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Analysis of Metaverse Knowledge Levels of Prospective Mathematics: ANFIS Approach

Matematik Öğretmen Adaylarının Metaverse Bilgi Düzeylerinin Analizi: ANFIS Yaklaşımı

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Abstract. Education is a field that is affected by technological development and requires rapid adaptation. Metaverse is one of these technologies and it is predicted that it will take its place widely in the world of the future, including education in research. However, it is seen that there are few studies on metaverse and the studies are generally analysed using statistical methods. From this point of view, the aim of this study was to predict the metaverse knowledge levels of pre-service mathematics teachers by using Adaptive Neuro-Fuzzy Inference System (ANFIS) and to create models. The use of fuzzy logic has spread to the field of education with the development of science and technology. ANFIS combines neural network research and fuzzy logic to utilise the relevant capabilities. Considering this important advantage, ANFIS model was established to predict the metaverse knowledge levels of pre-service teachers. The research was conducted with the participation of 192 pre-service teachers. Personal information form and metaverse scale were used as data collection tools. As a result of the study, the scores of the pre-service teachers obtained from the metaverse scale were found to be at a moderate level and the real and artificial scores of the pre-service teachers' metaverse knowledge levels were found to be quite close to each other.
Keywords: Metaverse, Education, Prospective Mathematics Teachers, Artificial intelligence, ANFIS

Öz. Eğitim alanı teknolojik gelişmeden etkilenen ve hızla uyum sağlama gerektiren bir alandır. Metaverse de bu teknolojilerden biridir ve araştırmalarda eğitim de dahil olmak üzere, geleceğin dünyasında yaygın şekilde yerini alacağı öngörülmektedir. Ancak metaverse üzerine yapılan çalışmaların az olduğu ve yapılan çalışmaların da genellikle istatistiksel yöntemler kullanılarak analiz edildiği görülmektedir. Buradan hareketle çalışmada, Uyarlanabilir Nöro-Bulanık Çıkarım Sistemi (ANFİS) kullanarak matematik öğretmen adaylarının metaverse bilgi düzeylerini tahmin etmek ve modeller oluşturmak amaçlanmıştır. Bulanık mantık kullanımı bilim ve teknolojinin gelişmesi ile eğitim alanına da yayılmıştır. ANFIS ile sinir ağı araştırması ve bulanık mantığı birleştirerek ilgili yeteneklerden yararlanılır. Bu önemli avantaj göz önünde bulundurularak öğretmen adaylarının metaverse bilgi düzeylerini tahmin etmek için ANFIS modeli kurulmuştur. Araştırma 192 öğretmen adayının katılımı ile gerçekleşmiştir. Araştırmada veri toplama aracı olarak kişisel bilgi formu ve metaverse ölçeği kullanılmıştır. Çalışma sonucunda, öğretmen adaylarının metaverse ölçeğinden elde edilen puanları orta düzeyde çıkmış ve öğretmen adaylarının metaverse bilgi düzeylerinin gerçek ve yapay puanları birbirine oldukça yakın olarak tespit edilmiştir.
Anahtar Kelimeler: Metaverse, Matematik öğretmen adayları, Yapay zekââ, ANFIS

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Genişletilmiş Özet

Giriş. Metaverse terimi 1992'de Stephenson'un Snow Crash romanında ilk kez kullanılmıştır. Araştırmacılar 2000 lerin başlarında beri terimi kullanmaya başlamışlardır ama gerçek anlamda ilgi çekici hale gelmesi 2020 lerin başlarında Mark Zuckerberg'in metaverse projesini ortaya atmasıyla olmuştur (Devy, 2022). Facebook'un metaverse teknolojisini duyurmasının ardından bu duyuru yeni bir heves yaratmış ve ilk yükseköğretim metaverse uygulamaları ortaya çıkmıştır (Slabeva, 2022). Birçok araştırma alanıyla birlikte eğitim alanında da metaversin potansiyel kullanımı, olası olumlu, olumsuz yanları gibi konularda çeşitli çalışmalar gündeme gelmeye başlamıştır.

Metaverse ve eğitim içerikli çalışmalar gittikçe yaygınlaşıyor olmakla beraber, terim oldukça yenidir ve metaverse üzerine yapılan eğitim araştırmaların artması gerekmektedir. Çünkü metaverse, bugünün en büyük potansiyele sahip teknolojilerinden biri olabilir ve geleceğin sosyal bağlantılarını şekillendirebilir. Büyük veri, yapay zekâ, blok zinciri ve diğer dijital teknolojileri entegre eden metaverse, bireylere açık ve kapsayıcı bir öğrenme alanı ve öğretim alanı sunabilir, yeni bir eğitim ve öğretim reformunu tetikleyebilir (Wu & Gao, 2022). Metaverse'in eğitimin gelişiminde rolü olacağı öngörülebilir olmakla birlikte, eğitimdeki metaverse yapıları henüz yeterince olgun değildir ve metaverse'in eğitim amaçları için kullanımı henüz yeteri kadar tartışılmamaktadır. Metaverse'in eğitimdeki kullanımıyla ilgili cevaplanması gereken birçok soru bulunmaktadır (Lin, 2022). Birçok eğitimci, metaverse'in özelliklerinden ve bu yeni gelişen teknolojinin potansiyel uygulamalarından haberdar olmayabilir (Hwang & Chien, 2022). Türkiye'nin gelecekte sanal ve dijital teknolojilere dayalı eğitime adaptasyonu için öğretmen adaylarının metaverse gibi yeni nesil internet teknolojileri ile tanıştırılması gerekmektedir (Akpınar et al., 2022). Çünkü metaverse eğitim hedefleri için kullanıldığında öğrencilerin birbirleri ile öğretmenleri ve çevresi ile etkileşime girmesi daha kolay olacaktır (Al-Adwan vd., 2023). Ayrıca, metaverse konusunda yapılan çalışmaların henüz oldukça yetersiz olduğu ve yapılmış olan çalışmaların çoğunluğunun analizlerinin istatistiksel yöntemler kullanılarak yapıldığı görülmektedir. Tüm bu sonuçlar çalışmanın önemini ortaya koymaktadır.

