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Prediction of Primary and Secondary Education Institutions Scholarship Examination (PSEISE) Success with Artificial Neural Networks

Rumeysa Demir, Metin Demir

Research Article

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Author for correspondence:
Rumeysa Demir
rumeysagokmendemir7@gmail.com
Kutahya Dumlupınar University, Education Faculty

Abstract

Background/purpose. This study aims to reveal in detail the extent to which the variables in The Primary and Secondary Education Institutions Scholarship Examination (PSEISE) predict the success of students on the scholarship exam with the help of artificial neural networks (ANN). In addition, in light of the findings obtained as a result of the research, it aims to contribute to improving the quality and content of PSEISE and to revising the variables in student selection.

Materials/methods. A descriptive-relational screening model and purposive sampling method were used in the study. The study group of the research included students who were studying in a provincial centre in the Aegean Region of Turkey in the 2023-2024 academic year and who took the PSEISE at the 5th-grade level. In the study, the prediction level of these students' 4th and 5th grade written exam scores (independent variable) of Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics courses (independent variable) and their PSEISE achievement status (dependent variable) were determined through MATLAB 2023a program classification interface and optimised to achieve the best result.

Results. This process, carried out with a 5-fold cross-validation method, concluded that the ANN model with sigmoid activation function, forward cascaded back propagation, and double layer (230 neurons in the first layer and 2 neurons in the second layer) has the highest performance and an accuracy rate of 91.7%.

Conclusion. The correct classification of unsuccessful students with high performance shows that the model effectively predicts these students. However, the lower accuracy rates obtained in predicting successful students indicate that additional variables (taking private lessons and courses, etc.) should be examined to improve the performance of the ANN model for this group.

1. Introduction

The right to education is recognized as one of the fundamental rights in Turkey, as in many countries worldwide. The fair enjoyment of this right by all individuals is related to the concept of equal opportunity in education. Equality of opportunity in education is a principle that aims to ensure that every individual has access to the right to education. This principle is supported by laws, regulations, and agreements at national and international levels. It has emerged with the idea that everyone should have equal rights to education. In this context, equality of opportunity in education is the creation of educational situations and environments where equal opportunities are provided regardless of gender, material status, and ethnic groups by eliminating disadvantages in individual and social conditions to reveal the potential of individuals (Tan, 1987, pp. 256-257; Başaran, 1982, p. 4; Seren, 1995; Special Expertise Commission Report, 2009, 8; İnan & Demir, 2018). One of Turkey's main obstacles to equal opportunity in education is income differentiation. Regarding this situation, the state has taken many measures to ensure equality of opportunity since the Ottoman period (Gülmez, 2021). In particular, to provide educational support to successful students with low-income levels, the state provides various opportunities, such as scholarships, student loans and free boarding (Sarıer, 2010; Aslankurt, 2013). In Turkey, as in many other countries, centralized exams are held to determine the success status of students in need and provide support according to the evaluation results.

Central exams are prepared and administered by the Ministry of National Education and the Student Selection and Placement Center, which measure the student's future achievements (Başol & Zabun, 2014) and support the shaping of academic life, career planning, career choice (Hanımoğlu & İnanç, 2011) and even scholarship and other situations aimed at ensuring equality of opportunity in education (Büyüköztürk, 2016). When the central exams conducted for different purposes are examined, one of the most crucial central exams conducted in today's world, where income inequality has increased, especially after COVID-19, is undoubtedly the scholarship exam implemented in our country on the grounds of ensuring equality of opportunity. This exam, previously called the State Examination for Boarding and Scholarship without Pay, and since 2020, the Primary and Secondary Education Institutions Scholarship Examination is a multiple-choice exam conducted by the Ministry of National Education (MoNE) every year to identify and support bright students with insufficient financial means (Başol, Yıldız & Tutkun, 2021).

The Primary and Secondary Education Institutions Scholarship Examination (PSEISE), which is administered in primary and secondary education institutions, provides educational opportunities to individuals within the scope of the articles "Students who are granted special rights by law, " "Students who are children of retired or deceased teachers who are working as permanent or contracted teachers in official schools or institutions affiliated to the Ministry," "Students whose family does not have a secondary school, special education secondary school or imam hatip secondary school in their residential unit," "Students affected by earthquakes" (PSEISE Regulation, 2023). There are many studies in the literature on the evaluation of both academic achievement and student performance in PSEISE and other central exams (e.g., LGS and YKS). These studies examine course content and quality (Jürges, Schneider, Senkbeil & Carstensen, 2012; Özden, Akgün, Çinici, Sezer, Yıldız & Taş, 2014; Delil & Tetik, 2015; Çolak, 2017; Batur, Ulutaş & Beyret, 2018; Tuzlukaya, 2019; Öztürk & Masal, 2020; Polat, 2020; Başol et al., 2021; Ökcü & Akgül, 2021; Sarıoğlan, Dolu & Sevim, 2021; Akpınar & Düz, 2022; Polat & Bilen, 2022; Şahin, 2022; Yegen, 2022; Gür, Köroğlu & Gür, 2023; Yanık, 2023), determining teacher and student opinions about the current central exams (Buyruk, 2014; Kahraman, 2014; Karaca, Bektaş & Armağan, 2015; Erol, 2016; Özkan & Karataş, 2016; Akman, 2017; Aksoy, Akgündüz, Demir, Tunacan & Uğur, 2017; Çelikel & Karakuş 2017; Ünsal, Korkmaz& Aydemir, 2018; Yılmaz, 2017; Buldur & Acar, 2018; Can, 2019; Karakaya, Arık, Çimen & Yılmaz, 2019; Kızkapan & Nacaroğlu, 2019; Özdaş, 2019; Acar & Buldur, 2021; Derman & Kaygısız,

