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Student opinions on the evaluation of performance with fuzzy logic method in art and design education

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ABSTRACT

This research was conducted to obtain students' views on the evaluation of artificial intelligence (AI)-supported design applications in art and design education using the fuzzy logic method. It aims to provide a new perspective for educators in identifying real learning situations and deficiencies in art and design education. The study utilized the DALL-E AI tool developed by OpenAI in design projects assigned to students in a basic art education course. The research took place during the autumn semester of the 2024-2025 academic year with 21 first-year students from the Visual Communication Department at the Faculty of Art and Design of a university located in western Turkey, all of whom participated voluntarily. A semi-structured interview, a qualitative research method, was employed as the data collection model. The interview questions were validated and analyzed using MAXQDA qualitative data analysis software, with an inter-coder agreement of 97.32%. The findings indicated that evaluating students' work with fuzzy logic increased their creativity, positively influenced their motivation towards the course, proved to be a more reliable evaluation method compared to traditional approaches, and enhanced their self-efficacy by improving their technological skills.

Contribution/ Originality: This study aims to contribute significantly to quality improvement efforts in art and design education. It supports the integration of emerging technologies with traditional visual arts by promoting the analysis of new concepts and the refinement of existing methods. In doing so, it offers theoretical support for practical research and advances the field of art and design education.

1. INTRODUCTION

Art education, which is an important part of education, has an important place in developing students' creative and critical thinking skills as well as their aesthetic perception by guiding them in certain technical ways (Egana-delSol, 2023). In order to measure and evaluate these skills at the end of the course, assessment tools different from traditional methods are needed. These assessments will also help teachers identify their own shortcomings and continuously improve themselves, thereby enhancing the overall quality of teaching. Additionally, assessment information can be fed back in a timely manner, increasing students' motivation to learn.

The evaluation of art teaching is the most important part of the whole art teaching activity. During this process, it is believed that the student's perceptual, aesthetic qualities, and self-expression skills improve. For this reason, the learning process and evaluation of the learning process are as important as product (outcome) evaluation. Especially in today's world, where artificial intelligence is becoming increasingly important, the courses taught in line with the traditional teaching approach are unable to meet the needs of the students. Therefore, traditional assessment models

need to be reorganized in line with the needs of the age (Yanko, 2021). It is a fact that real-world information can be uncertain or imprecise, i.e., unreliable or fragmented, that there is ambiguity in the data, or that there is conflicting information, all of which can lead to uncertainty (Mittal, Jain, Vaisla, Castillo, & Kacprzyk, 2020). It is a fact that real-world information can be vague or imprecise, which means that it is not reliable, or the information is presented in fragments, with ambiguity in the data, or contradictory information is present, and all of these can lead to uncertainty.

However, traditional artwork assessment activities are often limited by time, distance and cost (Chiu, Hwang, & Hsia, 2023). These regulations require that student performances be assessed accurately, quickly, and with technology-supported complementary assessment tools.

The evaluation phase provides essential feedback that contributes to students' cognitive, affective, and social development. Through evaluation, the thinking dimension of art activities is activated, allowing children to progress incrementally and develop new thinking and application techniques. In art and design education, various techniques can be employed to assess students' artistic learning. However, each assessment method measures different aspects of artistic development. Therefore, art and design educators need to understand these differences to select appropriate techniques. One assessment approach that can be utilized in art and design education is fuzzy logic. The fuzzy logic approach, which has been applied successfully in various fields and has produced effective results, has recently been adopted in the field of education.

In particular, the ability of a modeled system to think in verbal expressions just like humans and to work correctly with incomplete data makes the use of this approach necessary. Fuzzy logic seems to be an evaluation approach that can provide a natural way to solve problems, especially in situations where there is no clarity, such as art projects, and where the accuracy criteria cannot be clearly defined.

Fuzzy logic is a logical structure that emerged as a result of an article published by Zadeh (1965), titled “Fuzzy Sets.” Fuzzy logic is based on the concept of fuzzy sets. A fuzzy set is a generalization of the classical set. In the classical set approach, an entity is either an element of a set or not. Therefore, the characteristic function $X_A: E \{0,1\}$ of a classical set A takes only 0 or 1 values in terms of the entity-set membership relation. In the fuzzy set approach, each entity has a degree of membership to the set. The degree of membership of entities can take any value in the closed interval $[0,1]$. The characteristic function representing a fuzzy set A is called its membership function and is usually denoted by $\mu A:E \dashrightarrow [0,1]$ (Zadeh, 2015).

E being a universal set and A $\subset$ E being a classical set, the characteristic function representation of A, $X_A: E \{0,1\}$, is replaced by the membership function in fuzzy sets. This is represented as $\mu A:E \dashrightarrow [0,1]$. In the second representation, A is a fuzzy set.

Performance evaluation is generally the rating of the parameters of the system to be evaluated by giving numerical grades or using verbal expressions. These grades and verbal expressions are used to express the success of the system with the help of arithmetic or statistical methods. A combination of different evaluation components is often used with a different allocation of grades. In the use of arithmetic methods, for example, different scores from each assessment can be summed to obtain a single score. Simple statistical methods, such as calculating the average of scores from different assessments, are also frequently used. Performance evaluations can also be carried out using descriptive statistical methods such as measures of central tendency or measures of central dispersion.

