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Meta-analysis of Student Performance Assessment Using Fuzzy Logic

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ABSTRACT

The assessment system generally requires transparency and objectivity to assess student performance in terms of abstraction. Fuzzy logic method has been used as one of the best methods to reduce this uncertainty. Therefore, we have conducted a literature review to examine the application of fuzzy logic in assessing the performance of different students. The Preferred Reporting Items for the Systematics Review and Meta-Analysis Method (PRISMA) were used as the basic method for conducting systematic reviews and meta-analyses. The articles reviewed were 38 articles from 2008 until 2018. All articles were classified based on the author, year of publication, type of journal or conference, sample size, context, data type, fuzzy technique, and basic findings. The results of this review show the positive effects of using fuzzy logic on student performance assessment. Overall, this review provides an appropriate reference for further research by identifying research needs in aspects of student performance assessment.

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1. INTRODUCTION

Student performance assessment is a process in determining the level of performance for each student related to educational goals (Saleh and Kim, 2009). The assessment process for students is based on several elements such as examinations, assignments, tests, quizzes, research work, etc. (Daud *et al.*, 2011). Assessments must be carried out in a more impartial and transparent manner. Assessment is usually subjective, which can lead to differences of opinion in assessing student performance (Ingoley and Bakal, 2012). The assessment system must be regularly reviewed and improved to ensure that the assessment is appropriate, impartial

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and beneficial to all students. Therefore, the assessment system requires transparency, objectivity, logical reasoning, and easy computer implementation to assess student performance in terms of abstraction (Henriques *et al.,* 2018).

The education system in general usually uses classical performance assessment methods. Based on this system, student performance assessment depends on the results of the exam and is evaluated only as a factor of success or failure. As an alternative, non-classical performance assessment methods can be used, such as fuzzy logic can be applied to various forms of decision making including research on techniques and artificial intelligence (Barlybayev *et al.,* 2016; Gokmen *et al.,* 2010; Yadav and Singh, 2011). Fuzzy logic is used to manage intrinsic uncertainty associated with teacher subjective judgments and allows modeling of students in linguistic form (Darwish, 2016). This model approach provides various perspectives from different people, prevents subjectivity in the evaluation process, and allows students to take an active role in assessment. The software developed for the specific purpose of this study is user-friendly and has multi-criteria decision dimensions (Baba *et al.,* 2012). Based on this, it can be said that fuzzy logic can be used to solve problems in assessing student performance.

Student performance assessment using fuzzy logic is a research topic that has been carried out for many years and is an application used to facilitate assessment in the education system. In this paper, a literature review on student performance assessment using fuzzy logic from 2008 to 2018 is presented along with views in providing summaries and criticisms of the topics and research methods used until now. We can use this information to identify and answer problems or objectives in the literature and determine research directions on assessing student performance using fuzzy logic for further research.

The rest of the article is organized as follows. First, the relevant theoretical framework of this study provides a brief description of student performance assessment and fuzzy logic. Next, the report on how to search and choose the relevant literature study, and how this research is analyzed in the method section. Finally, the identified research topics and their related findings are reported in the results section, this is followed by the discussion and conclusion of the review.

2. THEORETICAL FRAMEWORK

2.1 Student performance assessment

Performance evaluation is one of the bases for monitoring the progress of student performance in higher education institutions. Based on this critical problem, grouping students into different categories according to their performance has become a complicated task. By using traditional grouping of students based on average scores, it is difficult to get a comprehensive view of the state of student performance and simultaneously find important details of student performance over time. The ability to monitor the progress of student academic achievement is an important problem for teachers for higher learning (Johanyák 2010; Oyelade *et al.,* 2010). Student performance assessment usually consists of several components, each involving a number of assessments often based on inappropriate data. This inaccuracy arises from the teacher's interpretation of student performance (Yadav *et al.*, 2014).

2.2 Fuzzy logic

Fuzzy logic was introduced in 1965 by Lotfi Zadeh as a mathematical way to represent linguistic uncertainty (Sakthivel *et al.*, 2013; Zadeh, 1965). The basis of fuzzy logic is fuzzy set theory. In fuzzy set theory, the role of membership degrees as a determinant of

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the existence of elements in a set is very important. The membership function (mf) is the main feature of reasoning with the fuzzy logic (Jafari and Khotanlou, 2013; Kusumadewi and Purnomo, 2010). Fuzzy logic generally has three stages. Fuzzification is a process where the actual value is an input in the system. Each input value is rated membership and transforms into linguistic forms. The second stage is giving algorithm rules. Input is adjusted to the rule table. The third stage is defuzzification, involving the transformation of fuzzy values to actual values (Yildiz *et al.,* 2013). In the past decade, fuzzy logic has not only been used in engineering and science but has also been widely applied in education (Sripan and Suksawat, 2010).

2.3 Student performance assessment using fuzzy logic

Student performance assessment involves measuring abilities, competencies and skills. Ability, competency and skills are fuzzy concepts and can be captured in fuzzy form. This usually involves giving numerical values to students who represent their achievements by reasoning using arithmetic or statistical methods. Various criteria are used in mathematical methods for evaluation purposes (Arora and Saini, 2013). According to fuzzy logic, factors and criteria can be classified without certain limits. Thus, the application of fuzzy logic models can be done with a more flexible student learning evaluation model. This also works for flexible non-homogeneous data and objective performance evaluations, which is reported by Gokmen *et al. (*2010). Evaluation of student performance assessment using fuzzy logic has great flexibility and reliability. It is proven theoretically but can be an integral part of decision making and evaluation processes in educational institutions, as well as influential in improving the quality of educational facilities, motivation, reliability, consistency, and assessment objectivity. Several reports have been reported, such as Baba *et al.* (2012), Bhatt and Bhatt (2011), Voskoglou (2012), and Inyang and Joshua (2013).