Yöntem. Çalışma araştırılmak istenen problemin var olan durumunu ortaya koymaya yönelik olduğu için nicel araştırma yöntemlerinden betimsel araştırma yöntemiyle gerçekleştirilmiştir. Çalışmada matematik öğretmen adaylarının metaverse bilgi düzeyleri yapay zekâ tabanlı model ile tahmin edilmiştir. ANFIS modeli oluşturulurken öğretmen adaylarının günlük teknolojiyi kullanma süresi ve bilgisayarı kullanma yeterliliği girdi fonksiyonu, metaverse bilgi düzeyi çıktı fonksiyonu olarak belirlenmiştir. Çalışma 2022-2023 eğitim öğretim yılında 192 öğrencinin katılımı ile gerçekleşmiştir. Çalışmada veri toplama aracı olarak kişisel bilgi formu ve Metaverse ölçeği kullanılmıştır. Matematik öğretmen adaylarının metaverse bilgi düzeylerinin ANFIS yaklaşımı ile analizinde bulanık sistem MATLAB R2021b Fuzzy Logic Toolbox kullanılmıştır. SPSS 20.0 programı kullanılarak matematik öğretmen adaylarının metaverse bilgi düzeylerinin gerçek ve yapay zekâ puanları eşleştirilmiş örneklemler t testi ile sınanmış ve gerçek ve yapay zekâ puanları arasındaki ilişkiyi belirlemek için korelasyon yapılmıştır.

Bulgular. Veriler, MATLAB bulanık sistem kullanılarak modellenmiştir. Öğretmen adaylarının günlük teknolojiyi kullanma süresi ve bilgisayarı kullanma yeterliliği girdi parametreleri, metaverse bilgi düzeyi ise çıktı parametresi olarak aktarılmıştır. Modelin girdi parametreleri öğretmen adaylarının günlük teknolojiyi kullanma süresi; kabul edilebilir, çok, çok fazla, aşırı, bilgisayarı kullanma yeterliliği; yetersiz,

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orta, yeterli, gelişmiş ve çıktı parametresi; düşük, orta, yüksek şeklinde oluşmaktadır. Öğretmen adaylarının metaverse ölçeğinden almış oldukları puanlar 33 ile 75 aralığında değişmekte olup ortalamanın 50.91 olduğu görülmektedir. Öğretmen adaylarının metaverse bilgi düzeyleri orta seviyededir (33-47 düşük, 48-61 orta, 62-75 yüksek). Gerçek puanlar tahmin edilen ANFIS puanları ile benzerlik göstermektedir ve ANFIS modelinin matematik öğretmen adayları metaverse puanıyla tutarlı sonuçlar öngörmektedir. Matematik öğretmen adaylarının gerçek ve ANFIS ile tahmin edilen puanları arasında istatistiksel açıdan anlamlı ve düşük bir korelasyona sahip olduğu ortaya çıkmıştır.