Fuzzy logic is used in social sciences as well as engineering and other quantitative fields. Uncertainty in social science research and the drawbacks of using precise language highlight the importance of fuzzy logic. Fuzzy logic approaches are preferred to draw consistent conclusions with uncertain information (Özdemir & Kalınkara, 2020). In art education, it is difficult to evaluate student practice assignments and exams within certain limits. These evaluations may vary from educator to educator. This is due to the subjective nature of art. Therefore, using fuzzy logic in the evaluation of artistic projects and assignments will help to reach more accurate results. The advantages of fuzzy logic, such as being easy to develop and understand, reducing implementation costs, having a stable and flexible structure, being easily applied by handling uncertain situations, having powerful inference tools, and working

with a small number of rules, emphasize the importance of its use in art education assessment (Tsiakmaki, Kostopoulos, Kotsiantis, & Ragos, 2021).

In many studies, fuzzy logic has proven to be a useful tool in eliminating uncertainty in performance evaluation systems (Dam, Majumder, Bhattacharjee, & Santra, 2022; Yadav & Patel, 2022). There are also research results indicating that fuzzy logic assessments in art education have a 95% higher accuracy rate than traditional assessment methods and increase the efficiency of art courses by boosting student motivation (Fu, Min, Liu, & Wang, 2022; Xinyi, 2023). In addition, there are also research results indicating that traditional assessment methods cause some deficiencies in making individual assessments, and that the effective use of fuzzy logic methods to deal with uncertainty and ambiguity in the given data leads to more accurate results in the assessment (Magar, Ruikar, Bhoite, & Mente, 2024; Nematzadeh, Ibrahim, Selamat, & Nazerian, 2020). There are also various research results indicating that students evaluated with fuzzy logic experience positive effects on their academic achievement (Rohani, Torabi, & Kianian, 2020; Tsiakmaki et al., 2021). There are also studies suggesting the use of fuzzy logic to extract useful information and hidden patterns from the big data generated by educational systems to predict students' performance and help them improve teaching and learning (El Mourabit, Jai-Andaloussi, & Abghour, 2022).

The aim of this study is to examine students' views on the use of tools that utilize fuzzy sets in performance evaluations, as opposed to traditional statistical evaluation methods. It is essential to assess performance by considering the complex cognitive structures involved in artistic works and to employ more flexible decision-making methods in this process. The purpose of this article is to measure the performance of artistic designs produced by students in the course. Since performance evaluation has a multifaceted structure that can vary from person to person, and to ensure consistent results while minimizing errors that may occur with classical logic, the fuzzy logic method was preferred for evaluation. In this study, a fuzzy logic-based model was designed to evaluate student performance for evaluation processes through fuzzy logic, depending on the parameters of evaluation of design studies. The current study is focused on making a major contribution to the implementation of quality improvement in art and design education. Moreover, it has been attempted to support a new application of the organic combination of new technologies and traditional visual arts, with an emphasis on the analysis of new concepts and the improvement of old methods in art and design education. In this way, it is intended to provide theoretical support for practical research aimed at the promotion and advancement of the field.

2. METHOD

2.1. Research Model

In this study, it was aimed to evaluate the designs of university students studying design within the framework of the design principles and elements unit in the basic art education course by using fuzzy logic and to determine their views on this process. Semi-structured interview model, which is one of the qualitative research methods, was used in the research. The reason for choosing the semi-structured interview model in the research is to obtain more in-depth opinions. This study, in which the existing situation was described in detail and student opinions about the event were collected, was conducted using a case study design, one of the qualitative research methods. The data were obtained through face-to-face interviews by creating a semi-structured interview form.

2.2. Study Group

The study group in the research consists of undergraduate students studying in the 1st year in the autumn semester of 2024-2025 in the Visual Communication Design Department of the Faculty of Art and Design of a university located in western Türkiye. Qualitative research allows for in-depth exploration of the views of the participants since the sample size is small. Therefore, researchers prefer purposive sampling (Creswell, 2009). In this study, criterion sampling, which is one of the purposeful sampling methods, was used to select participants according to the study's purpose. Through criterion sampling, individuals who meet a set of predetermined criteria are included

in the study (Jalali et al., 2025). Consequently, semi-structured interviews were conducted with 21 students who volunteered to participate among the 25 students with varying scores in the basic art course. A detailed lesson plan was prepared for the lessons, which were conducted within the predetermined period, and the lessons were delivered according to this plan. All those who wanted to participate in the interview were given explanations about the purpose of the research, the research process, what was expected of them, the position of the researcher, and that the identities of the participants would be kept confidential and would not be used elsewhere. Participants were asked to inform the time they were available for the interview. Participants were also asked in which way they would like to be recorded while expressing their opinions about the questions during the research process, and they were recorded according to their wishes. Those who did not want to be recorded answered in writing. The interviews were conducted face-to-face by the researcher at predetermined times in an environment where students felt comfortable and could express their opinions without hesitation.

2.3. Research Process

The study period in the research was conducted over four weeks, with eight hours of lessons per week on the unit subjects of design principles and elements (repetition, rhythm, contrast, harmony, unity, balance-symmetry, point, line, stain, plane, volume, shape, range, direction, color, texture, etc.). In the next stage, students were informed about the course process and design principles and elements (repetition, rhythm, contrast, appropriateness, harmony, unity, balance-symmetry, coram, sovereignty, point, line, stain, plane, volume, shape, range, direction, color, texture), and activities for planning learning processes were carried out.

Many studies have indicated that virtual technologies can improve students' creative performance (Chiu et al., 2023; Sonntag & Bodensiek, 2022). For this reason, students were guided to intervene in the designs produced by artificial intelligence and were asked to add different interpretations. In this way, the use of artificial intelligence as an auxiliary element in the creation of creative works was encouraged.