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2023), determining and predicting the relationships between various variables in central exams (Yanpar, 1998; Wößmann, 2002; Önen, 2003; Bahar, 2011; Neumann, Trautwein & Nagy, 2011; Doğan, Beyaztaş & Koçak, 2012; Scott-Clayton, 2012; Habacı, 2013; Bol, Witschge, Van de Werfhorst & Dronkers, 2014; Özdemir & Gelbal, 2016; Yavuz, Odabaş & Özdemir, 2016; Aslan, 2017; Dulkadir, 2017; Fincan, 2017; Anasız, Ekinci & Anasız, 2018; Karakoç & Köse, 2018; Okutan & Dasdemir, 2018; Erdağ, 2019; Akdemir, 2021; Köroğlu & Doğan, 2022; Kayalı & Savaş, 2022; Keleş, 2023).

Another prominent issue related to centralized exam practices is artificial intelligence applications. Artificial intelligence technologies, whose development continues rapidly in the current period, are used in many fields, such as medicine, engineering and education (Wardat, Tashtoush, AlAli & Jarrah, 2023). With the help of artificial intelligence applications used in education, it aims to increase the quality and efficiency of different processes, such as learning-teaching, assessment and evaluation (Chen, Chen & Lin, 2020; Naqvi, 2020). In the assessment and evaluation process, artificial intelligence algorithms and machine learning make predictions and classifications based on data. In this way, the evaluation of students' performances, interpretation of learning outcomes, and prediction of future outcomes are carried out more efficiently by saving time (Yadav, Bharadwaj & Pal, 2012; Khan & Ghosh, 2021; Luo, Han & Zhang 2022; Huang & Lii, 2023). In Turkey, artificial intelligence applications are used in measurement and evaluation (Ayık, Özdemir & Yavuz, 2007; Tosun, 2007; Altaş & Gürpınar, 2012; Çokluk & Çırak, 2012; Şengür & Tekin, 2013; Alan, 2014; Demir, 2015; Benzer & Benzer, 2017; Akgün & Demir, 2018; Aydoğan & Zırhlıoğlu, 2018; Toprak & Gelbal, 2020; Arslan, 2020; Güre, Kayri & Erdoğan, 2020; Aghalarova & Keser, 2021; Bastem, 2021; İşler & Kılıç, 2021; Ada & Demir, 2022; Atasayar & Demir, 2022; Öztürk, 2022; Kadirhanoğulları & Köse, 2023) and abroad (Al-Radaideh, Al-Shawakfa& Al-Najjar, 2006; Zaidah & Daliela, 2007; Fong & Biuk-Aghai, 2009; Kabakchieva, 2012; Yadav et al. , 2012; Isljamovic and Suknovic, 2014; Cheewaprakobkit, 2015; Mesarić and Šebalj, 2016; Nakhkob and Khademi, 2016; Alsalman. Halemah, AlNagi & Salameh, 2019; Feng, 2019; Lau, Sun & Yang, 2019; Vijayalakshmi & Venkatachalapathy, 2019; Mengash, 2020; Domladovac, 2021; Abideen, Mazhar, Razzaq, Haq, Ullah, Alasmary & Mohamed, 2023; Owan, Abang, Idika, Etta & Bassey, 2023). According to the modern understanding of assessment and evaluation, monitoring and controlling the process to minimize the margin of error and taking measures in this direction increase the efficiency towards the target (Aydın, 2007). Therefore, achieving more realistic outputs through classification and prediction model applications supports realizing educational goals. The use of artificial neural networks, decision trees, regression, etc., for classification or prediction is increasing day by day. ANNs (Artificial Neural Networks) are systems that resemble the neural networks and cells of the human brain, imitate human mental skills and the working principles of biological neurons, and perform functions, such as learning, classification and prediction (Efe & Kaynak, 2000; Elmas, 2003; Öztemel, 2003; Saraç, 2004; Akgün & Demir, 2018). The classification model was used to meet the purpose of the research. Figure 1 below shows the artificial neural network and biological neural cell model.

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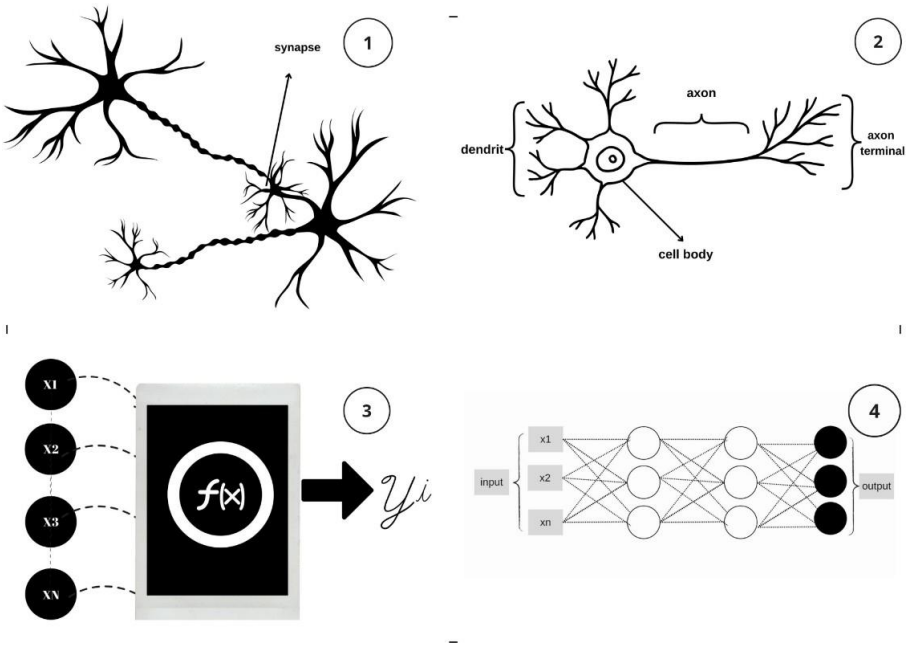

Figure 1. Artificial neural network and biological neural cell.