3. METHOD

This literature review is carried out based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) method, which was introduced by Moher et al. (Moher *et al.,* 2009). PRISMA is one of the best methods that can help the author to carry out systematic reviews and meta-analyses correctly and also help author to review a structure like a road map. PRISMA is also the most commonly used method in articles such as literature reviews, such as Moher *et al.* (2009, 2010, 2015), Hutton *et al.* (2016), Shamseer *et al. (*2015), and Stewart *et al. (*2015). Systematic review is a valuable source of evidence, where the author must summarize and analyze the scientific literature that can be relied upon by using a structured procedure based on the objectives that have been determined so that the different researchers can use them as reported by Gopalakrishnan and Ganeshkumar (2013). In addition, this review must also define qualified criteria so that they can be carefully selected to describe the hypothesis (Ressing *et al.,* 2009). This can be an important role in solving problems by explaining, synthesizing, and assessing quantitative or qualitative evidence as reported by Ahmadi *et al.* (2018).

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3.1 Search strategies

In this stage, we choose scientific articles related to student performance assessment using fuzzy logic published in journals indexed in the SCOPUS database (60) and Google Scholar (64900). Other searches were carried out through the publisher databases of Elsevier (2093), Emerald (1507), Hindawi (60), IEEE (16), IET Journals (82), Routledge or Taylor, and Francis Online (6275), Springer (66553), and Wiley Online Library (6076). Literature search is done using keywords including "performance assessment", "student performance assessment", "fuzzy logic" and "student performance assessment using fuzzy logic". These articles were searched from January 2008 until October 2018. Based on the search strategy, 154 articles were taken and put into citation management software such as Mendeley. By doing the PRISMA method, the next step is the elimination of duplication automatically by the software. Duplication remove is done, where the same 12 articles have been removed. Finally, 142 articles remained after the stages were carried out.

3.2 Inclusion and exclusion criteria

Eligibility criteria are needed in selecting the appropriate article such as reported by Ahmadi *et al.*, (2018). Articles are filtered based on inclusion and exclusion criteria described in **Table 1**. According to exclusion criteria, articles that meet the requirements are selected, but for chapter book types, thesis, short reports, non-empirical study or articles, and non-English papers have been removed. In other words, only international conference proceeding and journals paper are considered in accordance with the inclusion criteria. In this case, 17 articles that did not match were removed and the article became 125 articles. The screening of articles was carried out by investigating the title and abstract based on the relevance of the subject of the article related to the student performance assessment using fuzzy logic. During this stage, irrelevant articles have been removed. Overall, there are 38 articles that match the inclusion criteria and relevant to this literature review research objectives.

3.3 Data extraction and analysis

In the final step, the 38 full text articles that would contribute to this literature review are examined. Articles are thoroughly examined to extract and summarize important information needed in order to answer the research objectives in this literature review. Based on the information needed, we consider several classifications and criteria that are in accordance with the objectives.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Language: English	Articles written in other languages
Time: January 2008 until October 2018	Before year 2008
Empirical research published through international conferences and international journals	Chapter book types, thesis, short reports, non-empirical study or articles.
Related to the student performance assessment using fuzzy logic	All scientific disciplines except in student performance assessment using fuzzy logic

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Data extraction is designed to classify, analyze and synthesize articles that meet the requirements based on specified criteria. Then, based on the analysis of data extraction, we can achieve the best results and recommendations. The criteria are the author, year of publication, type of article, journal or conference, sample size, context, data type, fuzzy technique, and basic findings. After reviewing and summarizing the articles collected, 38 articles from 26 international scientific journals and 12 conferences from 2008 to 2018 were matched with the inclusion criteria recognized as suitable articles to be analyzed and interpreted in this literature review. The whole texts were read, and the details for selecting articles related to the application of fuzzy logic in student performance assessment were taken into account. However, it is still carried out in accordance with the PRISMA method although choosing the right article requires a lot of time but because of its special structured nature of this method, it was sure that the most appropriate and relevant articles related to the subject of this literature review have been selected.

4 RESULTS

Findings from the results of analysis and synthesis of related articles are presented in this section. Based on systematic reviews and the results of meta-analysis data, various fuzzy logic methods that have been applied in student performance assessment are found out. Therefore, studies that fulfill the requirements regarding the application of fuzzy logic methods used in student performance assessment are summarized and classified as follows. This is based on various categories considered in relation to the research objectives.

4.1. The frequency of articles published during the last several year

The articles reviewed in this literature review were 38 articles that met the inclusion criteria. The article included 24.68% of the total articles taken through database searches based on keywords and year the article was published in the first step. The frequency of articles published in the period between 2008 and 2018 is shown in **Figure 1**. The graph shows that there was a significant increase in articles published from 2008 to 2018. In this case, almost 23.68% of articles were published in 2013. However, based on the graph below, it can be seen that there was a decrease interest in 2014 and 2015. This is evidenced by the little research that has been done. Even in 2017 there are no articles that discuss more specifically related to the application of fuzzy logic in student performance assessment. On the other hand, significant progress has been made in several years with achieving about six articles in 2012, nine articles in 2013, and seven articles in 2016. Therefore, based on these results it is clear that increasing interest in applying the fuzzy logic method in student performance assessment is presented.

4.2. Articles distribution based on international journal and conference type

Reviewed articles in this literature review were taken from 38 different international scientific journals and international conferences in 2008 until 2018. The distribution of articles based on of publication type is presented in **Figure 2**.