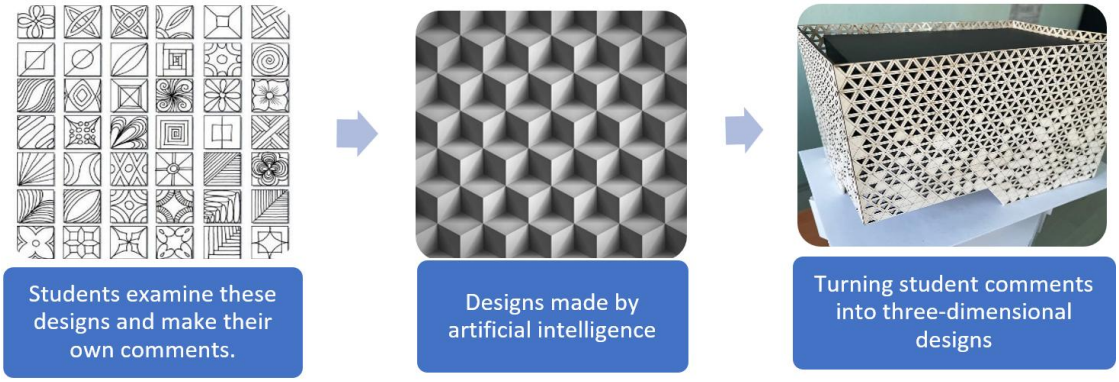

Figure 1. Original design applications made by students using artificial intelligence.

After the topics of the students were determined and clarified, information was provided on how they could realize their projects using the program selected for planning and preparation, including material definition and artificial intelligence program features. Based on the visuals obtained, students were informed that they would create their own unique designs by utilizing design elements through artificial intelligence applications, and that the information obtained would be presented in the classroom at the end of the experimental process. At the conclusion of the process, a timetable was created, and planning was made for the organization of the design exhibition, which would feature original works (Figure 1). Students shared their designs in class on the specified date. During the presentations, students used PowerPoint and poster presentations, and they critiqued their peers after the presentations. The designs produced were evaluated artistically through chatbots. These chatbots, developed based on fundamental design theory and practices, aimed to enhance students' critical thinking and aesthetic evaluation skills.

In the fuzzy-based evaluation algorithm for student performances, input and output parameters and rule base were designed and developed by taking expert opinions (instructors). These algorithms, which were prepared according to expert opinion, are predicted to give accurate results since they only deal with the relevant problem as an expert system. While preparing the performance evaluation model, the literature was also utilized (Armağan, 2021; Bakar, Rosbi, & Bakar, 2020; Nasab et al., 2024; Wardoyo & Yuniarti, 2020). When evaluating the performance status, the output parameters were rated as 'Unacceptable, Poor, Satisfactory, Good, and Excellent'. Information about this entire evaluation process was provided to the students. Active participation of students was ensured both during peer assessment and during data entry into the fuzzy logic system.

2.4. Fuzzy Logic Use Processes

- Simulation was performed in MATLAB using scripts and the fuzzy logic toolbox.
- A fuzzy logic-based evaluation algorithm was used to evaluate the design applications supported by artificial intelligence (AI) with the fuzzy logic method. This evaluation was based on three parameters: 'creativity parameter', 'design principles parameter', and 'design elements parameter'. A study was conducted with the participation of first-year students of the Faculty of Art and Design at a university in western Turkey to determine the students' perspectives on evaluation using fuzzy logic. The data obtained from the artificial intelligence-supported design application study were utilized to calculate the performance evaluation with the developed fuzzy logic-based evaluation model.
- MATLAB Fuzzy Logic Toolbox was used in the design and implementation of the algorithm. For the setup and analysis of a fuzzy system, the following steps were applied.

i) Fuzzification of input variables: For this process, the verbally defined evaluation statements were converted into numerical values in the range [0,1] with the help of membership functions. In the design of the algorithm, two different membership functions were created to represent the "poor" and "excellent" states, and fuzzification operations were performed over these functions. The membership functions and their types are given in Table 1. The comparative graph of the membership functions used is given in Figure 2.

