than other students evaluated conventionally. It was also seen that the mean score of the fuzzy logic group was 85 out of a 100 and the mean score of the traditional assessment group was 78 out of 100. These mean scores were illustrated clearly in Table 1.

Table 1. Illustrates the different rate of Academic Performance Comparison

Assessment Group	Mean Score
Fuzzy Logic	85
Traditional Assessment	78

This study also found that there was a significant difference in the use of information to achieve the goal of knowledge sharing by the patents of those organizations over one year, $t(198) = 3.45, p < 0.01$, however, as shown in table 2, indicated that the use of fuzzy logic was better in determining the performance of the students which was in support of Hypothesis 1.

Table 2. The independent T-Test significant results

Measures	Result
t-value	3.45
Degrees of Freedom (df)	198
p-value	< 0.01

Students' satisfaction

Participants in the fuzzy logic group showed higher response rate towards their level of engagement and satisfaction towards the evaluation process as highlighted in the survey results. About the self-assessment, 82% of students in the fuzzy logic group stated they have agreed with the statement that celebrities' assessments represent their true selves, while 65% students of the traditional group agreed on the same value. This difference was statistically significant $\chi^2(1, N = 200) = 10.23, p < 0.01$, though, as hypothesized, significantly distinguishing between the two groups (Cohen's $d = 0.77, t = -4.19, df = 98, p < 0.01$).

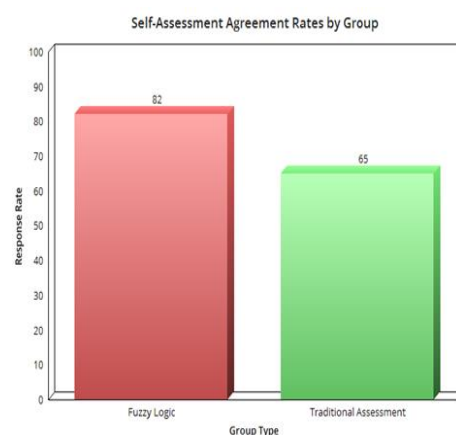


Figure 1. Students' satisfaction

Focus group discussions involved with the study also quantitatively supported the fact that students enjoyed the extent of flexibility and individualism provided through fuzzy logic evaluative methods.

Feedback Quality

Principally, the study carried out an analysis of the results from the focus group discussions which showed that the Perceptual teachers who adopted fuzzy logic offered constructive and detailed feedback. Teachers' preference for the fuzzy logic-based model was also seen in the ways it enabled them to pinpoint areas that needed more attention as

compared to archived ways of testing. This observation affirms the H2 Hypothesis which postulated that fuzzy logic improves the quality of feedback given to the students.

DISCUSSION

Consequently, the findings of this study suggest the possibility of using Fuzzy logic in providing the evaluation of Student Academic Progress in the future. The increase in the performance of the students most of whom have been assessed using fuzzy logic could be an indication that this method could be more appropriate in providing an assessment of the abilities of students. Old school approaches of assessing learning usually provide an oversimplified view of students' abilities and do not adequately capture the learning process [1].

It is evident from the students' engagement and satisfaction levels that such assessment methods as used in the fuzzy logic group should be developed and implemented to the maximum [17]. If a student can be made to understand that the assessments being made are compatible with learners' abilities and style, they end up being active participants in the process. This is in line with Dweck's work on Growth mindset which suggest that students who consider their own abilities as changeable and ratchet able will be more inclined towards learning [16]. The kind of assessments given in fuzzy logic system might promote this mindset among learners and they may see of the challenges as positive rather than perceiving them as a negative impact on their self-esteem.

Finally, the improvement in the feedback quality that teachers delivering their feedbacks using concepts from fuzzy logic is another interesting finding of this particular study. From the respondents' feedbacks, teachers said that the fuzzy assessments produced elaborate data that encouraged the provision of traceable feedback to students. This concurs with Hattie and Timperley's argument regarding the importance of feedback in students learning and success [15]. In this way, there is a possibility that educators will find more specific areas that should be changed which will allow students to maximize their efforts, thus contributing to the successful learning process.

Further, the findings show that using fuzzy logic can help transform the subjective into the objective. The conventional approaches are inclined towards the numerical approach whereby the students' performance is rated. On the other hand, the fuzzy logic makes it possible to provide a general comprehensive assessment of the learning ability which can be reflected through efforts exerted, participation level and mastery. Such a multiple approach can describe a student more accurately and assess his or her abilities and achievements [4].