This study aimed to reveal in detail to what extent the written exam scores of the students predict the success of PSEISE with ANN. In addition, in light of this research's findings, it aims to contribute to improving the quality and content of PSEISE and revising the variables in student selection. For this purpose, the research problem statement can be expressed as 'Students' written exam scores predict PSEISE achievement at the level?'. The sub-problem of the research is as follows:

- With the ANN model, to what extent do the students' 4th and 5th-grade courses (Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics) written exam scores predict their success in the Primary and Secondary Education Institutions Scholarship Examination (PSEISE) at the 5th-grade level?

1.1. Assumptions

Students' written exam scores in 4th and 5th-grade courses (Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics) are assumed to reflect their achievements in these courses. It was assumed that school and teacher differences did not affect the students' written scores in 4th and 5th grade (Turkish, Mathematics, Science, Social Sciences, Religious Culture and Ethics) courses and thus their course achievement.

1.2. Limitations

- This study was limited to the 5th-grade written exam scores of the "Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics" courses of the students who studied in a provincial center in the Aegean Region and entered the PSEISE at the 5th-grade level in the 2022-2023 academic year and the 4th-grade written exam scores of the same courses in the 2021-2022 academic year.

- In this study, students' PSEISE achievement at the 5th-grade level was limited to the achievement status in the 2023 PSEISE result document.

- The analysis of this research was limited to MATLAB R2023a ANN (Artificial Neural Networks) classification algorithms.

2. Method

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2.1. Research Model

In this study, the descriptive-relational survey model was used since the 4th and 5th grade written exam scores of the students for the courses within the scope of PSEISE (Turkish, Mathematics, Science, Social Sciences, Social Studies, Religious Culture, and Ethics) and the success status of PSEISE at the 5th-grade level were examined. Descriptive-relational survey is used to determine the existence and effect level of the relationship between variables belonging to a phenomenon, situation or event by employing all or part of the research and to reach a general conclusion about the universe (Bailey, 1982; Kaya, Balay & Göçen, 2012; Karasar, 2023).

2.2. Working Group

In the study group of this research, students were studying in a provincial center in the Aegean Region in the 2023-2024 academic year and taking PSEISE at the 5th-grade level. Since the 4th and 5th grade written exam scores of these students belonging to "Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics" courses were examined in this study, a purposeful sampling method was used in sampling. Purposive sampling is the determination of people, situations, and events that have the desired qualities in line with the purpose of the research and are preferred as a sample (Büyüköztürk, Akgün, Demirel, Karadeniz & Çakmak, 2015). In this study, first of all, 965 students from 44 secondary schools who entered PSEISE at the 5th-grade level were identified, and 926 students' written exam scores and demographic information of the 5th-grade Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics courses of the 2022-2023 academic year were obtained. Then, it was tried to reach the 4th grade written exam scores of these students for the courses they were responsible for in PSEISE (Turkish, Mathematics, Science, Social Sciences, Religious Culture and Ethics) in the 2021-2022 academic year. Finally, the study group was determined to be 603 students, for whom both 4th and 5th grade data were obtained.

2.3. Data Collection Tools

The achievement certificates of 926 6th-grade students who entered the PSEISE at the 5th-grade level in the 2023-2024 academic year, and the previous semester transcripts of the 1st and 2nd semester written exam scores of the "Turkish, Mathematics, Science, Social Sciences, Religious Culture and Ethics" courses of the 5th grade in 2022-2023 and the 4th grade in 2021-2022 constituted the data collection tools of this study.

2.4. Data Collection Process and Analysis

The data collection process was carried out in three stages. In the first stage, the number of students who were in the 6th grade and entered the PSEISE at the 5th-grade level in September of the 2023-2024 academic year was determined as 965 by applying to the school directorates in the city center through the Provincial Directorate of National Education. In the second stage, 926 of these students' 5th grade Turkish, Mathematics, Science, Social Sciences, Religious Culture and Ethics courses 1st and 2nd semester written scores for the 2022-2023 academic year were obtained through the retrospective transcripts in the e-school system through the school directorates. In the last stage, 323 of the 926 students were excluded from the data set for reasons such as attending secondary school in different schools after primary school or not being able to access the primary school where they were enrolled by the researcher. The 1st and 2nd semester written exam scores of the 4th grade Turkish, Mathematics, Science, Social Sciences, Religious Culture and Ethics courses of the remaining 603 students for the 2021-2022 academic year were obtained from the retrospective transcripts in the e-school system through the school directorates.