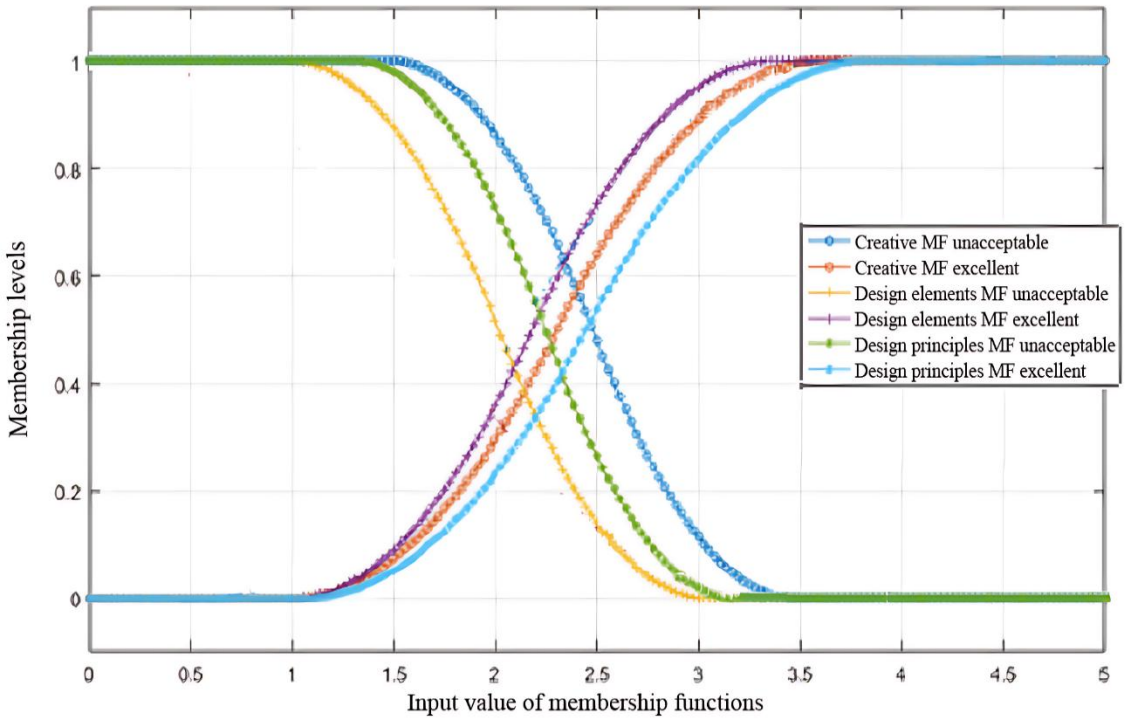

Figure 2. Membership functions (MF) and input-output values of the fuzzy logic-based evaluation algorithm.
Note: MathWorks Inc (2024a) and MathWorks Inc (2024b)

Table 1. Membership functions and types of the fuzzy set-based evaluation algorithm.

Parameter	"weak" Membership Function	"perfect" Membership Function
Creativity Design principles Design elements	$Z(x)=\begin{cases}1, x\le a\\ 1-2\left(\frac{x-a}{b-a}\right)^2, a\le x\le\frac{a+b}{2}\\ 2\left(\frac{x-b}{b-a}\right)^2, \frac{a+b}{2}\le x\le b\\ 0, x\ge b\end{cases}$	$S(x)=\begin{cases}0, x\le a\\ 2\left(\frac{x-a}{b-a}\right)^2, a\le x\le\frac{a+b}{2}\\ 1-2\left(\frac{x-b}{b-a}\right)^2, \frac{a+b}{2}\le x\le b\\ 1, x\ge b\end{cases}$

Note: MathWorks Inc (2024c) and MathWorks Inc (2024d)

In the fuzzy set-based evaluation algorithm, two membership functions of the types "Z" and "S" are used to represent the "poor" and "excellent" states for each input parameter, respectively (MathWorks Inc, 2024b, 2024d). These membership functions were designed and developed using expert opinions. Therefore, the priority and determinant coefficients were determined based on creativity during the system evaluation.

ii) Creating the rule base: the "Mamdani" method was used as a fuzzy inference system. The Mamdani method is a system that transforms membership functions into fuzzy sets. In the Mamdani system, the output of each rule is an element of the fuzzy set (Mamdani & Assilian, 1975).

The rule base in the Mamdani system is simple and convenient. Therefore, it has a high success rate in expert-system applications using expert opinions. The Sugeno inference system is not preferred in this study because it converts the input parameters into a linear function.

Student Performance Fuzzification: The design variable student_performance is a representation of student performance scores with a domain of [0, 100]. The design variable student_performance has five sets of design terms: Unacceptable, Poor, Satisfactory, Good, and Excellent (Grading Rubrics: Sample Scales, 2024).

Table 2. Fuzzy set of student performance outcome variable.

Performance term	Symbol	Support
Unacceptable	U	[0, 40]
Poor	P	[20, 60]
Satisfactory	S	[40, 80]
Good	G	[60, 95]
Excellent	E	[80, 100]

Table 2 shows the linguistic terms, symbols, and ranges for the Design variable student performance. For example, the term Satisfactory design has a range where the lower limit of the performance score is 40 and the upper limit is 80 [40, 80].

In the fuzzy set-based evaluation algorithm, 15 fuzzy rules were formulated to fulfill the exact and consistent requirements of "unacceptable, poor, satisfactory, good, and excellent" depending on the input parameters of the system (creativity level, ability to use design principles, and ability to use design elements). As in the previous step, it was designed and developed using expert opinions (lecturers).

In order for the system to output to the "excellent" membership function, creativity must receive input through membership functions defined as "excellent". Otherwise, in all other cases, output will be made over the "poor" membership function. The rule base created and used in the fuzzy logic-based evaluation algorithm is given in Table 3.

iii) Application of fuzzy operators: At this stage, two different operators work. The first operator (fuzzy operator) is the transformation of the values of the membership functions of the input parameters into a single fuzzy set for the sub-conditions that make up each rule in the rule base. In this study, the "MIN" operator is used as the fuzzy operator.

The second operator is the apply implication operator. The value of the fuzzy set obtained from the first operator corresponds to the output membership function that forms the rule base. As a result, it is the fuzzy set value produced by the relevant rule (set of conditions) in the rule base. In our study, the "MIN" operator is used as the application operator.

Table 3. Part of the rule base of the fuzzy set-based evaluation algorithm.

No.	Rule
1	If (Creativity is perfect) and (Design Principles is perfect) and (Design Elements is perfect), then (Project presentation is perfect) (1)
2	If (Creativity is weak) and (Design Principles is excellent) and (Design Elements is excellent), then (Project presentation is excellent) (1)
3	If (Creativity is excellent) and (Design Principles is weak) and (Design Elements is excellent), then (Project presentation is weak) (1)
4	If (Creativity is weak) and (Design Principles is weak) and (Design Elements is excellent), then (Project presentation is weak) (1)
5	If (Creativity is excellent) and (Design Principles is excellent) and (Design Elements is weak), then (Project presentation is weak) (1)
6	If (Creativity is weak) and (Design Principles is excellent) and (Design Elements is weak), then (Project presentation is weak) (1)
7	If (Creativity is excellent) and (Design Principles is weak) and (Design Elements is weak), then (Project presentation is weak) (1)
8	If (Creativity is weak) and (Design Principles is weak) and (Design Elements is weak), then (Project presentation is weak) (1)

iv) Merging the results: The fuzzy sets representing the outputs of each rule are merged into a single fuzzy set. The output of the aggregation process is also a fuzzy set. In this study, the "SUM" operator is used as the merging operator.

v) Clarification: The input of the process is the combination of fuzzy sets representing the outputs of each rule. It is the process of converting the combination of the fuzzy sets used as input in the process into a single fuzzy number by averaging the points where the combination of the fuzzy sets used as input is maximum.