Tartışma ve Sonuç. Çalışmanın ilk araştırma probleminde, günlük teknolojiyi kullanma süresi ve bilgisayarı kullanma yeterliliği değişkenleri kullanılarak ANFIS modeli ile öğretmen adaylarının metaverse bilgi düzeyleri puanları elde edilmiştir. Bu puanlar; 33-47 aralığında düşük, 48-61 aralığında orta, 62-75 aralığında ise yüksek olarak ifade edilmiştir. Öğretmen adaylarının metaverse bilgi düzeyleri nöro-bulanık çıkarım sistemi yaklaşımı ile değerlendirilmiştir. Bu yaklaşım ile modelin girdi ve çıktı değişkenlerine bağlı olarak bulanık kural kümesi oluşturulmuş ve eğri altında kalan alanın merkezini alan defuzzification yaklaşımı centroid yöntemi ile doğru değerlere ulaşılmıştır. 1000 döngü sayısı oluşturularak kesin tahmin bulguları elde edilmiştir. Öğretmen adaylarının metaverse bilgi düzeyi puanları bu işlemlerden sonra yapay olarak elde edilmiştir. Literatürde metaverse ile ilgili yapılmış olan çalışmalarda istatistiksel yöntemler kullanılarak analizler yapılmıştır. Yapay zekâ yöntemleri kullanılarak yapılmış çalışmalara rastlanılmamaktadır. Bu çalışma hem öğretmen adayların çeşitli eğitsel özelliklerini değerlendirip ortaya çıkarmak hem de nörobilimsel yaklaşımların eğitimde kullanılmasına rehberlik etmesi açısından önemli bir örnek teşkil etmektedir. Çalışmanın ikinci araştırma probleminde çarpıcı sonuçlar ortaya çıkmıştır. Betimsel istatistik sonuçları, öğretmen adaylarının metaverse ölçeğinden elde edilen puanlarının orta düzeyde çıktığını göstermektedir. Alanyazında yapılan çalışmalarda benzer sonuçlar ile karşılaşılmaktadır. Ipsos (2022)'un 29 ülkeyi kapsayan anket çalışmasında metaverse hakkında bilgi sahibi olan kişilerin %52 oranında olduğunu bulmuştur. 2022 Haziran ayında Amerika Birleşik Devletleri'nde yapılan bir çevrimiçi araştırmada Z kuşağının metaverse hakkında bilgi düzeyinin diğer kuşaklara göre daha fazla olduğu tespit edilmiştir. Talan ve Kalınkara (2022) yaptıkları araştırmada da Bilgisayar Mühendisliği Bölümü'nde okuyan üniversite öğrencilerinin %70,6'sının metaverse kullanmadığını tespit etmiştir. Buradan öğrencilerin metaverse konusunda yeterli bilgi sahibi olmadıkları, uygulamayı çok iyi bilmedikleri ve deneyimlerinin yetersiz olduğu söylenebilir. Dolayısıyla metaverse uygulamasının henüz yaygın olarak kullanılmaması öğrenme öğretme ortamlarında etkinliği konusunda yeteri kadar araştırma bulunmaması bunun önemli bir nedenidir. Çalışmada matematik öğretmen adaylarının metaverse bilgi düzeylerinin gerçek puanları ile ANFIS yaklaşımıyla oluşturulan yapay zekâ puanları arasında karşılaştırma yapılmıştır. Öğretmen adaylarının metaverse bilgi düzeyleri gerçek ve yapay puanları birbirine oldukça yakın olarak tespit edilmiştir. ANFIS yaklaşımı ile tahmin edilen metaverse bilgi düzeyi puanları ile ölçekten elde edilen metaverse bilgi düzeyi puanları arasında istatistiksel olarak anlamlı bir fark yoktur. Ölçekten elde edilen puanlar ile ANFIS yaklaşımı ile oluşturulan yapay zekâ puanları arasında anlamlı ve düşük bir korelasyon vardır. Bu sonuçlar, ANFIS yaklaşımının öğretmen adaylarının metaverse bilgi düzeylerini tahmin etmek için kullanılabilecek uygun bir alternatif bir yöntem olduğunu ortaya koymaktadır.

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Introduction

The term metaverse was first used in 1992 in Stephenson's novel Snow Crash. Researchers have been using the term since the early 2000s, but it really became interesting in the early 2020s when Mark Zuckerberg introduced the metaverse project (Devy, 2022). After Facebook announced the Metaverse technology, this announcement created a new enthusiasm and the first higher education Metaverse applications emerged (Slabeva, 2022). Along with many research areas, various studies on the potential use of metaverse in the field of education, its possible positive and negative aspects have started to come to the agenda.

With the expansion of the metaverse in the field of education, new possibilities for combining the virtual world with physical classrooms, collaborative, co-operative and problem-based learning can be created (Araya & Avila, 2018). Venugopal et al. (2023) asserts that the use of metaverse technology to transform the learning process can result in a truly successful learning environment by allowing students to "live" a particular experience and improving the visual component of the educational process. This is in contrast to traditional classroom education, where students absorb knowledge more intensively and of higher quality. In addition, Sebastian (2022) found that increased awareness of the metaverse can lead to a better understanding of its potential and reduced concerns about its adoption. Research demonstrates that virtual and digital technologies have the ability to revolutionize traditional education (Dickey, 2005; Sheehy, Ferguson & Clough, 2007).

The bibliographic study of Tlili et al. (2022) on metaverse in education presents interesting results. Some of these include the fact that the USA is the leading country in academic studies, about 42% of the studies use mixed methods, 53% of the studies are in the fields of mathematics, natural sciences and engineering, and 63% of the studies were conducted at the higher education level (Tlili et al., 2022). Although metaverse and educational studies are becoming more and more widespread, the term is quite new and educational research on metaverse needs to increase. Because one of the technologies that has the most promise right now could be the Metaverse, which has the ability to influence how people interact in the future. Big data, AI, blockchain, and other digital technologies can all be integrated into the Metaverse to provide people with an inclusive, open learning environment. This might lead to a new wave of education and training reform (Wu & Gao, 2022). While it is foreseeable that the Metaverse will have a role in the development of education, Metaverse in education are not yet mature enough and the use of the Metaverse for educational purposes is not yet sufficiently discussed. There are many questions to be answered about the use of the metaverse in education (Lin et al., 2022). It's possible that many educators are unaware of the metaverse's features and the possible uses for this cutting-edge technology (Hwang & Chien, 2022). For Turkey's adaptation to virtual and digital technologies-based education in the future, preservice teachers should be introduced with new generation internet technologies such as metaverse (Akpınar et al., 2022). When the metaverse is used for educational goals, it will be easier for students to interact with each other, their teachers and the environment (Al-Adwan et al., 2023). In addition, it is seen that the studies on Metaverse are still quite insufficient and the analyses of the majority of the studies have been conducted using statistical methods. All these results reveal the importance of the study.