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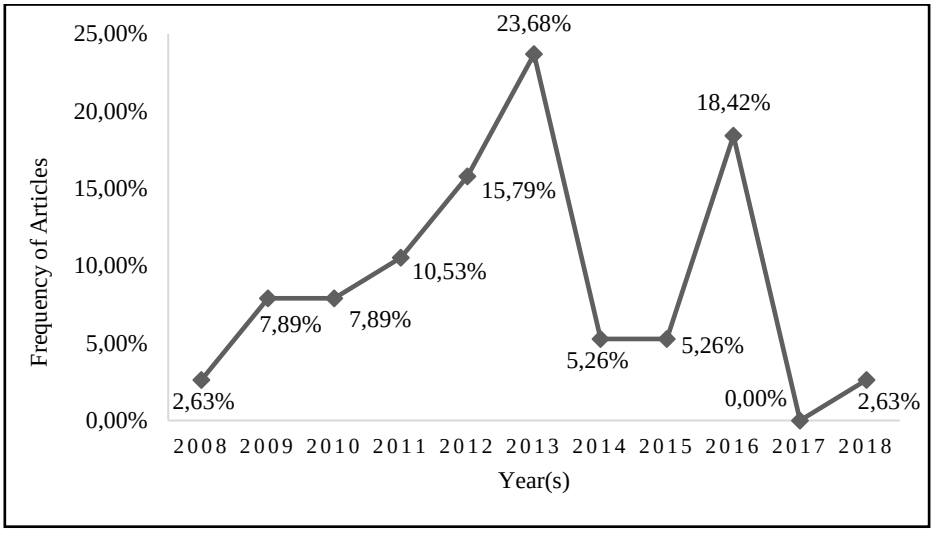

Figure 1. Frequency of articles based on publication year.

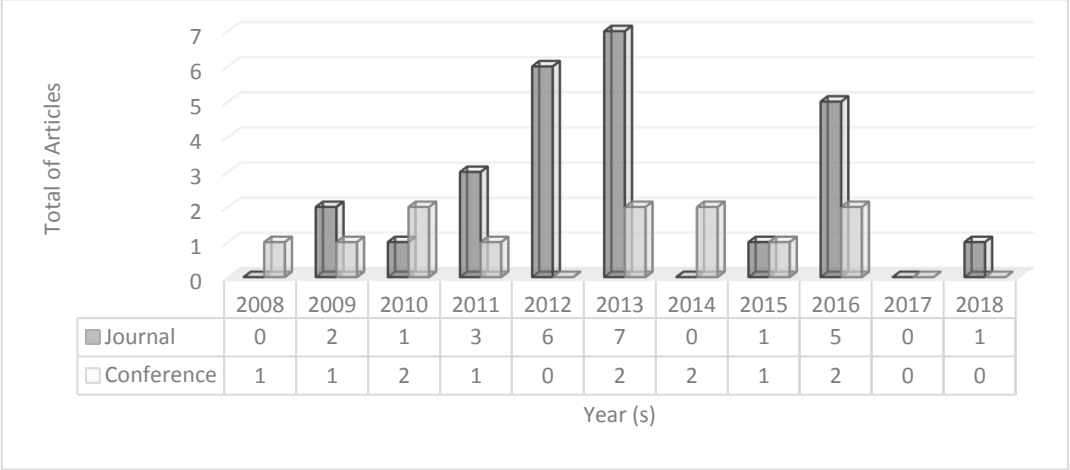

Figure 2. Articles distribution based on international journal and conference type.

As shown in the **Figure 2**, articles published in international scientific journals are significantly more dominant than articles presented in international conferences. This was shown in 2012 reaching six international scientific journals publication, but there were no articles presented at international conferences.

4.3. Articles distribution based on sample size

In this section, the sample size used in various articles has been surveyed. In this survey, researchers found a minimum sample size of nine samples in one of the articles published in 2015 (Prokhorov and Kulikovskikh, 2015), and the maximum sample size was 1121 in one of the articles published in 2008 (Rusli *et al.*, 2008).

The most widely used sample average was 20 samples from 7 articles reviewed, such as Gokmen *et al. (*2010), Yadav and Singh (2011), Darwish (2016), Yadav *et al. (*2014), Sakthivel *et al. (*2013), Bhatt and Bhatt (2011), and Inyang and Joshua (2013). Based on these findings, we also found that three out of 38 articles did not explain explicitly the number of sample sizes in the article, such as Ingoley and Bakal (2012), Owais

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(2009), and Do and Chen (2013). The distribution of articles based on sample size is more clearly shown in **Figure 3.**

4.4. Articles distribution based on context

In articles distribution based on this aspect, it is found several uses of fuzzy logic in the academic field such as:

- behavior (Vesely *et al.,* 2016),
- e-learning (Herrera-Viedma *et al*., 2009; Dias and Diniz, 2013; Almohammadi and Hagras, 2013; Deborah *et al.,* 2015; Arguedas *et al.,* 2018),
- intelligent tutoring system (Chrysafiadi and Virvou, 2012; Machado *et al.*, 2016),
- laboratory application (Gokmen *et al.,* 2010; Yıldız and Baba, 2014),
- library service quality (Jamali and Sayyadi Tooranloo, 2009),
- presentation skills (Daud *et al.*, 2011; Ozdemir and Tekin, 2016),
- problem solving (Voskoglou, 2012; Voskoglou, 2013; Owais, 2009),
- student academic performance (Ingoley and Bakal, 2012; Yadav and Singh, 2011; Oyelade *et al.,* 2010; Yadav *et al.,* 2014; Sakthivel *et al.,* 2013; Yildiz *et al.,* 2013; Arora and Saini, 2013; Inyang and Joshua, 2013; Rusli *et al.*, 2008; Do and Chen, 2013; Hidayah *et al.,* 2013; Borkar and Rajeswari, 2013),
- student learning assessment (Sripan and Suksawat, 2010),
- student performance assessment (Barlybayev *et al.,* 2016; Darwish, 2016; Baba *et al.,* 2012; Bhatt and Bhatt, 2011; Prokhorov and Kulikovskikh, 2015; Patil *et al.,* 2012; Pöysä-Tarhonen *et al.,* 2016), and
- students' choice (Henriques, *et al.,* 2018; Kabra and Bichkar, 2011).