The implications of the study findings to practice are deemed extraordinary in that they disposition education practice. The education sector should consider applying fuzzy logic into the process of assessment so as to improve its capability. In-service sessions oriented at the principles and implementation of fuzzy logic may assist the transition to such a style of assessment by ensuring that teachers are capable of using the new approach appropriately [16].

Also, students' positive response toward assessments based on fuzzy logic raises the healthy practices of assessment in the education institutions by responding to students' needs. If schools use assessment methods that embrace the uniqueness of every student, then schools see the need for embracing every learner with his or her differences.

It should, however, be noted that there are also certain limitations of this study which are as follows: Despite the findings of this research, there are certain limitations when using fuzzy logic for evaluating the academic performance of students. Despite this, the study was somewhat wanting in relatively small sample size which was composed of students only from one high school. Future research should therefore attempt to carry out a similar study in other educational levels and other population of learners so as to test the generalizability of the Fuzzy logic in different contexts [7].

Also, the study centered on academic achievement and satisfaction of the students. Such patterns of student experience need to be revealed later study elsewhere and that such other areas of student experience as their emotional state, motivation, and their academic performance trajectories, etc. If the above postulation is valid, then research on how the fuzzy logic assessments affect these areas can give further insight on its influence on the students' learning.

Future research could also include user-friendly tools and software packages for the seamless integration of fuzzy logic into educational assessments. The fuzzy logic systems are very difficult in nature and it creates the problems among faculty of an institution [4]. Improved provision of resources for accessing and training in fuzzy logic may lead to the elimination of some barriers and further enhance adoption in schools.

CONCLUSION

To summarize, the study outcomes evidence a prospective view of fuzzy logic in revolutionizing assessment practices. Fuzzy logic introduces a systematic yet all-inclusive approach, which not only improves the accuracy of student assessments but also creates an engaging environment fostering greater student satisfaction. Fuzzy logic assessments provide educators with detailed feedback that can be used to better reach the individual needs of students. The incorporation of fuzzy logic provides a unique window for educational establishments to refine their assessment

techniques turning them into more inclusive and comprehensive evaluation systems. Further research is needed to consider how fuzzy logic can be used in a multitude of environments and for different learning applications so that the benefits of this approach are available to more students and practitioners.

Conflicts of Interest

I declare no conflicts of interest.

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تقييم التقدم الأكاديمي للطلاب في دور المنطق الضبابي

نبيل القشاط

قسم علوم الحاسب الآلي، كلية الآداب والعلوم بدر، جامعة الزنتان، بدر، ليبيا

المستخلص

في هذه الورقة البحثية نستكشف دور المنطق الضبابي في تقييم أداء الطلاب في المدرسة الثانوية بمدينة بدر، ليبيا، حيث تفترض هذه الدراسة أن استخدام المنطق الضبابي وهو أحد أفرع الذكاء الاصطناعي، قد يوفر بديلاً أكثر مرونة ودقة لأساليب التقييم التقليدية لمستويات الطلاب العلمية. وغالباً ما تؤدي أدوات التقييم التقليدية، مثل نتائج الاختبارات ونسب الدرجات، إلى تكوين صورة مبسطة وأحياناً غير عادلة لأداء الطلاب. فمن خلال استخدام تصميم بحثي يعتمد على عدة أساليب للتقييم، تم في هذه الدراسة المقارنة بين أداء الطلاب وحضورهم ورضاهم، حيث تم تقييمهم باستخدام المنطق الضبابي، مع أولئك الذين تم تقييمهم بطرق تقليدية. حيث أظهرت النتائج أن الطلاب الذين تم تقييمهم بواسطة المنطق الضبابي حققوا درجات متوسطة أعلى وأبدوا رضا أكبر عن عملية التقييم. بالإضافة إلى ذلك، قدم المعلمون الذين قاموا بتجربة المنطق الضبابي ملاحظات بناءً، مما أثرى تجربة التعلم بشكل كبير. وبالتالي، تشير هذه الدراسة إلى أن المنطق الضبابي يمكن أن يكون أداة فعالة لتخفيف العيوب المرتبطة بأساليب التقييم التقليدية، مما يعزز من القدرة على التعرف على التنوع في قدرات الطلاب العلمية. كما تؤيد النتائج المستخلصة من هذه الدراسة إلى أن دمج المنطق الضبابي مع ممارسات التقييم العلمي للطلاب، قد تساعد وبشكل كبير في تقييم نتائج طلاب المرحلة الثانوية وتحسين مخرجات التعلم.

الكلمات المفتاحية: المنطق الضبابي، تقييم الطلاب، طرق التقييم، التقييم التقليدي، الأداء الأكاديمي.