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Literature review

Studies examining the level of metaverse knowledge according to various variables

According to the results obtained by Savaş et al. using statistical methods on the metaverse knowledge level scale with physical education teacher candidates, it is seen that the knowledge level of male teacher candidates is higher. In the same study, it was reported that there was no statistically significant difference in the metaverse knowledge levels of the participants related their daily internet usage status, but those with higher internet usage skills had higher metaverse knowledge levels (Savaş et al., 2022). In a study conducted by Statista (2022c), it was determined that 14% of adults in the United States had very good knowledge of the metaverse, 24% had some knowledge, 31% had heard of the concept of metaverse but did not know what it was, and 31% had never heard of the term metaverse before. In the survey conducted by Ipsos (2022) covering 29 countries, it was found that 52 per cent of those who have information about the metaverse are 52 per cent and more men than women (59 per cent) answered yes (Ipsos, 2022). Talan and Kalınkara (2022), in their research on a sample of 34 second-year students studying in the Computer Engineering Department of a state university, found that the majority of students (70.6%) had not used Metaverse before (Talan & Kalınkara, 2022). In their study on 157 physical education teachers to determine the level of metaverse knowledge, Turan et al. concluded that those who heard the term metaverse in the general metaverse knowledge level were higher than those who did not, and those in the age group of 37 years and over were at a higher level than those in the 27-31 age group (Turan, et al., 2023). Aburbeian et al. (2022) stated that in their research, they found that participants at younger ages (less than 20 years old) were more interested in the Metaverse than other age groups (Aburbeian et al., 2022). Statista evaluated the results of the research conducted in Singapore in February 2022 and announced that similarly, they found that the metaverse knowledge level of younger participants (between the ages of 18-35) was found to be higher, while the level of knowledge decreased towards older ages (Statista, 2022a). In an online survey conducted in the United States in June 2022, it was found that Generation Z had more knowledge about the metaverse than any other generation (Statista, 2022b). In a another study, participants who used the Internet for four hours a day had a greater understanding of what the metaverse meant than those who used it for one hour (Akpınar et al., 2022). According to Akpınar's conclusion, this circumstance is most likely caused by people's knowledge with and interest in modern technologies—the Internet (Akpınar et al., 2022). Özdemir stated that the finding of a weak positive correlation between the participants' daily average social media use and the average score of the technology sub-dimension could be associated with the students' following the developments in the metadata through social media (Özdemir et al., 2022).

Neuro-fuzzy systems (ANFIS)

Artificial intelligence methods can be used as an alternative method to reduce research cost, minimise information processing time and predict the performance of complex systems. One of the widely used algorithms in artificial intelligence methods is ANFIS (Wiangkham & Vongvit, 2023). Adaptive Neuro Fuzzy Inference System (ANFIS) is an artificial neural network method developed by Jang in the early 1990s (Yücel, 2010). The advantages of artificial neural networks are combined with

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fuzzy logic in the hybrid analytical method known as ANFIS (Mehdi & Nachouki, 2022). ANFIS has the ability to update itself by using input and output functions due to its network structure (Taş, 2022).

ANFIS gives perfect results by determining the most appropriate functions with the least error rate (Yücel, 2010). It works with the least error rate because it is multi-layered. There are five layers in ANFIS method. In layer 1, which is also called the defuzzification layer, the number of networks and the number of input variables are equal. In the 2nd layer, rules are generated and each network corresponds to these rules and number generated by ANFIS. In layer 3, the normalisation layer, each network sees the networks from layer 2 as input values and represents the firing power of each rule. In layer 4, which is the clarification layer, the parameters are also called result parameters. The last layer is layer 5, which is the collection layer. With a single network, the sum of the outputs of all rules is calculated. The output value of each network is summed and the real value is reached (Cemil, 2015).

Classical performance assessment is used as an evaluation method in education systems (Gokmen et al., 2010). In this system, students' performances such as achievement and attitude are evaluated based on test results. However, while evaluating the characteristics of students, evaluating only by looking at the test results brings some limitations. Fuzzy logic, which is not a classical performance evaluation, provides effective results to overcome these limitations. The use of fuzzy logic model provides flexibility in evaluation methods (Gokmen et al., 2010). With the development of science and technology, the use of fuzzy logic has spread to wide areas (Arslan & Zirhlioğlu, 2021). One of these areas is the field of education (Namlı & Şenkal, 2018). ANFIS combines neural network research and fuzzy logic to utilise the relevant capabilities (Gokmen et al., 2010). Considering this important advantage, ANFIS model was established to predict the metaverse knowledge levels of pre-service teachers.

This study

The field of education is a field that is affected by technological development and requires rapid adaptation. Many issues such as meeting the demands of children born in the age of technology, keeping up with the contemporary world, making education programmes compatible with new technologies, informing and training teachers, providing the necessary technical infrastructure and equipment have entered the world of education and require rapid study. Metaverse is one of these technologies and research is predicted to take its place widely in the world of the future, including education. However, it is seen that there are few studies on metaverse and the studies that have been conducted are generally analysed using statistical methods. According to this perspective, the study's objectives are to develop models and use the Adaptive Neuro-Fuzzy Inference System (ANFIS) to anticipate pre-service math instructors' levels of metaverse knowledge. The study aimed to provide answers to the following questions:

1. Is it possible to predict the metaverse knowledge levels of pre-service mathematics teachers with ANFIS approach?
2. Does the artificial intelligence score produced by the ANFIS approach differ from the real scores of pre-service math instructors' metaverse knowledge levels?

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Methodology

Research model

Since the study aimed to reveal the existing situation of the problem to be investigated, it was carried out with descriptive research method, one of the quantitative research methods. Descriptive research is a research model that tries to reveal the event, individual or object that is the subject of the research with its existing situation (Gay & Airasian, 2000). In the study, the metaverse knowledge levels of pre-service mathematics teachers were estimated with an artificial intelligence-based model. While constructing the ANFIS model, daily technology usage time and computer usage proficiency of pre-service mathematics teachers were determined as input functions and metaverse knowledge level was determined as output function.