Based on these findings, it turns out that the application of fuzzy logic is numerous and in various aspects, especially in terms of predicting student academic performance. The distribution of articles based on context is shown in **Figure 4.**

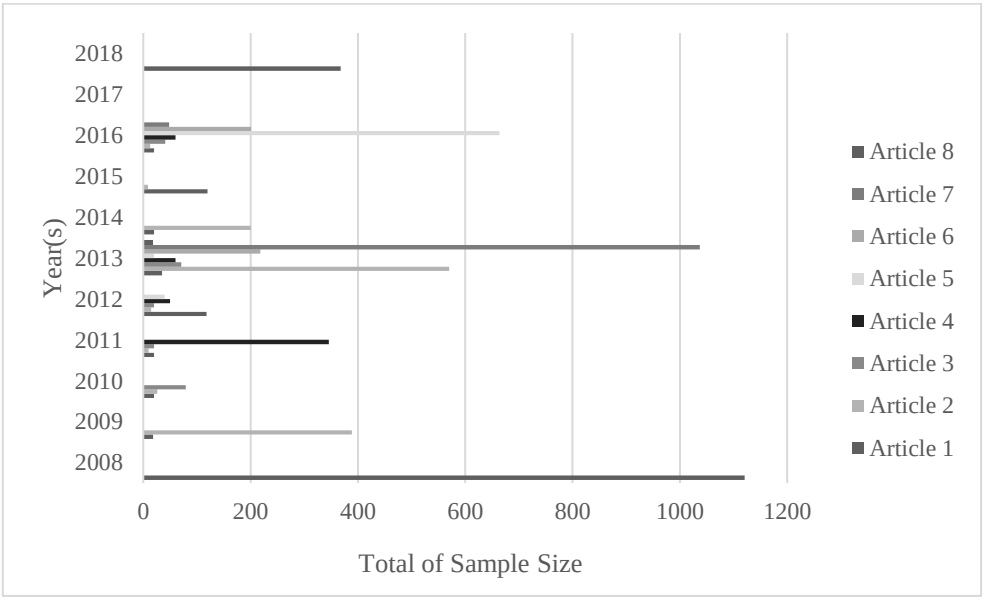

Figure 3. Articles distribution based on sample size.

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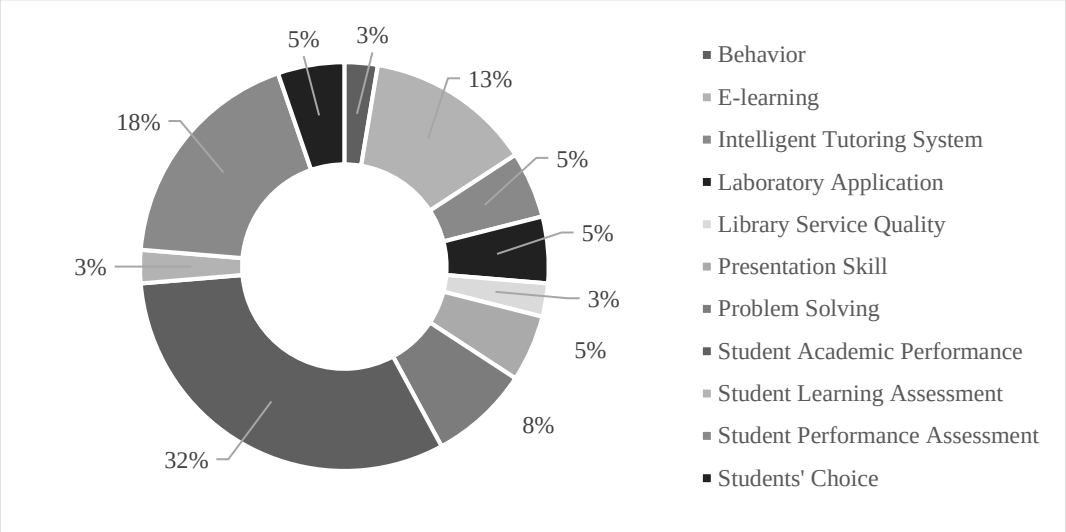

Figure 4. Articles distribution based on context.

4.5. Articles distribution based on data type

Based on the data type in each article reviewed, it was found several methods that are often used in this study such as:

- case studies (Machado *et al.,* 2016),
- comparative analysis (Daud et al., 2011; Ingoley and Bakal, 2012; Barlybayev *et al,* 2016; Gokmen *et al.,* 2010; Yadav and Singh, 2011; Darwish, 2016; Oyelade *et al.,* 2010; Sakthivel *et al.,* 2013; Bhatt and Bhatt, 2011; Rusli *et al.,* 2008; Ozdemir and Tekin, 2016; Owais, 2009; Do and Chen, 2013),
- experiment (Arora and Saini, 2013; Prokhorov and Kulikovskikh, 2015; Herrera-Viedma *et al*., 2009; Dias and Diniz, 2013; Almohammadi and Hagras, 2013; Deborah *et al.,* 2015; Arguedas *et al.,* 2018; Voskoglou, 2013; Borkar and Rajeswari, 2013),
- mix methods (Henriques *et al.*, 2018; Baba *et al.,* 2012; Yadav *et al.,* 2014; Yildiz *et al.,* 2013; Sripan and Suksawat, 2010; Voskoglou, 2012; Inyang and Joshua, 2013; Vesely *et al.,* 2016; Chrysafiadi and Virvou, 2012; Patil *et al.,* 2012; Pöysä-Tarhonen *et al.,* 2016; Kabra and Bichkar, 2011), and
- questionnaire (Yıldız and Baba, 2014; Jamali and Sayyadi Tooranloo, 2009; Hidayah *et al.*, 2013).