In the data analysis, the data consisting of the 1st and 2nd semester written exam scores of 926 students from the 5th grade Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics courses were organized in the Microsoft Excel program. Then, the 4th and 5th grade written

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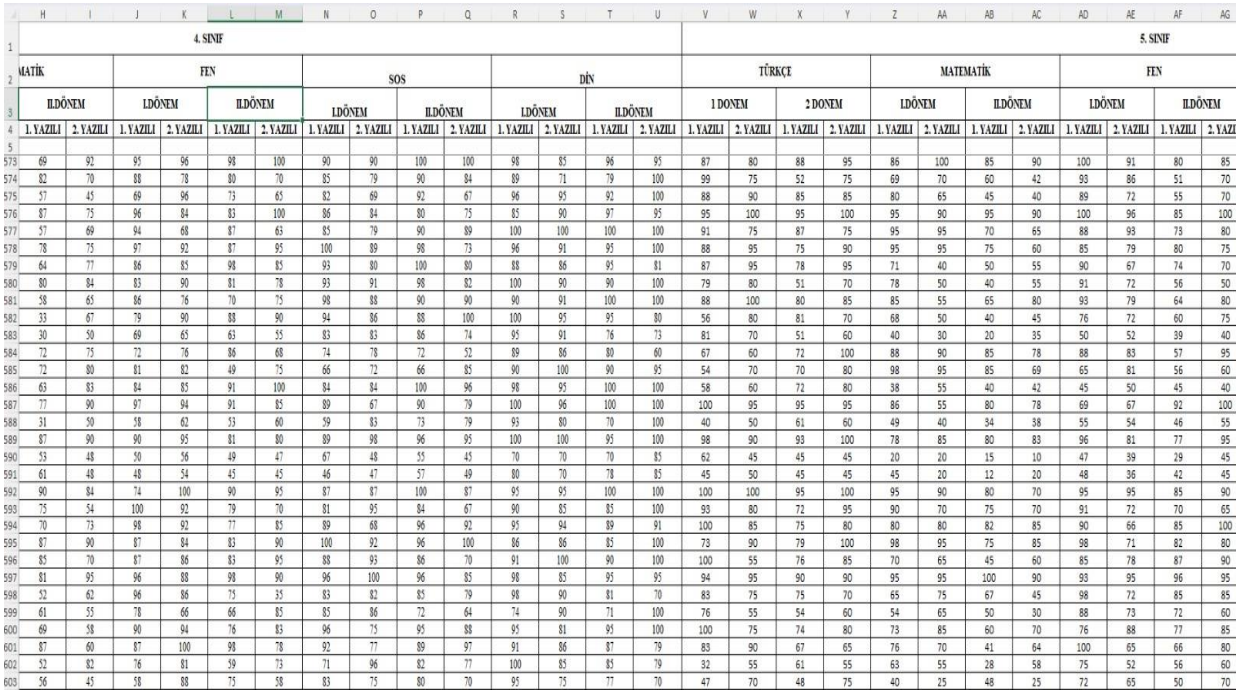
exam scores of 603 students whose 4th grade data were accessed were matched in the Microsoft Excel program. A part of the data is presented in Figure 2.



	4. SINIF																5. SINIF									
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	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZILI	1. YAZILI	2. YAZI
573	69	92	95	96	98	100	90	90	100	100	98	85	96	95	87	80	88	95	86	100	85	90	100	91	80	85
574	82	70	88	78	80	70	85	79	90	84	89	71	79	100	99	75	52	75	69	70	60	42	93	86	51	70
575	57	45	69	96	73	65	82	69	92	67	96	95	92	100	88	90	85	85	80	65	45	40	89	72	55	70
576	87	75	96	84	83	100	86	84	80	75	85	90	97	95	95	100	95	100	95	90	95	90	100	96	85	100
577	57	69	94	68	87	63	85	79	90	89	100	100	100	100	91	75	87	75	95	95	70	65	88	93	73	80
578	78	75	97	92	87	95	100	89	98	73	96	91	95	100	88	95	75	90	95	95	75	60	85	79	80	75
579	64	77	86	85	98	85	93	80	100	80	88	86	95	81	87	95	78	95	71	40	50	55	90	67	74	70
580	80	84	83	90	81	78	93	91	98	82	100	90	90	100	79	80	51	70	78	50	40	55	91	72	56	50
581	58	65	86	76	70	75	98	88	90	90	90	91	100	100	88	100	80	85	85	55	65	80	93	79	64	80
582	33	67	79	90	88	90	94	86	88	100	100	95	95	80	56	80	81	70	68	50	40	45	76	72	60	75
583	30	50	69	65	63	55	83	83	86	74	95	91	76	73	81	70	51	60	40	30	20	35	50	52	39	40
584	72	75	72	76	86	68	74	78	72	52	89	86	80	60	67	60	72	100	88	90	85	78	88	83	57	95
585	72	80	81	82	49	75	66	72	66	85	90	100	90	95	54	70	70	80	98	95	85	69	65	81	56	60
586	63	83	84	85	91	100	84	84	100	96	98	95	100	100	58	60	72	80	38	55	40	42	45	50	45	40
587	77	90	97	94	91	85	89	67	90	79	100	96	100	100	100	95	95	95	86	55	80	78	69	67	92	100
588	31	50	58	62	53	60	59	83	73	79	93	80	70	100	40	50	61	60	49	40	34	38	55	54	46	55
589	87	90	90	95	81	80	89	98	96	95	100	100	95	100	98	90	93	100	78	85	80	83	96	81	77	95
590	53	48	50	56	49	47	67	48	55	45	70	70	70	85	62	45	45	45	20	20	15	10	47	39	29	45
591	61	48	48	54	45	45	46	47	57	49	80	70	78	85	45	50	45	45	45	20	12	20	48	36	42	45
592	90	84	74	100	90	95	87	87	100	87	95	95	100	100	100	100	95	100	95	90	80	70	95	95	85	90
593	75	54	100	92	79	70	81	95	84	67	90	85	85	100	93	80	72	95	90	70	75	70	91	72	70	65
594	70	73	98	92	77	85	89	68	96	92	95	94	89	91	100	85	75	80	80	80	82	85	90	66	85	100
595	87	90	87	84	83	90	100	92	96	100	86	86	85	100	73	90	79	100	98	95	75	85	98	71	82	80
596	85	70	87	86	83	95	88	93	86	70	91	100	90	100	100	55	76	85	70	65	45	60	85	78	87	90
597	81	95	96	88	98	90	96	100	96	85	98	85	95	95	94	95	90	90	95	95	100	90	93	95	96	95
598	52	62	96	86	75	35	83	82	85	79	98	90	81	70	83	75	75	70	65	75	67	45	98	72	85	85
599	61	55	78	66	66	85	85	86	72	64	74	90	71	100	76	55	54	60	54	65	50	30	88	73	72	60
600	69	58	90	94	76	83	96	75	95	88	95	81	95	100	100	75	74	80	73	85	60	70	76	88	77	85
601	87	60	87	100	98	78	92	77	89	97	91	86	87	79	83	90	67	65	76	70	41	64	100	65	66	80
602	52	82	76	81	59	73	71	96	82	77	100	85	85	79	32	55	61	55	63	55	28	58	75	52	56	60
603	56	45	58	88	75	58	83	75	80	70	95	75	77	70	47	70	48	75	40	25	48	25	72	65	50	70