It was calculated with the fuzzy logic-based evaluation algorithm developed to determine the academic success of the students. Creativity, design principles, and design elements were used as parameters when calculating the design performances of the students. The creativity parameter was particularly decisive when the system design was made (while designing the membership function and creating the rule base). The effect of the parameters of creativity and design principles and elements on the student design performances is given in Figure 3.

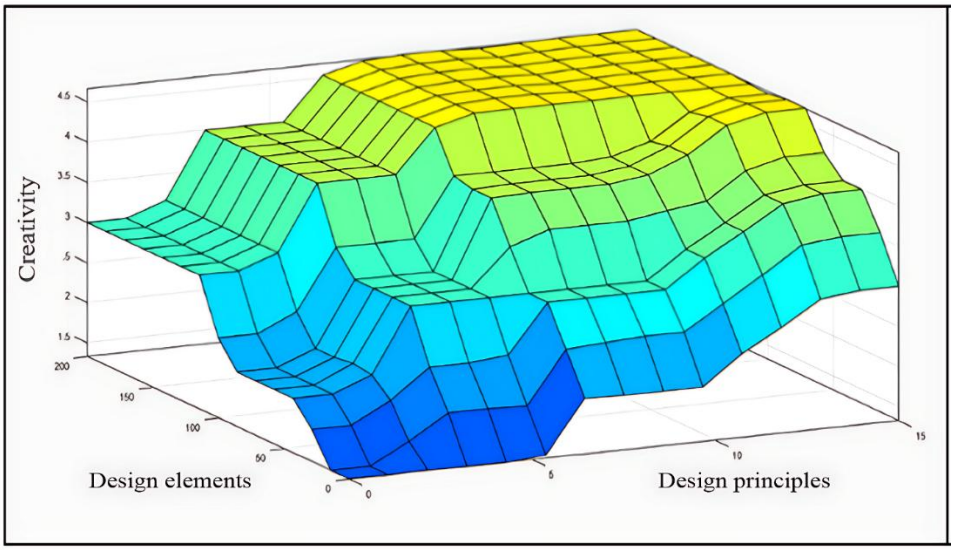

Figure 3. The effect of membership functions of creativity and design principles and elements on student performance in the fuzzy logic-based evaluation algorithm.

Table 4. Calculated results and central tendency measurements for some input values of the fuzzy logic-based evaluation algorithm (Student performances related to the design process).

Student	Creativity (0-100)	Design elements (0-100)	Design principles (0-100)	*System success (Fuzzy)*	Arithmetic mean	Geometric average	Harmonic average	Weighted average	Squared average
1	92.4	100.0	100.0	**95.35**	90.00	100.00	100.00	100	100
2	92.4	98.0	100.0	**90.88**	87.00	90.00	90.00	85.50	90
3	100.0	70.0	95.0	**92.00**	87.00	90.00	90.00	87	90
4	92.2	65.0	90.5	**85.22**	87.00	90.00	90.00	88	90
5	100.0	70.5	90.5	**95.32**	85.00	95.00	95.00	90	93
6	100.0	80.0	95.0	**90.12**	78.00	75.00	75.00	78	77
7	45.0	50.0	60.5	**55.70**	67.00	75.00	75.00	78.22	77
8	95.5	65.0	70.5	**60.10**	60.00	70.00	70.00	75.19	75
9	96.5	90.5	95.0	**95.50**	93.00	90.50	90.50	85.25	90
10	99.2	50.5	60.5	**65.70**	60.00	65.00	65.00	63	64
11	85.0	55.0	60.0	**70.44**	63.00	67.50	67.50	65	67
12	100.0	70.5	80.5	**75.00**	75.90	75.00	75.00	70	72
13	100.0	85.5	90.0	**90.40**	90.50	90.00	90.00	93.10	92
14	98.0	60.0	75.5	**70.34**	70.10	70.50	70.50	73.80	72.7
15	97.5	60.0	75.0	**75.90**	78.90	75.00	75.00	78	77
16	100.0	60.0	70.0	**65.90**	75.80	70.00	70.00	72	73
17	65.0	50.0	40.0	**40.16**	40.50	50.00	50.00	55	55
18	68.0	50.0	50.5	**50.50**	53.10	50.00	50.00	57.1	55
19	50.0	40.0	40.5	**40.66**	45.40	40.00	40.00	40	40
20	48.0	35.0	30.5	**30.00**	30.22	35.00	35.00	30	30
21	50	35.5	30.5	**30.00**	35.00	35.00	35.00	30	30

Table 4 shows the results and central tendency measures obtained from the evaluation of student performances by the system, where the three main input parameters of the fuzzy logic-based evaluation software creativity, design elements, and design principles are used.

In the calculations made, the student performance evaluation for design practices and the GPA data of the students were matched. The correlation between the data was calculated as 0.19. In addition, when we wanted to design a mathematical model using the MATLAB application, R-square=0.4687 for the ninth-order polynomial regression model and R-square=1 for the linear interpolation model used as the second.

At the end of these processes, a semi-structured interview form was applied to volunteer students (n=21) in the fourteenth week.