The method often used in research using fuzzy logic is more directed towards comparative analysis methods, where the study compares the use of fuzzy logic with classical models. The distribution of articles based on data type is presented in **Figure 5.**

4.6. Article distribution based on fuzzy technique

Based on fuzzy technique in the literature review on articles from 2008 until 2018, they are very diverse, especially the application in assessing student performance. There are several fuzzy techniques that are often used in student performance assessment such as FST, FRB, FIS, and FES. The distribution of articles included based on fuzzy techniques is presented in **Figure 6**.

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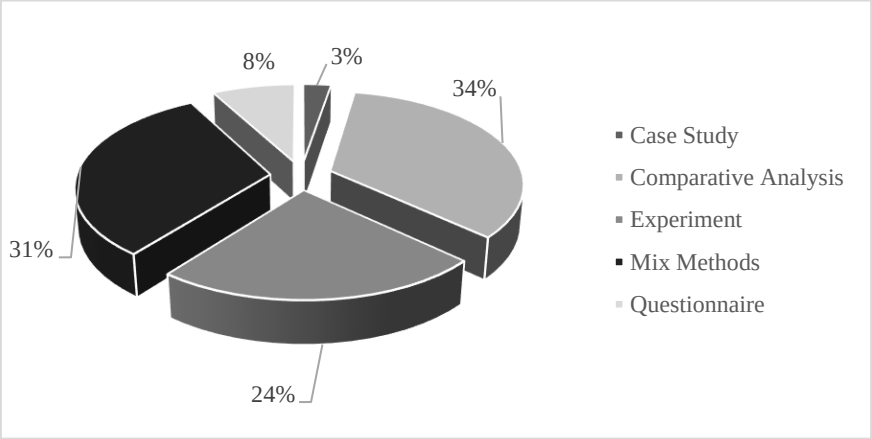

Figure 5. Articles distribution based on data type.

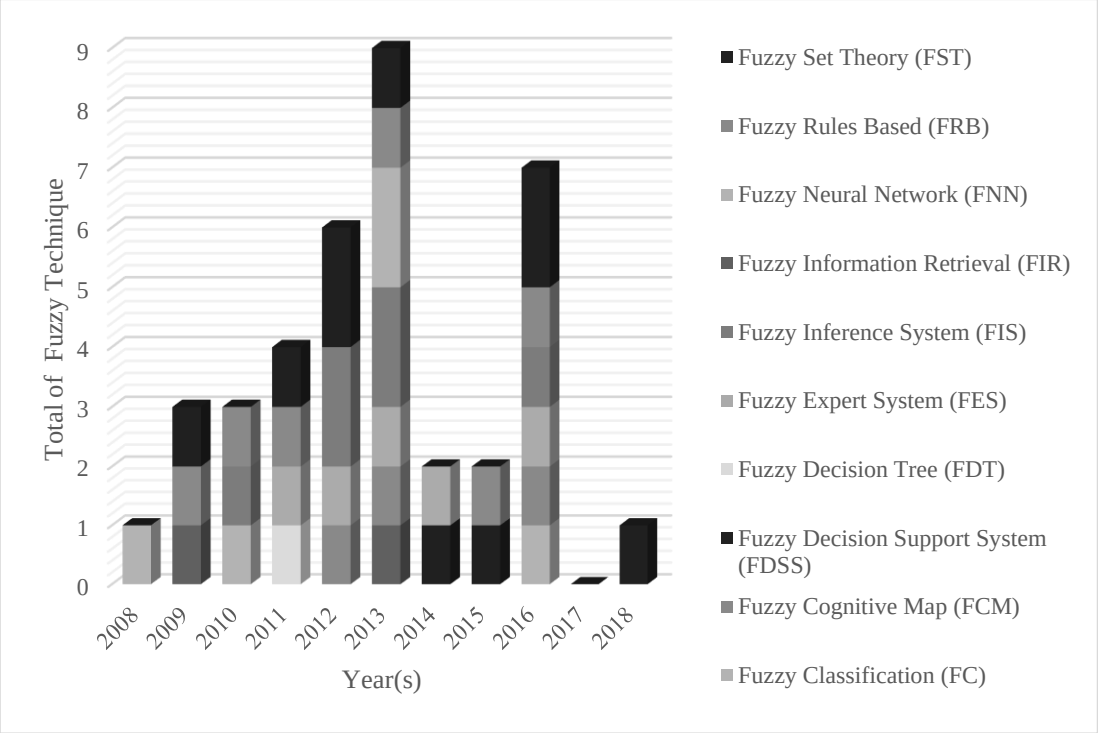

Figure 6. Articles distribution based on fuzzy technique.

4.7. Article distribution based on basic findings

Basic findings that were examined from this literature review are whether or not the fuzzy method used can have a positive effect on student performance assessment. Therefore, the reported effects of the fuzzy method on student performance assessment based on the different articles surveyed in this review were examined. The results obtained that almost 97.37% of articles illustrate the positive effects of the fuzzy methods application in improving student performance assessment. The article that illustrate the negative effects of the application of fuzzy methods because the results obtained do not make the significant changes due to a

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decrease in some student scores (Ozdemir and Tekin, 2016). However, this result is limited to only 38 articles selected in this review. To show how far the application of fuzzy methods, they have shown a positive effect on student performance assessment. The effect of fuzzy methods according to each fuzzy method in terms of student performance assessment is shown in **Figure 7**.