Figure 2. Students' 4th and 5th grade written exam score information

To reach the artificial neural network architecture that gives the best performance in the research, the prepared data were run in MATLAB 2023a program by selecting "all ANN models and optimized ANN models" in the classification interface. The results were generated automatically. The learning algorithm was determined as "Feed Forward Backpropagation." This algorithm is a multilayer perceptron model widely used for neural network prediction and classification problems. The model consists of layers that progress from data input to output. The model is trained by updating the weights using the backpropagation algorithm during training. In this way, the model gains the ability to learn complex relationships (Goodfellow, Bengio & Courville 2016).

In addition, the "k-fold cross-validation" technique was used in this research. In this technique, the "k-1" of the data divided into k-equal sub-data sets are used for training, and the remaining 1 is used for testing. This procedure is repeated "k" times to test the performance and stability of the model (Han, Kamber & Pei, 2012). The "k" value of the research is suggested as "5" by the program. The screenshots of the MATLAB 2023a program, classification interface validation technique, and data set properties are given in Figure 3.

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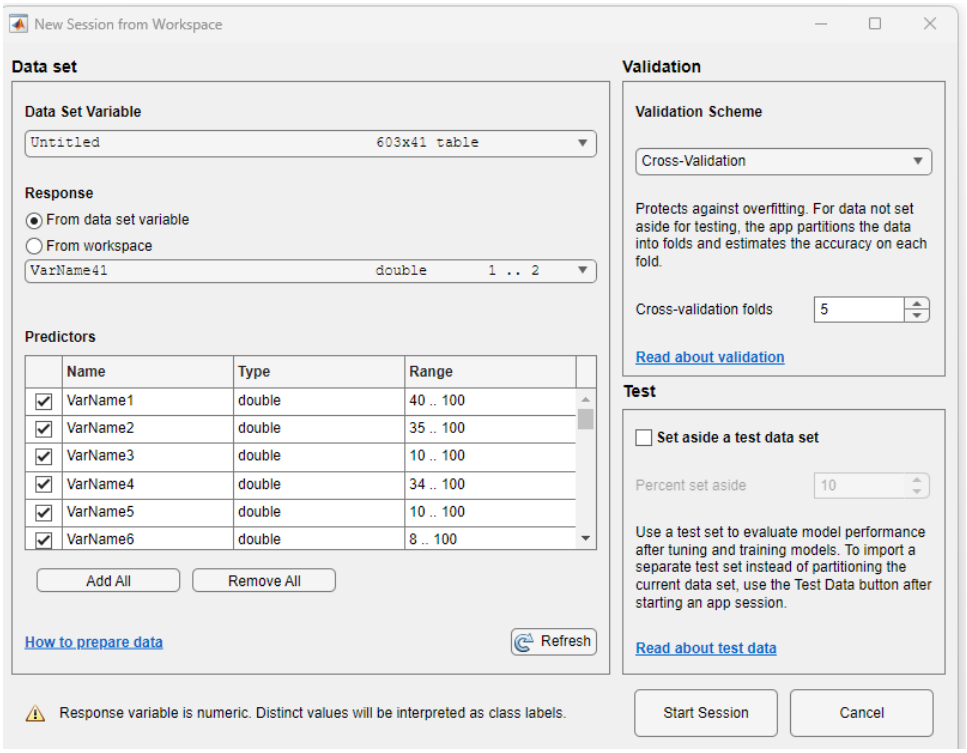

Figure 3. MATLAB 2023a classification interface validation technique and dataset properties screen

In this research, all ANN models were selected, and the optimization process was carried out after determining the best-performing model. Bayesian optimization was used as an optimization method because it is functional in terms of time and accuracy (Wu, Chen, Zhang, Xiong, Lei & Deng, 2019). It estimates the most efficient values that can be achieved by using the best results as a reference instead of randomly selected parameters.

3. Findings

The findings obtained as a result of the data analysis carried out for the purpose of this study are presented and interpreted under the sub-problem heading.

3.1. Findings and Comments related to the Sub-problem

The findings and interpretations related to the sub-problem "To what extent do the written exam scores of the students in the 4th- and 5th-grade courses (Turkish, Mathematics, Science, Social Sciences, Religious Culture, and Ethics) predict the success of the Primary and Secondary Education Institutions Scholarship Examination (PSEISE) at the 5th-grade level?" are presented in this section.