2.5. Dataset and Tools

2.5.1. Semi-Structured Interview Form

The primary purpose of employing an interview technique is generally not to test a hypothesis; rather, it is to understand other people's experiences and how they interpret them (Smith, 2024). For this reason, semi-structured interview formats were utilized to explore students' experiences in greater depth. The interview guide was initially composed of six questions; however, the number was reduced to three based on expert feedback. The researchers conducted individual interviews within a basic design course. Each interview lasted approximately 20 minutes.

The data obtained from semi-structured interviews were transferred to a computer environment and analyzed using content analysis, a qualitative data analysis method. The qualitative data collected from student interviews were imported into MAXQDA qualitative data analysis software. It was observed that the agreement values between coders increased the reliability of the qualitative dimension, with a result of 97.32%. The agreement rate for code frequency was 99.15%. According to Miles, Huberman, and Saldana (2013), an inter-coder agreement of 85% to 90% is recommended, indicating that the coding process in this study exceeded the standard reliability thresholds.

3. FINDINGS

This research was conducted with the participation of first-year students of the Visual Communication Design Department of the Faculty of Art and Design at a university located in the west of Türkiye. An evaluation study was

conducted to obtain student' opinions on the scoring of their design work using the fuzzy logic method. This section includes data obtained from student opinions.

3.1. Student Opinions on the use of the Fuzzy Logic Approach in Performance Evaluation

In order to answer the research questions and test the hypothesis, the interview question "Can you tell us about your evaluation experiences with the fuzzy logic method in the basic design course? What advantages and disadvantages did you encounter?" was answered. Figure 3 shows that all of the students expressed positive opinions. When the remarkable findings are analyzed, it is understood that the majority of the students found this practice reliable and thought that it increased their motivation. They also stated that they believed this assessment was fairer, that their exam anxiety and worries were reduced, that there was no need to be a software developer or programmer to evaluate with fuzzy logic, and that being informed about the evaluation process helped them identify their strengths and weaknesses.

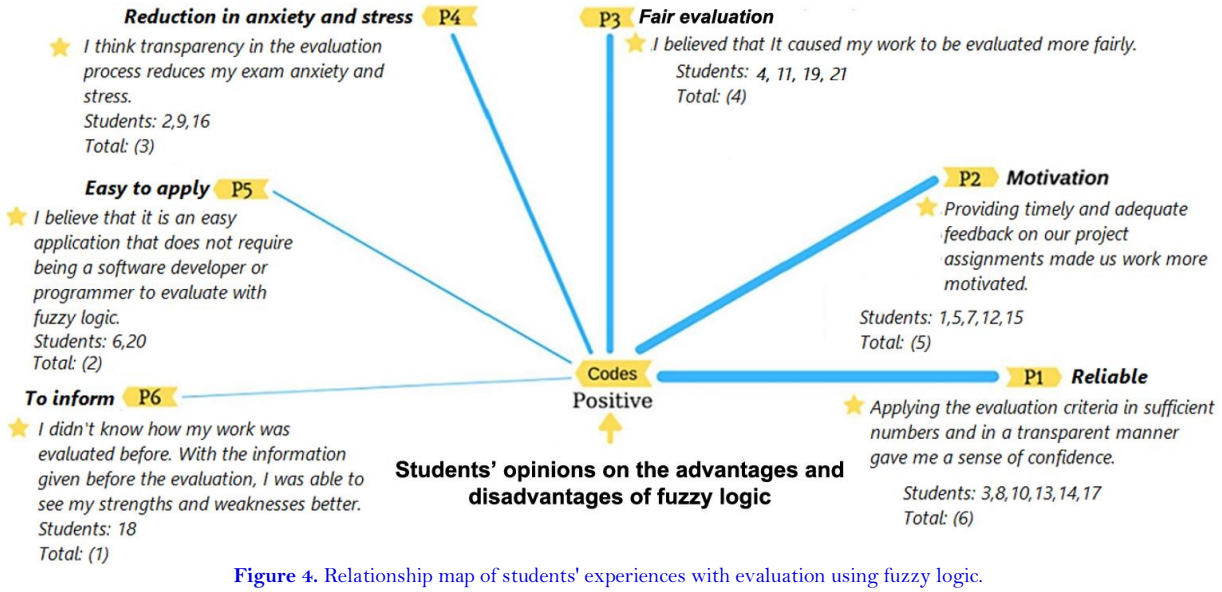

Figure 4. Relationship map of students' experiences with evaluation using fuzzy logic.

The interview question "Do you think that the evaluation of your performances with fuzzy logic had an effect on your interest in the course? If so, what kind of effects did it have?" was answered. Figure 4 shows that a total of 21 students were completely positive. Additionally, the students predominantly stated that this process increased their creativity and that it was a positive experience for them to participate in the evaluation process, unlike traditional methods. They also mentioned that knowing the evaluation criteria in advance increased their sense of responsibility, improved their sense of competence in research, and enhanced their problem-solving skills.

The following Figure 5 is a summary of student opinions regarding the evaluation process using fuzzy logic. Students mostly stated that it had a positive impact on their creativity.

The question "Do you think that the use of fuzzy logic in assessments had any effects on your professional self-efficacy? If so, what kind of effects did it have?" was asked. Figure 6 shows that respondents believe it had positive effects on their professional self-efficacy, with student opinions selected based on the highest weighting score. Most students reported improvements in their skills related to the use of technology and indicated that permanent learning occurred. Additionally, they stated that this practice contributed positively to their professional development and helped them recognize their professional deficiencies.