5. DISCUSSION

This literature review is designed to review the use of fuzzy logic methods in student performance assessment. Previous research has noted the importance of applying this fuzzy method, but few articles have examined how far fuzzy logic is applied to student performance assessment. As a result, this review can be seen as one of the most valuable studies in reviewing fuzzy methods used to improve student performance assessment and also to assess the effects of this method. In this review, we were able to identify and review 38 articles that applied different fuzzy logic techniques in student performance assessment from 2008 until 2018.

In this review, researchers consider the classification suitable for the survey on the fuzzy method. One of these classifications is about classifying a number of articles published every year. In recent years, there has been an increase in interest in applying fuzzy methods in student performance assessment. It is shown that an increase in articles published from 2.63% in 2008 reached 23.68% of all articles published in 2013. However, there was a significant decrease of articles published in 2014 and 2015, even in 2017 there were no article published about fuzzy method in student performance assessment. But in 2016, articles that have been published increased again and almost reached 18.42%. Improvement of fuzzy techniques is possible because the results are useful in improving student performance assessment, supporting teacher activity in the classroom, and helping students develop independent learning processes (Baba *et al.,* 2012; Inyang and Joshua, 2013; Herrera-Viedma *et al.,* 2009; Arguedas *et al.,* 2018; Chrysafiadi and Virvou, 2012).

The second classification is about the distribution of an articles number based on sample size. The sample size used in 38 reviewed articles was very diverse. But we also found that three out of the 38 articles did not explain explicitly the number of sample sizes they used (Ingoley and Bakal, 2012; Owais, 2009; Do and Chen, 2013).

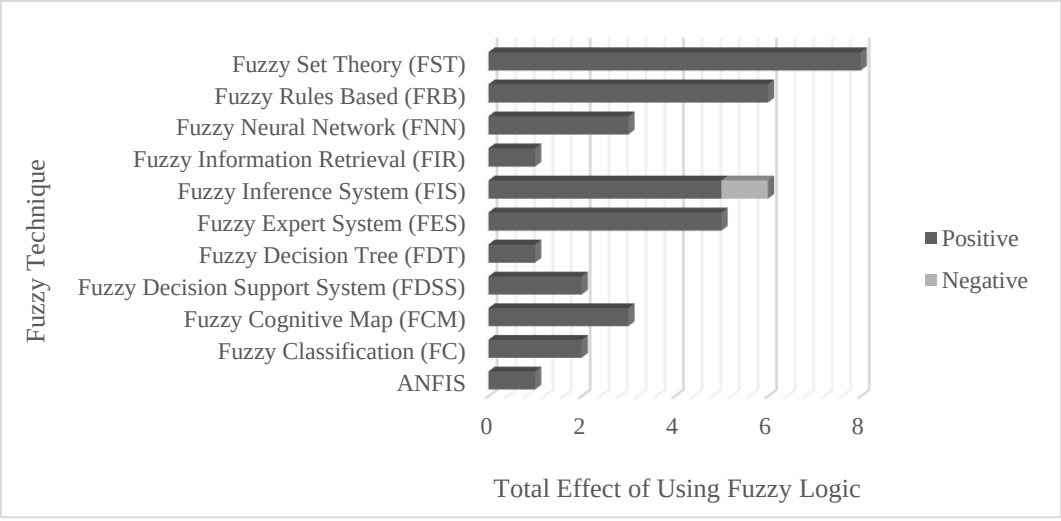

Figure 7. Articles distribution based on basic findings.

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The third classification is about the distribution of a number of articles based on context. We found 11 aspects used in this review. Based on these findings, it turns out that the application of fuzzy logic is more widely used in predicting student academic performance. This is because the fuzzy logic method is a practical method for evaluating academic students and is very helpful in evaluating types of subjective answers (Ingoley and Bakal, 2012; Yadav and Singh, 2011; Oyelade *et al.*, 2010; Yadav *et al.,* 2014; Sakthivel *et al.,* 2013; Yildiz *et al.,* 2013; Arora and Saini, 2013; Inyang and Joshua, 2013; Rusli *et al.*, 2008; Do and Chen, 2013; Hidayah *et al.*, 2013; Borkar and Rajeswari, 2013).

The next classification is about the distribution of an article number based on data types. Data types that are often used in the application of fuzzy logic are more directed towards comparative analysis methods, where the study compares the use of fuzzy logic with classic models (Daud *et al.*, 2011; Ingoley and Bakal, 2012; Barlybayev *et al.*, 2016; Gokmen *et al.,* 2010; Yadav and Singh, 2011; Darwish, 2016; Oyelade *et al.*, 2010; Sakthivel *et al.,* 2013; Bhatt and Bhatt, 2011; Rusli *et al.*, 2008; Ozdemir and Tekin, 2016; Owais, 2009; Do and Chen, 2013). The fifth classification is about the distribution of an article number based on fuzzy techniques. Based on the analysis of the researchers, 11 different fuzzy methods have been applied in the reviewed articles. The FST, FRB, FIS, and FES techniques have a high level among other fuzzy techniques. The results show that the level of use of this method is more applicable in the assessment of student performance. It is clear that fuzzy logic is the most widely used method in science disciplines that have high complexity and obscurity (Henriques *et al.*, 2018; Darwish, 2016; Sakthivel *et al.,* 2013; Zadeh, 1965).

The last classification is about the distribution of articles based on basic findings. Basic findings that were examined from this literature review are whether or not the fuzzy method used can have a positive effect on student performance assessment. Through the analysis, it was found that around 97.37% of the 38 reviewed articles believe that the use of the fuzzy logic method could have a positive effect on student performance assessment. The most interesting finding is that among the fuzzy logic methods applied, the eight studies used the FST method, which has been able to show the positive effects of fuzzy logic in student performance assessment. This shows the positive impact of FST as one of the most common fuzzy logic methods used to improve fuzzy logic and a reduction ambiguity in predictions due to the subjective assessment. In each of these methods, 21.05% of the eight articles applying this method have reported positive effects on fuzzy logic (Daud *et al.*, 2011; Henriques *et al.,* 2018; Baba *et al.,* 2012; Voskoglou, 2012; Vesely *et al.,* 2016; Jamali and Sayyadi Tooranloo, 2009; Voskoglou, 2013; Pöysä-Tarhonen *et al.*, 2016), and 2.63% of articles considering the effects of fuzzy method because the results obtained do not make significant changes due to a decrease in some student scores (Ozdemir and Tekin, 2016).