Information about the dependent and independent variables used in the processes carried out to determine the model with the best network performance among Artificial Neural Network (ANN) classification models using the Classification Interface of MATLAB 2023a program is given in Table 1.

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Table 1. Information about the variables in the study

Variables		
	Input layer	Output layer
X1	Grade 4 Turkish 1st semester 1st written exam score	
X2	Grade 4 Turkish 1st semester 2nd written exam score	
X3	Grade 4 Turkish 2nd semester 1st written exam score	
X4	Grade 4 Turkish 2nd semester 2nd written exam score	
X5	Grade 4 Mathematics 1st semester 1st written exam score	
X6	Grade 4 Mathematics 1st semester 2nd written exam score	
X7	Grade 4 Mathematics 2nd semester 1st written exam score	
X8	Grade 4 Mathematics 2nd semester 2nd written exam score	Y: Grade 5 PSEISE Success Status
X9	Grade 4 Science 1st semester 1st written exam score	
X10	Grade 4 Science 1st semester 2nd written exam score	
X11	Grade 4 Science 2nd semester 1st written exam score	
X12	Grade 4 Science 2nd semester 2nd written exam score	
X13	Grade 4 Social Studies 1st-semester 1st written exam score	
X14	Grade 4 Social Studies 1st-semester 2nd written exam score	
X15	Grade 4 Social Studies 2nd-semester 1st written exam score	
X16	Grade 4 Social Studies 2nd-semester 2nd written exam score	
X17	Grade 4 Religious Culture and Ethics 1st semester 1st written exam score	
X18	Grade 4 Religious Culture and Ethics 1st semester 2nd written exam score	
X19	Grade 4 Religious Culture and Ethics 2nd semester 1st written exam score	
X20	Grade 4 Religious Culture and Ethics 2nd semester 2nd written exam score	
X21	Grade 5 Turkish 1st semester 1st written exam score	
X22	Grade 5 Turkish 1st semester 2nd written exam score	
X23	Grade 5 Turkish 2nd semester 1st written exam score	
X24	Grade 5 Turkish 2nd semester 2nd written exam score	
X25	Grade 5 Mathematics 1st semester 1st written exam score	
X26	Grade 5 Mathematics 1st semester 2nd written exam score	
X27	Grade 5 Mathematics 2nd semester 1st written exam score	
X28	Grade 5 Mathematics 2nd semester 2nd written exam score	
X29	Grade 5 Science 1st semester 1st written exam score	
X30	Grade 5 Science 1st semester 2nd written exam score	
X31	Grade 5 Science 2nd semester 1st written exam score	
X32	Grade 5 Science 2nd semester 2nd written exam score	
X33	Grade 5 Social Studies 1st-semester 1st written exam score	
X34	Grade 5 Social Studies 1st-semester 2nd written exam score	
X35	Grade 5 Social Studies 2nd-semester 1st written exam score	
X36	Grade 5 Social Studies 2nd-semester 2nd written exam score	
X37	Grade 5 Religious Culture and Ethics 1st semester 1st written exam score	
X38	Grade 5 Religious Culture and Ethics 1st semester 2nd written exam score	
X39	Grade 5 Religious Culture and Ethics 2nd semester 1st written exam score	
X40	Grade 5 Religious Culture and Ethics 2nd semester 2nd written exam score	

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Table 1 shows that 40 independent (input layer) and one dependent (output layer) variables were used in this study. Independent variables were introduced into the model to predict the students' success. All independent variables were continuous. The dependent variable consisted of two categories: successful and unsuccessful. The findings of the parameters of ANN classification models created with the aforementioned variables are given in Table 2.

Table 2. Results for the parameters of ANN classification models

Model	Number of Layers	Activation Function	Number of hidden layer neurons	Number of hidden layer neurons	Number of hidden layer neurons	Verification Percentage	Error Percentage
1. Narrow Neural Network	1	ReLU	10	-	-	86.2	13.8
2. Middle Neural Network	1	ReLU	25	-	-	86.6	13.4
3. Large Neural Network	1	ReLU	100	-	-	87.4	12.6
4. Two Layer Neural Network	2	ReLU	10	10	-	86.7	13.3
5. Three Layered Neural Network	3	ReLU	10	10	10	86.1	13.9

As shown in Table 2, the number of layers of the models was 1, 2, and 3. The number of neurons varied between 10-100 in the first hidden layer, 0-10 in the second hidden layer and 0-10 in the third hidden layer. The model with the highest validation percentage in these experiments conducted to classify the PSEISE achievement status of the students was the large neural network model with

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forward cascade backpropagation algorithm, which was ranked 3rd in the table. The ANN activation map of this model is given in Figure 4.

Figure 4. Activation map of the created ANN model

There were 40 neurons in the input layer Figure 4. These represented 40 continuous variables consisting of students' 4th and 5th-grade written exam scores. There were 100 neurons in one hidden layer. In the output layer, two neurons represented the pass-fail categories of the dependent variable. Using the ReLU activation function, this model had a validation percentage of 87.4 and an error percentage of 12.6. After this process, optimization was performed to reach the best performance value of the model. The results of 10 performances and 30 trials in each performance are given in Table 3.