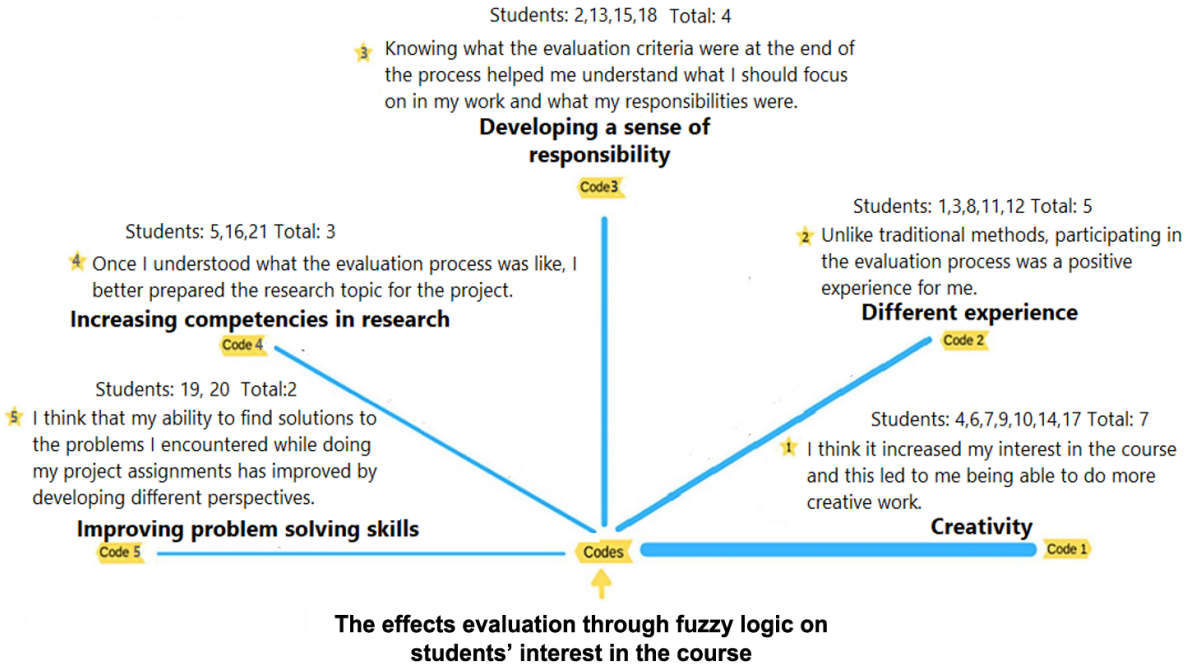

Figure 5. The effect map of students' performance evaluation with fuzzy logic on their interest in the course.

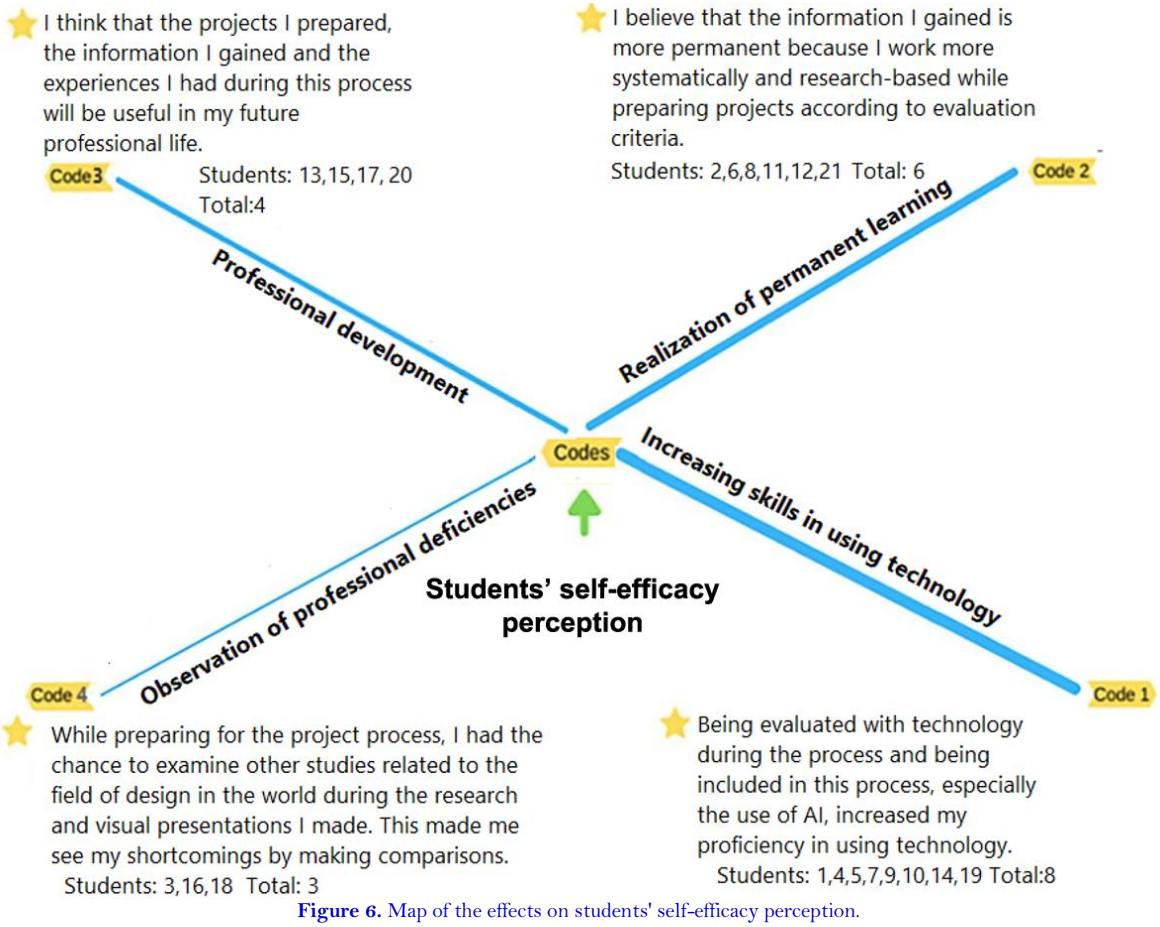

Figure 6. Map of the effects on students' self-efficacy perception.