Sample of the study

The participants of the study were selected using convenience sampling method among the students of Primary Mathematics Teacher Education at Biruni University in Istanbul and the students of Secondary Mathematics and Primary Mathematics Teacher Education at Dokuz Eylül University in Izmir. The study was carried out in 2022-2023 academic year with the participation of a total of 192 students, 144 students of Primary Mathematics teaching and 48 students of Secondary Mathematics teaching. 76 of these students are studying at a foundation university and 116 of them are studying at a state university.

Data collection tools

The characteristics of the data collection tools used in the study are given below.

Personal information form

In the personal information form, there are questions about gender, grade level, department, university type, daily technology usage time, technological development follow-up, taking technology course at university, computer usage competence and playing games in digital environment. In the study, the appropriate data for fuzzy logic are the duration of daily technology use and computer usage proficiency of pre-service teachers. Other variables are not suitable for fuzzy logic because it is not possible to blur them due to their nature.

Metaverse Scale

The Metaverse scale was developed by Süleymanoğulları et al. (2022) to determine the knowledge levels and awareness of students studying at various levels at a state university. The scale consists of 15 items. The data were analyzed using confirmatory and explanatory factor analyses. The scale consists of four sub-dimensions: technology (7 items) digitalisation (3 items), social (2 items) and lifestyle (3 items). The scale is a Likert-type five-point scale. The response options for the items are 1

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(strongly disagree) 2 (disagree) 3 (undecided) 4 (agree) 5 (strongly agree). The total scale's Cronbach's α value was determined to be 0.813, while the values for each element were 0.805, 0.732, 0.705, and 0.713, respectively. The entire scale has a minimum score of 15 and a maximum score of 75. To ascertain the students' levels of metaverse understanding, these scores were divided into three groups. The range of 33-47 points corresponds to low knowledge level, the range of 48-61 points corresponds to medium knowledge level, and the range of 62-75 points corresponds to high knowledge level.

Data analyses

Fuzzy system MATLAB R2021b Fuzzy Logic Toolbox was used to analyse the metaverse knowledge levels of pre-service mathematics teachers with ANFIS approach. The input variables of the model created with ANFIS approach are daily technology usage time and computer usage competence. The output variable is the level of metaverse knowledge. The rule base was created by defining the cluster intervals, membership levels and membership functions of the input and output variables. Fuzzy inference system (FIS) was trained using the optimisation technique for the best performance of the ANFIS model. Then, artificial metaverse scores of pre-service teachers were created. The artificial scores obtained are given in Appendix 1 together with the real scores.

In the second research question, using SPSS 20.0 programme, the real and artificial intelligence scores of pre-service mathematics teachers' metaverse knowledge levels were tested with paired sample t test and correlation was performed to determine the relationship between real and artificial intelligence scores.

Findings

Prediction of metaverse knowledge levels of prospective mathematics teachers with ANFIS model

The data were modelled using MATLAB fuzzy system. Pre-service teachers' daily technology usage time and computer usage competence were used as input parameters, and metadiscourse knowledge level was used as output parameter. In the input parameter of the model, pre-service teachers' daily technology usage time and computer usage competence consist of four membership functions and in the output parameter, pre-service teachers' metadiscourse knowledge level consists of three membership functions. Input and output parameters were created with the data obtained in line with the answers given by pre-service teachers to the metaverse scale (Table 1).

Tablo 1.
Fuzzy variable sets

	Input variable fuzzy sets	**Fuzzy sets of output variables**
Usage time	Proficiency level	Metaverse knowledge leve
Acceptable	İnsufficient	Low
Much	Medium	Medium
Too much	Sufficient	High