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Table 3. Results of ANN model parameters obtained after optimization

Number of Performances	Number of Layers	Activation Function	Number of hidden layer neurons	Number of hidden layer neurons	Number of hidden layer neurons	Verification Percentage	Error Percentage
1.	2	Sigmoid	288	282	-	88.2	11.8
2.	2	Tanh	21	1	-	89.2	10.8
3.	2	Sigmoid	230	2	-	91.7	8.3
4.	3	Tanh	171	2	244	87.4	12.6
5.	1	Tanh	27	-	-	90.7	9.3
6.	1	Sigmoid	1	-	-	88.9	11.1
7.	3	ReLU	26	79	2	86.9	13.1
8.	2	ReLU	100	142	-	87.7	12.3
9.	1	ReLU	1	-	-	87.9	12.1
10.	3	ReLU	1	180	1	89.6	10.4

When Table 3 is examined, it is seen that the number of layers created in the models is 1, 2, or 3. The number of neurons varied from 1 to 288 in the 1st hidden layer, 0-282 in the 2nd hidden layer and 0-244 in the 3rd hidden layer. The model with the highest accuracy percentage was the neural network model with forward cascade backpropagation algorithm and double hidden layers, ranked 3rd in the table. The lowest error percentage graph with the findings of this model is given in Figure 5. The ANN activation map is also shown in Figure 6.

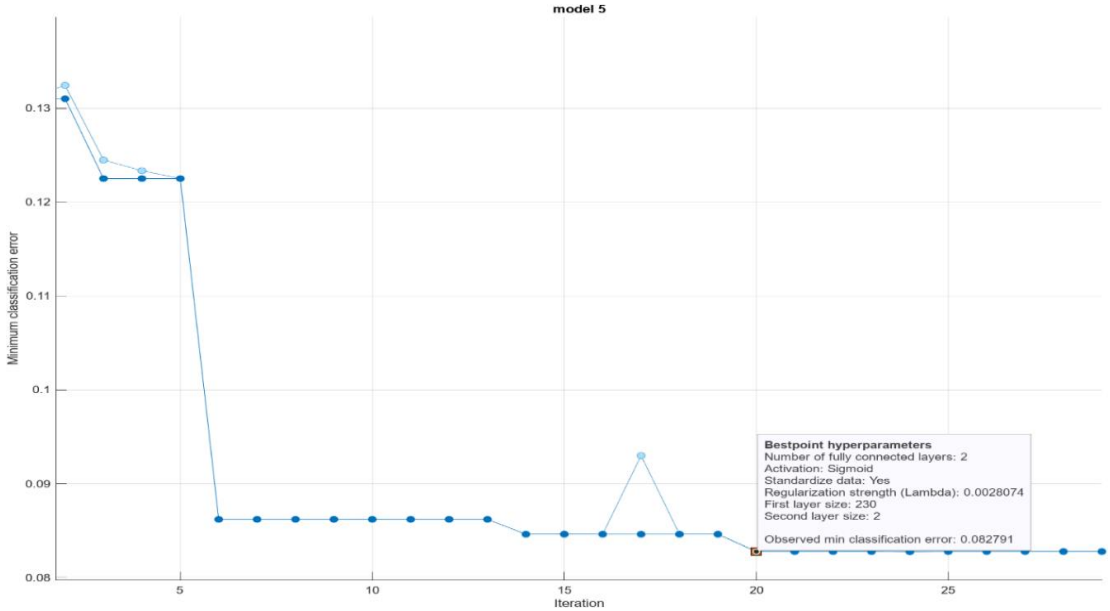

Figure 5. Results of the lowest error percentage graph

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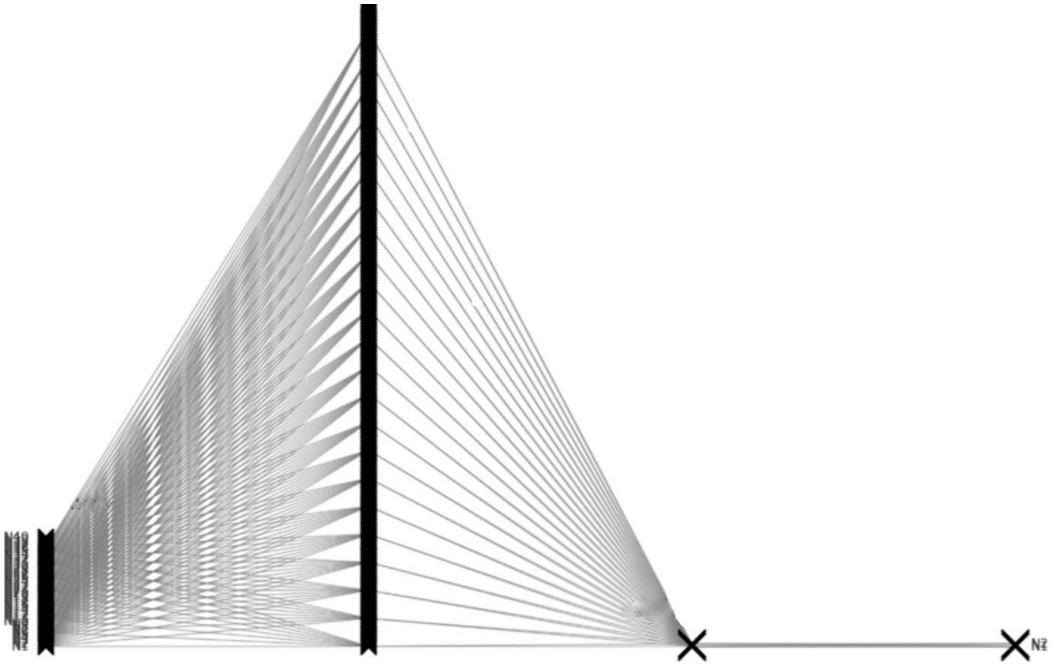

Figure 6. Activation map of the ANN model created after optimization

When Figures 5 and 6 were analyzed, the validation percentage of this model using the Sigmoid activation function was 91.7, and the error percentage was 8.3. There were 40 neurons in the input layer of the model and two neurons in the output layer representing the pass-fail categories of the dependent variable. In the double hidden layer model, there were 230 and two neurons, respectively. One of the findings of this model was the complexity (error) matrix, which is the indicator comparing the actual values with the prediction values. The findings of the complexity matrix of the best performance model are given in Table 4.