6. CONCLUSION

This literature review states about previous research conducted on the use of fuzzy logic methods on student performance assessment. In this case, several databases were chosen to retrieve articles published in the period of 2008 until 2018. To meet the objectives of this study, all articles found were classified by author, year of publication, type of journal or conference, sample size, context, data type, fuzzy technique, and basic findings to improve student performance assessment. The results show that the level of

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articles published has been increased even though there has been a decrease in several years. Another goal in this review is to determine which fuzzy methods are most widely used among researchers. The most obvious finding emerging from this study is that applying fuzzy methods not only can improve student performance assessment, but also can support teacher activities in the classroom and help students to develop independent learning processes. Overall, when more than 90% of studies reported positive impacts using fuzzy methods to improve student performance assessment, the effectiveness of this method cannot be ruled out.

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8. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the data and the paper are free of plagiarism.

9. REFERENCES

Ahmadi, H., Gholamzadeh, M., Shahmoradi, L., Nilashi, M., & Rashvand, P. (2018). Diseases diagnosis using fuzzy logic methods: A systematic and meta-analysis review. *Computer Methods and Programs in Biomedicine*, 161, 145-172.

Almohammadi, K., & Hagras, H. (2013). An adaptive fuzzy logic-based system for improved knowledge delivery within intelligent E-Learning platforms. *In 2013 IEEE International Conference on Fuzzy Systems* (FUZZ-IEEE) (pp. 1-8).

Arguedas, M., Xhafa, F., Casillas, L., Daradoumis, T., Peña, A., & Caballé, S. (2018). A model for providing emotion awareness and feedback using fuzzy logic in online learning. *Soft Computing*, *22*(3), 963-977.

Arora, N., & Saini, J. R. (2013). A fuzzy probabilistic neural network for student's academic performance prediction. *International Journal of Innovative Research in Science, Engineering and Technology, 2*(9), 4425-4432.

Baba, A. F., Cin, F. M., & Bakanay, D. (2012). A fuzzy system for evaluating students' project in engineering education. *Computer Applications in Engineering Education, 20*(2), 287-294.

Barlybayev, A., Sharipbay, A., Ulyukova, G., Sabyrov, T., & Kuzenbayev, B. (2016). Student's performance evaluation by fuzzy logic. *Procedia Computer Science*, 102, 98-105.

Bhatt, R., & Bhatt, D. (2011). Fuzzy logic-based student performance evaluation model for practical components of engineering institutions subjects. *International Journal of Technology and Engineering Education, 8*(1), 1-7.

Borkar, S., & Rajeswari, K. (2013). Predicting students academic performance using education data mining. *International Journal of Computer Science and Mobile Computing, 2*(7), 273-279.

Chrysafiadi, K., & Virvou, M. (2012). Evaluating the integration of fuzzy logic into the student model of a web-based learning environment. *Expert Systems with Applications, 39*(18), 13127-13134.

Darwish, S. M. (2016). Uncertain measurement for student performance evaluation based on selection of boosted fuzzy rules. *IET Science, Measurement & Technology, 11*(2), 213-219.

Daud W S W, Aziz K A A and Sakib E (2011). An evaluation of students' performance in oral presentation using fuzzy approach. *Organization, 5,* 70-73.

Deborah, L. J., Sathiyaseelan, R., Audithan, S., & Vijayakumar, P. (2015). Fuzzy-logic based learning style prediction in e-learning using web interface information. *Sadhana, 40*(2), 379-394.

Dias, S. B., & Diniz, J. A. (2013). FuzzyQoI Model: A fuzzy logic-based modelling of users' quality of interaction with a learning management system under blended learning. *Computers & Education,* 69, 38-59.

Do, Q. H., & Chen, J. F. (2013). A neuro-fuzzy approach in the classification of students' academic performance. *Computational intelligence and neuroscience*, 6. 67-76.

Gokmen, G., Akinci, T. Ç., Tektaş, M., Onat, N., Kocyigit, G., & Tektaş, N. (2010). Evaluation of student performance in laboratory applications using fuzzy logic. *Procedia-Social and Behavioral Sciences, 2*(2), 902-909.

Gopalakrishnan, S., & Ganeshkumar, P. (2013). Systematic reviews and meta-analysis: understanding the best evidence in primary healthcare. *Journal of family medicine and primary care, 2*(1), 9.

Henriques, P. L., Matos, P. V., Jerónimo, H. M., Mosquera, P., da Silva, F. P., & Bacalhau, J. (2018). University or polytechnic? A fuzzy-set approach of prospective students' choice and its implications for higher education institutions' managers. *Journal of Business Research*, 89, 435-441.

Herrera-Viedma, E., López-Herrera, A. G., Alonso, S., Moreno, J. M., Cabrerizo, F. J., & Porcel, C. (2009). A computer-supported learning system to help teachers to teach fuzzy information retrieval systems. *Information Retrieval, 12*(2), 179-200.

Hidayah, I., Permanasari, A. E., & Ratwastuti, N. (2013). Student classification for academic performance prediction using neuro fuzzy in a conventional classroom. *International Conference on Information Technology and Electrical Engineering*, *1*, 221-225

Hutton, B., Catala-Lopez, F., & Moher, D. (2016). The PRISMA statement extension for systematic reviews incorporating network meta-analysis: PRISMA-NMA. Med Clin (Barc), 147(6), 262-266.