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Excessive	Advanced

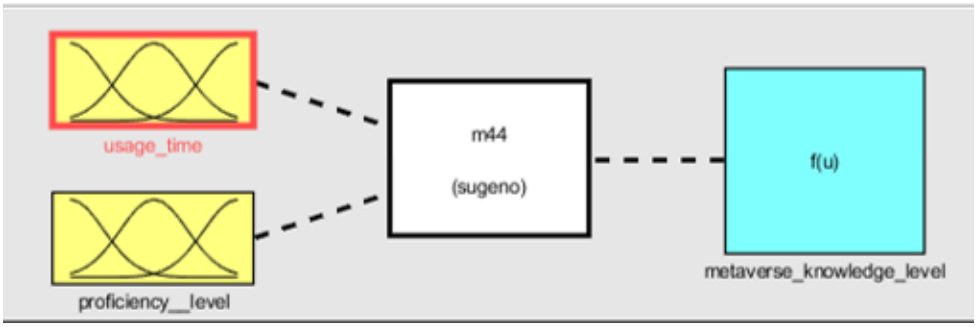

Figure 1. ANFIS model structure

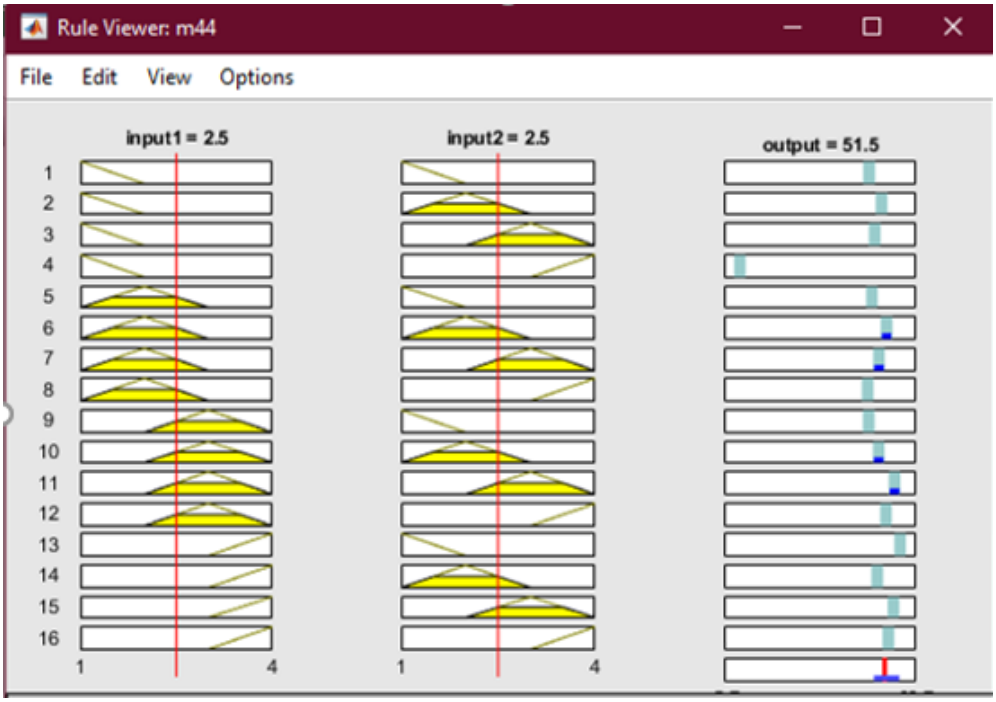

Figure 2. Rule viewer of the ANFIS

Figure 1 shows the adaptive neuro-fuzzy based model that was created for the study, and Figure 2 shows one of the outcomes that came from this neuro-fuzzy model. Membership functions are defined according to the input and output parameters of the model. The defined membership functions are shown in Figure 3. The input parameters of the model are defined in Table 1 as acceptable, much, too much, excessive, computer usage proficiency as insufficient, medium, sufficient, advanced and output parameters as low, medium, high. Estimation was made by creating a number of 1000 cycles. Among the 192 datasets, 134 (or 70%) were utilized to train the model, and the remaining 58 (30%) were used to test it. Figure 4 displays the ANFIS model's structure.

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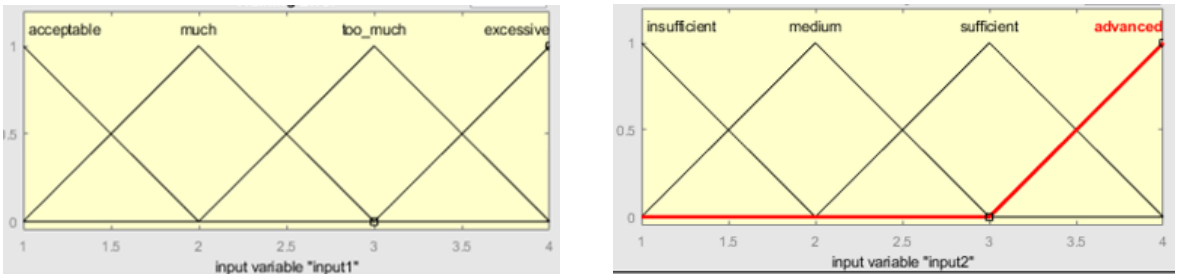

(a) (b)

Figure 3. Fuzzy sets of input variables usage time (a), proficiency level (b)

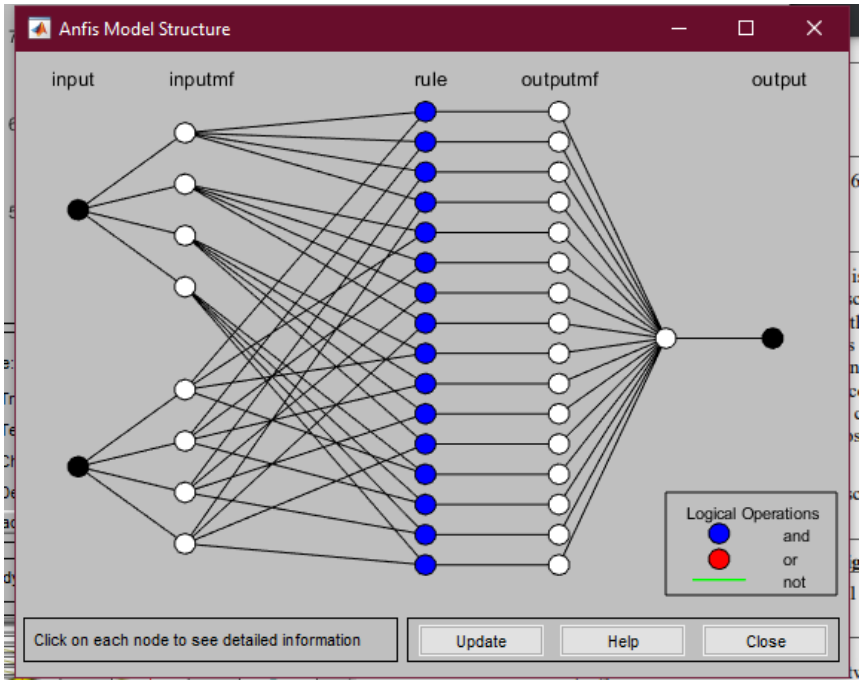

Figure 4. The developed ANFIS model

Comparison of metaverse knowledge levels of prospective mathematics teachers in actual and model prediction

It was investigated if there was a statistically significant difference between the artificial scores predicted by ANFIS techniques and the real scores computed based on the pre-service math instructors' responses to the metaverse scale. Table 2 displays the descriptive statistics results for the artificial intelligence and real scores.