Table 4. Complexity (Error) matrix of the ANN Model

	Real	
Forecast	Successful (1)	Fail (2)
Successful (1)	41 (%77.4)	12 (%6.9)
Fail (2)	38 (%22.6)	512 (%92.1)

When Table 4 was analyzed, 41 of 79 students who were successful in PSEISE were classified as successful in the ANN model, and 38 of them were classified as unsuccessful. Accordingly, 77.4% of the students who were actually successful were correctly predicted in the model, while 22.6% were incorrectly predicted. Of the 524 students who failed in PSEISE, 512 were classified as unsuccessful, and 12 were classified as successful in the model. In this case, 92.1% of the students who were actually unsuccessful were predicted correctly, and 6.9% were predicted incorrectly in the model. Considering the sample of this study, the fact that the number of unsuccessful students in PSEISE (87%) was higher than the number of successful students (13%) may be the reason for the higher percentage of correct classification of unsuccessful students ((92.1%) in the ANN model.

4. Conclusion, Discussion and Recommendations

In this study, 5th-grade PSEISE achievement status was predicted with artificial neural networks using students' 4th and 5th grade Turkish, Mathematics, Science, Social Sciences, Religious Culture,

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and Ethics courses 1st and 2nd semester written exam scores. According to the results of this research, it was concluded that the artificial neural network model with sigmoid activation function, forward cascaded backpropagation and double layer (230 neurons in the first layer and two neurons in the second layer) had the highest performance with an accuracy rate of 91.7%. In particular, the correct classification of unsuccessful students with high performance shows that the model is effective in predicting these students. However, the lower accuracy rates obtained in predicting successful students indicate that additional variables (taking private lessons and courses, etc.) should be examined to improve the performance of the ANN model for this group.

The results of this study support other studies in the literature that students' written exam scores are one of the many variables that are effective in predicting students' success in central exams (Yakar, 2011; Karakoç & Köse, 2018; Daşdemir & Okutan, 2019; Demir, 2022; Köroğlu & Doğan, 2022). Similarly, Atasayar and Demir (2022), in their study on the prediction of students' Science achievement in the High School Entrance Examination (LGS), concluded that Science course written exam scores were a significant predictor of the LGS Science subtest.

When the literature on the ANN model used in this study is examined, Isljamovıc and Suknovıc (2014) and Lau et al. (2019) concluded that ANN gives better results in predicting students' achievement by comparing with traditional methods. In addition, other studies comparing ANN and artificial intelligence-supported prediction models (Tepehan, 2011; Kabakchieva, 2012; Uzun & Çokluk-bökeoglu, 2012, Şengür & Tekin, 2013; Toprak & Gelbal, 2020; Benzer & Benzer, 2017; Alsalman et al., 2019; Vijayalakshmi, & Venkatachalapathy, 2019; Vijayalakshmi & Venkatachalapathy, 2019; Mengash, 2020), reported that the highest verification percentage belonged to the ANN model. It can be stated that the ANN classification model created in this study is an effective method for predicting the achievement status of students with a high validation percentage (91.7%). In addition, other studies conducted with students in the middle school and above age group in the literature (Alsalman et al., 2019; Ayık et al., 2007; Özdemir & Yavuz, 2007; Altaş & Gülpınar, 2012; Şengür & Çırak, 2012; Şengür & Tekin, 2013; Alan, 2014; Demir, 2015; Akgün & Demir, 2018; Aghalarova & Keser, 2021; Kadirhanoğlulları & Köse, 2023) it is thought that this model, which was created by moving the primary school data set to secondary school, will contribute to creating a data-based decision support system in determining the PSEISE scholarship exam quotas in our country.

Based on the results of this study and its limitations, the following recommendations can be made: i) The research data consisted of 4th and 5th grade Turkish, Mathematics, Science, Social Sciences, Social Studies, Religious Culture and Ethics 1st and 2nd semester written exam scores in a single provincial center. A similar study can be applied regionally by recruiting different provinces. (ii) This research is limited to the data of students who took the PSEISE at the 5th-grade level. More in-depth results can be obtained by conducting research at different grade levels. (iii) The types of independent variables used in the research can be increased, and their effects on the dependent variable can be examined. (iv) Research can be conducted using different classification models from artificial neural networks to determine the model that gives the best results. (v) In the study, additional variables can be identified and utilised to improve the classification performance of students who are successful in PSEISE. (vi) The research results can contribute to creating data-supported decision-making systems to determine PSEISE quotas.

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About the Contributor(s)

Rumeysa DEMİR Master's Student, Kutahya Dumlupınar University, Education Faculty, Elementary Education Department, Kutahya,Turkey
E- mail: rumeysagokmendemir7@gmail.com
ORCID: 0000-0002-4435-0382
Prof. Dr. Metin DEMİR Kutahya Dumlupınar University, Education Faculty, Elementary Education Department, Kutahya,Turkey
E – mail: metin.demir@dpu.edu.tr
ORCID: 0000-0001-9223-7811