Ingoley, S., & Bakal, J. W. (2012). Use of fuzzy logic in evaluating students' learning achievement. *International Journal on Advanced Computer Engineering and Communication Technology (IJACECT), 1*(2), 47-54.

Inyang, U. G., & Joshua, E. E. (2013). Fuzzy clustering of students' data repository for at-risks students identification and monitoring. *Computer and Information Science, 6*(4), 37.

Jafari, M., & Khotanlou, H. (2013). A routing algorithm based an ant colony, local search and Fuzzy inference to improve energy consumption in wireless sensor networks. *International Journal of Electrical and Computer Engineering, 3*(5), 640-650.

Jamali, R., & Sayyadi Tooranloo, H. (2009). Prioritizing academic library service quality indicators using fuzzy approach: Case study: libraries of Ferdowsi University. *Library Management, 30*, 319-333.

Johanyák, Z. C. (2010). Survey on five fuzzy inference-based student evaluation methods. *Computational Intelligence in Engineering, 1,* 219-228.

Kabra, R. R., & Bichkar, R. S. (2011). Performance prediction of engineering students using decision trees. *International Journal of computer applications, 36*(11), 8-12.

Kusumadewi, S., & Purnomo, H. (2010). *Fuzzy Logic Applications for Decision Support*. Graha Science, Yogyakarta.

Machado, M. A. S., Moreira, T. D. R. G., Gomes, L. F. A. M., Caldeira, A. M., & Santos, D. J. (2016). A fuzzy logic application in virtual education. *Procedia Computer Science,* 91, 19-26.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS medicine, 6*(7), e1000097.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2010). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine, 151*(4),264-269

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews, 4*(1),1.

Owais, M. A. (2009, August). Subjective decision-making using type-2 fuzzy logic advisor. *International Conference on Information and Communication Technologies, 1*, 127-133.

Oyelade, O. J., Oladipupo, O. O., & Obagbuwa, I. C. (2010). Application of k Means Clustering algorithm for prediction of Students Academic Performance. arXiv preprint arXiv:1002.2425.

Ozdemir, O., & Tekin, A. (2016). Evaluation of the presentation skills of the pre-service teachers via fuzzy logic. *Computers in Human Behavior*, 61, 288-299.

Patil, S., Mulla, A., & Mudholkar, R. R. (2012). Best Student Award—A fuzzy Evaluation Approach. *International Journal of Computer Science and Communication, 3*(1), 9-12.

Pöysä-Tarhonen, J., Elen, J., & Tarhonen, P. (2016). Student teams' development over time: Tracing the relationship between the quality of communication and teams' performance. *Higher Education Research & Development, 35*(4), 787-799.

Prokhorov, S., & Kulikovskikh, I. (2015). Fuzzy learning performance assessment based on decision making under internal uncertainty. *Computer Science and Electronic Engineering Conference, 7,* 65-70.

Ressing, M., Blettner, M., & Klug, S. J. (2009). Systematic literature reviews and meta-analyses: part 6 of a series on evaluation of scientific publications. Deutsches ärzteblatt international, 106(27), 456.

Rusli, N. M., Ibrahim, Z., & Janor, R. M. (2008). Predicting students' academic achievement: Comparison between logistic regression, artificial neural network, and Neuro-fuzzy. *International Symposium on Information Technology. 1*, 1-6.

Sakthivel, E., Kannan, K. S., & Arumugam, S. (2013). Optimized evaluation of students performances using fuzzy logic. *International Journal of Scientific & Engineering Research, 4*(9), 1128-1133.

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| p- ISSN 2528-1410 e- ISSN 2527-8045

Saleh, I., & Kim, S.I. (2009). A fuzzy system for evaluating students' learning achievement. *Expert Systems with Applications, 36*(3), 6236-6243.

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *Bmj, 349*, g7647.

Sripan, R., & Suksawat, B. (2010). Propose of fuzzy logic-based students' learning assessment. *ICCAS, 1*, 414-417.

Stewart, L. A., Clarke, M., Rovers, M., Riley, R. D., Simmonds, M., Stewart, G., & Tierney, J. F. (2015). Preferred reporting items for a systematic review and meta-analysis of individual participant data: the PRISMA-IPD statement. *Jama, 313*(16), 1657-1665.

Vesely, S., Klöckner, C. A., & Dohnal, M. (2016). Predicting recycling behaviour: Comparison of a linear regression model and a fuzzy logic model. *Waste management, 49*, 530-536.

Voskoglou, M. G. (2012). A fuzzy model for analogical problem solving. arXiv preprint arXiv:1204.6415.

Voskoglou, M. G. (2013). Problem solving, fuzzy logic and computational thinking. *Egyptian Computer Science Journal, 37*(1), 131-145.

Yadav, R. S., & Singh, V. P. (2011). Modeling academic performance evaluation using soft computing techniques: A fuzzy logic approach. *International Journal on Computer Science and Engineering, 3(*2), 676-686.

Yadav, R. S., Soni, A. K., & Pal, S. (2014). A study of academic performance evaluation using Fuzzy Logic techniques. *International Conference on Computing for Sustainable Global Development, 1*, 48-53.

Yildiz, O., Bal, A., & Gulsecen, S. (2013). Improved fuzzy modelling to predict the academic performance of distance education students*. The international review of research in open and distributed learning, 14*(5),144-165.

Yıldız, Z., & Baba, A. F. (2014). Evaluation of student performance in laboratory applications using fuzzy decision support system model. *IEEE Global Engineering Education Conference, 1,* 1023-1027.

Zadeh, L. A. (1965). Fuzzy sets. *Information and control, 8*(3), 338-353.