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Table 2.
Descriptive statistics results for real scores and artificial intelligence scores

Metaverse knowledge level scores	N	Min	Max	$\bar{X}$	SD
Real scores	192	33.0	75.0	50.91	6.91
Artificial scores	192	45.5	57.0	50.90	2.84

Paired examples The difference between the real and artificial scores that ANFIS predicted was calculated using the t-test (Table 3). The scores of the pre-service teachers from the metaverse scale ranged between 33 and 75 and the mean score was 50.91. Pre-service teachers' metaverse knowledge levels are at medium level (33-47 low, 48-61 medium, 62-75 high). The artificial scores of the metaverse knowledge level created with the ANFIS model vary between 45.5 and 57.0 and the mean is 50.90. Similarly, the artificial scores of the pre-service teachers' metaverse knowledge levels created with the ANFIS model are at medium level (33-47 low, 48-61 medium, 62-75 high). It is seen in Table 2 that the real and artificial scores of pre-service teachers' metaverse knowledge level are very close to each other. Furthermore, upon examination of the standard deviations, it is observed that the scale scores' standard deviation is greater than the ANFIS model scores' standard deviation.

The Paired Samples t-test was used to compare the real and artificial ratings of pre-service teachers' metaverse knowledge levels (Table 3).

Table 3.
Paired Samples t-test actual and ANFIS model predicted scores

Metaverse knowledge level scores	N	Mean	SD	df	t	p
Real scores	192	50.91	6.91	191	.022	.982
Artificial score	192	50.90	2.84			

The actual scores from the metaverse scale and the scores derived using the ANFIS technique do not differ statistically significantly, as shown by the analytical results in Table 3 [t(191)=.022; p>.05]. This finding indicates that there is no discernible difference between the actual and ANFIS-predicted metaverse scale scores. In other words, the actual scores are similar to the predicted ANFIS scores and the ANFIS model predicts consistent results with pre-service mathematics teachers' metaverse scores.

A correlation was made between the actual and ANFIS predicted scores of pre-service mathematics teachers' metaverse knowledge levels (Table 4). The correlation coefficient was assessed as low in the range of 0.00-0.30, medium in the range of 0.30-0.70, and high in the range of 0.70-1.00 during correlation interpretation.

Table 4.
Paired Samples correlations actual and ANFIS model estimated scores

	N	Correalation	Sig.
Real and Aritificial score	192	.248	.001

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Table 4 shows that there is a statistically significant and low correlation between the actual and ANFIS predicted scores of pre-service mathematics teachers (r=.248; p<.05).

Discussion, Conclusion and Recommendations

The study aims to predict the metaverse knowledge levels of pre-service mathematics teachers by creating an ANFIS model. In order to develop the input and output variables of the ANFIS model, real data were acquired from the responses provided by pre-service mathematics teachers on the metaverse scale and the personal information form. Pre-service teachers' degrees of metaverse knowledge were assessed based on their daily technology usage time and computer proficiency. The ANFIS model of the research was estimated according to the inputs of daily technology usage time and computer usage proficiency and the output of metaverse knowledge level scores. The similarity between pre-service teachers' metaverse real scores and artificial intelligence scores generated by ANFIS approach was analysed by statistical tests.

In the first research problem of the study, the scores of metaverse knowledge levels of pre-service teachers were obtained with the ANFIS model by using the variables of daily technology usage time and computer usage competence. These scores were expressed as low in the range of 33-47, medium in the range of 48-61, and high in the range of 62-75. The neuro-fuzzy inference system approach was used to assess pre-service teachers' metaverse knowledge levels. With this approach, a fuzzy rule set was created depending on the input and output variables of the model and the correct values were reached with the centroid method of the defuzzification approach that takes the centre of the area under the curve. The number of 1000 cycles was created and exact prediction findings were obtained. The metaverse knowledge level scores of pre-service teachers were obtained artificially after these procedures. In the studies on metaverse in the literature, analyses were made using statistical methods. There are no studies using artificial intelligence methods. This study constitutes an important example in terms of both evaluating and revealing various educational characteristics of pre-service teachers and guiding the use of neuroscientific approaches in education.

Remarkable findings surfaced in the study's second research problem. The metaverse scale scores of pre-service teachers are at a medium level, according to the findings of descriptive statistics. Similar results are encountered in the studies conducted in the literature. In the survey study of Ipsos (2022) covering 29 countries, it was found that the rate of people who had knowledge about the metaverse was 52%. In an online study conducted in the United States in June 2022, it was determined that the level of knowledge of Generation Z about the metaverse is higher than other generations. Mundy et al. (2019) applied a questionnaire on augmented reality to special education and instructional technology teachers and stated that teachers perceived themselves as intermediate or advanced in augmented reality. Uygur et al. (2018) stated that 51% of pre-service teachers had knowledge about augmented reality applications in their study with pre-service teachers. Savaş et al. (2022) examined the metaverse knowledge levels of prospective physical education and sports teachers in terms of various variables and concluded that the metaverse knowledge levels of prospective teachers with high internet usage skills were also high. Therefore, it can be said that metaverse knowledge level is closely related to the competence of using technology. In contrast to

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these results, in a study conducted by Statista (2022c), it was determined that 14% of adults living in the United States as of January 2022 had very good metaverse levels, 24% had some knowledge, 31% had heard the term metaverse but could not define what it was, and 31% had never heard the term metaverse. In their study, Talan and Kalınkara (2022) found that 70.6% of university students studying in the Department of Computer Engineering did not use metaverse. From this point of view, it can be said that students do not have sufficient knowledge about metaverse, they do not know the application very well and their experience is insufficient. Therefore, the fact that the metaverse application is not yet widely used and there is not enough research on its effectiveness in learning and teaching environments is an important reason for this.