4. DISCUSSION

This research was conducted to obtain the opinions of design students on the evaluation of their design projects realized with the DALL-E AI tool using the fuzzy logic method. MATLAB Fuzzy Logic Toolbox was used in the design and implementation of the algorithm. Mohler and Mihalcea (2009) stated that measuring and assessing the

knowledge gained is a vital aspect of evaluating the learning process. Especially today, the exponential increase in student development has become a challenging factor for educators (Jamil & Hameed, 2023). Therefore, it is inevitable to employ different assessment tools for the assessment of developing student behaviors. As Marsh and Farrell (2015) argue, educators need to be familiar with different data sources and use multiple assessment strategies, including criterion-referenced methods and standardized tests. The existence of different assessment methodologies can affect the improvement of teaching policies. In the fuzzy set-based assessment algorithm, the input parameters of the system were determined as creativity level, ability to use design principles, and ability to use design elements, and accordingly, student performance was calculated by formulating 15 fuzzy rules to fulfill the exact and consistent requirements of "unacceptable, poor, satisfactory, good, and excellent". While designing the membership function and creating the rule base, the creativity parameter was particularly decisive among these parameters. Students participated in the design and implementation of the fuzzy-based evaluation algorithm, and the necessary guidance was provided by the researcher. In this respect, it is similar to Rasmani and Shen (2005) study in which students were involved in the assessment process to help them understand their own performance. In another similar study involving students in the evaluation process, Ma and Zhou (2000) found that the criteria and weights in the evaluation table were determined collaboratively with the students through brainstorming. This approach was adopted because when only the teacher determines the criteria and their weights, student interest tends to decrease. In this study, as in others, selecting the evaluation criteria together with the students enabled them to focus on their own performance and observations. This process increased their self-confidence and contributed to a more accurate evaluation. Such an approach is particularly important for making healthy and consistent decisions when multiple criteria and alternatives are involved.

5. CONCLUSION

When analyzing the opinions of students regarding the process, it is observed that all responses to the first interview question contain positive codes. These codes include perceptions that the application was reliable, increased motivation, was fair, reduced exam anxiety and worries, was easy to use, and helped identify strengths and weaknesses through information about the evaluation process. All responses to the second interview question also contained positive codes. The positive codes derived from these answers are that the process increased creativity, was a positive experience, enhanced the sense of responsibility, improved self-efficacy, and strengthened problem-solving skills. Regarding the third interview question, students indicated that the process had positive effects on professional self-efficacy, led to improvements in technology-related skills, and facilitated permanent learning. Additionally, they stated that this practice contributed positively to their professional development and helped them recognize their professional deficiencies. In the study conducted by Westphal, Vock, and Kretschmann (2021) similarly, it is seen that evaluating with fuzzy logic accelerates the development of students' problem-solving skills.

There are many different studies on assessing students' knowledge and performance with fuzzy logic (Chrysafiadi, Troussas, & Virvou, 2020; Doz, Felda, & Cotič, 2022; Eryılmaz & Adabashi, 2020; Fu et al., 2022; Wardoyo & Yuniarti, 2020). The common point of these studies is that fuzzy logic is a suitable assessment tool for such variables since the assessment of students is an imprecise construct. On the other hand, some studies investigating the difference between traditional assessment methods and those based on fuzzy logic did not find a significant difference (Saliu, 2005; Sripan & Suksawat, 2010; Yadav, Soni, & Pal, 2014), as well as some studies that found that fuzzy logic assessment is less reliable than traditional assessment (Doz et al., 2022; Gokmen et al., 2010; Petrudi, Pirouz, & Pirouz, 2013).

In this research, the opinions of art and design students about their experiences in the process in which they actively participated were obtained through fuzzy logic. The point that should be emphasized in this study and which is different from other studies, is that, with the application of fuzzy logic principles to the evaluation of art and design performances, the desired flexibility can be provided for the existing system. This flexibility is especially important

considering the difficulty of making evaluations within precise lines due to the nature of art education. In the process of artistic activity, the student identifies with the subject they want to work on, objectifies it, and transforms it into a concrete form. Although the products appear in concrete form, their spiritual dimensions are also an important issue to be considered in product evaluation. The nature of art includes both the visible and the invisible. The evaluation of visible and invisible art outputs is quite difficult and subjective. It requires extensive knowledge and experience. Therefore, there are various problems in evaluation in art education. This view is supported by studies in the literature on the current situation, which reveal that there are various factors such as deficiencies, subjectivity, and arbitrariness in evaluation, lack of sufficient evaluation skills and knowledge among educators, and time constraints (Al-Amri, 2011; Ellmers, 2006; Garvis & Pendergast, 2010). In this study, it has been observed that the evaluation criteria of the fuzzy logic application used in the assessment of art and design studies are predetermined in a way that is known to the students, providing a more effective evaluation compared to traditional methods.

6. SUGGESTIONS

In future studies, academic performances should be measured with different methods; the results should be compared, and it should be investigated whether there is a significant difference between the results. More objective and efficient evaluations can be made by designing a new system that increases the number of criteria in the model and makes changes to their weights. More precise results can be obtained by increasing the number of fuzzy sets used in performance evaluation. With the development of the model, not only scores but also more comprehensive and guiding comments and feedback can be given to the evaluated individuals.

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