The real scores of pre-service math instructors' metaverse knowledge levels were compared to the artificial intelligence scores produced using the ANFIS approach in this studyIt was discovered that there was little difference between the real and artificial metaverse knowledge level ratings of pre-service math teachers. The metaverse knowledge level scores derived from the scale and the metaverse knowledge level scores computed using the ANFIS technique do not differ statistically significantly. Between the scale results and the artificial intelligence scores produced by the ANFIS method, there is a strong yet weak association. These results reveal that the ANFIS approach is a suitable alternative method that can be used to estimate the metaverse knowledge levels of pre-service teachers.

In the study, the metaverse knowledge levels of pre-service teachers were analysed using artificial intelligence techniques. Considering the fact that artificial intelligence applications are rarely used in educational environments and the efforts to integrate them into the education system, the importance of the study emerges.

Limitations and recommendations

There are some limitations in the study. The sample of the study consists of pre-service mathematics teachers studying in two universities in Turkey. In future studies, the metaverse knowledge levels of teachers or secondary and high school students can be investigated. In the study, the metaverse knowledge levels of pre-service teachers were analysed with the ANFIS model approach. Since a causal inference cannot be made, more precise results can be obtained by adding longitudinal studies. As input variables of the ANFIS model, daily technology usage time and computer usage competence were used. The model can be created by using alternative variables instead of these variables. Since there are few academic studies on fuzzy logic and artificial intelligence methods in educational environments, their number can be increased.

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Appendix

Student	Real Scores	Artificial Scores
S1	46	50
S2	57	55
S3	52	49
S4	55	55
S5	58	55
S6	58	49
S7	45	46
S8	48	46
S9	57	49
S10	66	55
S11	45	55
S12	49	49
S13	66	50
S14	63	52
S15	59	55
S16	56	52
S17	45	52
S18	57	50
S19	57	47
S20	60	49
S21	45	49
S22	43	46
S23	47	46
S24	45	46
S25	46	47
S26	51	48
S27	43	48
S28	51	49
S29	50	49
S30	60	55
S31	59	52
S32	58	52
S33	45	49
S34	45	55
S35	55	55
S36	50	50
S37	52	49
S38	45	52
S39	51	49
S40	51	49
S41	53	49
S42	51	50
S43	43	55
S44	50	48
S45	46	50
S46	55	49
S47	51	52
S48	51	47
S49	62	55
S50	59	52
S51	53	55

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S52	42	49
S53	53	55
S54	49	49
S55	52	55
S56	60	55
S57	45	50
S58	46	50
S59	51	49
S60	65	55
S61	40	53
S62	50	53
S63	51	50
S64	35	50
S65	54	49
S66	50	50
S67	45	46
S68	63	52
S69	38	52
S70	51	49
S71	58	55
S72	45	52
S73	51	49
S74	49	55
S75	46	49
S76	55	52
S77	46	46
S78	52	55
S79	56	55
S80	45	53
S81	46	49
S82	45	49
S83	47	49
S84	43	47
S85	45	46
S86	48	46
S87	49	53
S88	60	50
S89	52	49
S90	57	55
S91	45	52
S92	47	55
S93	42	49
S94	44	49
S95	58	53
S96	75	53
S97	48	49
S98	53	52
S99	45	49
S100	61	52
S101	50	49
S102	55	52
S103	51	50
S104	47	52

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S105	56	57
S106	42	49
S107	52	52
S108	53	52
S109	45	49
S110	56	52
S111	59	55
S112	58	57
S113	53	50
S114	53	49
S115	56	55
S116	45	50
S117	48	49
S118	49	52
S119	55	50
S120	45	49
S121	61	49
S122	45	55
S123	44	49
S124	34	52
S125	57	52
S126	60	55
S127	54	52
S128	52	50
S129	45	50
S130	38	47
S131	45	49
S132	56	55
S133	45	50
S134	47	49
S135	63	49
S136	37	55
S137	53	46
S138	33	53
S139	55	50
S140	57	50
S141	45	52
S142	53	52
S143	58	52
S144	45	52
S145	54	55
S146	56	50
S147	58	47
S148	59	46
S149	51	55
S150	46	55
S151	36	50
S152	58	49
S153	45	49
S154	56	55
S155	55	52
S156	35	46
S157	54	49

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S158	50	55
S159	49	57
S160	50	52
S161	56	49
S162	55	50
S163	46	55
S164	43	49
S165	55	53
S166	56	49
S167	50	48
S168	49	49
S169	45	49
S170	51	55
S171	50	52
S172	53	49
S173	46	55
S174	46	50
S175	45	52
S176	59	49
S177	47	49
S178	45	46
S179	45	50
S180	52	52
S181	52	52
S182	49	47
S183	60	52
S184	56	46
S185	44	47
S186	75	49
S187	45	50
S188	45	55
S189	61	55
S190	44	49
S191	55	46
S192	55	52

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