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INVESTIGATION OF MIDDLE SCHOOL 8TH GRADE STUDENTS' ORIENTATIONS TO MATHEMATICAL PROOF SCHEMAS BY USING ARTIFICIAL NEURAL NETWORK MODEL

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Abstract
Although the general purpose in this research is to use the artificial neural network model in mathematics education, the main purpose is to show the relationship between students' tendency towards the types of mathematical proof and the learning styles they have by using the artificial neural network model. In addition, SOM-Ward clustering algorithm based on artificial intelligence was used to investigate the relationship between students' tendency towards the types of mathematical proof and the learning styles they have. In the qualitative data collection process, the criterion sampling method was used as the purposeful sampling. In the process of training the artificial neural network model, feed forward back propagation network structure was used. In the study, a lesson hour was given to the students to answer the open ended questions about the proposals and the learning style inventory. As a data collection tool, four questions from four different mathematical fields were asked for that students should be able to rank towards the proposition closest to them and that the reasons underlying the ranking formats were found. The learning styles of the students were tried to be predicted by taking advantage of the verbal expressions of the students. In addition, the results in the learning style inventory were combined with predictive learning styles. During the training of the artificial neural network model, placements that were ranked towards the proposition closest to students were used as input. Also predictive learning styles were used as output. As a result of the research, consistency between the results produced by the model and the predicted learning styles was observed sufficiently. It was seen that the students who placed the inductive proposals in the first place often had the learning style of accommodation. It was seen that the students who placed the perceptual proposals in the first place often had the learning style of assimilating. It was seen that the students who placed the perceptual proposals in the first place often had the learning style of assimilating. İt was seen that some of the students who put the algebraic proposal in the first place had the learning style of assimilating and some of the students who put the algebraic proposal in the first place had the learning style of converging. Also it was seen that the students who placed the visual proposals in the first place often had the learning style of diverging. The proportion of girls was found to be higher than that of boys in the learning style of converging, as opposed to the students with other learning styles.
Keywords: Artificial Neural Networks Model, Mathematics Education, Proof Schemas, Learning Styles.

Introduction

The examination of proving process in various branches of mathematics has continued with math modern movement of the 1950s and gained a different dimension. During math lessons which was based on proving, some learning difficulties occured so they created an awareness of enhancing proving skills (Lee, 2002). In the middle school, teachers prefer some activities that involve crosschecks and defending the validity of solutions so these activities give students the ability to realize multi-dimensional thinking. According to some studies, when teachers provide a supportive learning environment for children, the idea of proving may occur in a natural way (Stylianou, Blanton, & Knuth, 2010 p. 120-122). Ministry of Education claims that some steps should be taken in the classroom on a mathematical proof so some gains are included in the secondary school curriculum (2013). These gains focus on being able to generalize and to evaluate the accuracy or inaccuracy of the inferences. Before the implementation stage in the teaching of mathematical concepts, studies which require proving may be important in terms of improving students' reasoning skills. With this phase, which is also called discovery, students might grasp the aesthetic direction of mathematics and progress towards analytical thinking. The methods used by the students provide the qualities that will

elicit the student's thought structure. Thought structures were called by Harel and Sowder (1998) as proof schemes. The underlying reason for the diversity of methods was that students might be in different cultures, might be in different time zones, and that different conditions of living influence students' approach to mathematical proposals. So, the proof scheme in which a student takes place shows the attitude towards mathematical proposition and the way to be convinced.

Learning styles are an important factor for the success of students in that they show how students learn individually, how they should observe, and how they should prepare the program for their own learning styles (McLoughlin, 1999). Kolb defined learning styles as ways of learning that students choose individually. Kolb identified the classification in the learning style model that he created through two dimensions; according to students' perceptions and adoption. The Kolb Learning style model was chosen as the inventory because this thesis study was conducted to examine students' perception of proof methods and how to use their approaches. Kaplan and Ozdemir (2014) presented the proposal that mathematical proof should be handled with attention that students have different learning styles and that only permanent learning might be achieved in this way. Then, they emphasized the existence of relationship between students' tendency towards the types of mathematical proof and the learning styles. In the light of this information, it was aimed to examine the mathematical expressions of the 8th Grade students in the master's thesis by creating an artificial neural network model.

The purpose of the study was to investigate middle school 8th grade students' orientations to mathematical proof schemas by using artificial neural network model. For this purpose, the following questions were sought.
1. Can the effect of having 'diverging' learning style on students' rankings according to mathematical propositions be examined by artificial neural network model?
2. Can the effect of having 'diverging' learning style on students' rankings according to mathematical propositions be examined by artificial neural network model?

Material and Method

In the process of training the artificial neural network model, feed forward back propagation network structure was used. In forward feed networks, neurons are shaped as regular layers from the input to the output. There is a bond only from one layer to the next layer. It was hoped that in this thesis study by using Backpropagation artificial neural network model, successful results in estimation and classification processes might be obtained.

MATLAB modeling program was used to create models. In Matlab applications Neural Networks Toolbox was used. Neural Networks Toolbox algorithms provide pre-trained models and various programs in order to create, train, and visualize superficial or deep neural networks.

The four mathematical judgments, which will be presented under numbers, geometry, probability and algebra, have been adapted from Yating Liu's (2013) question examples that examine the reasoning skills and proof schemes of middle school students. The students, who chose the best proof by themselves, were also asked to add an open-ended question as to why they had chosen the best proposition. In the adaptation of mathematical propositions from Liu's (2013) study, the opinions of primary school mathematics teachers were used. Mathematical judgments were four in total and the total number of proposals was 16. Thus, the number of neurons in the input vectors was determined to be 16. The answers given to each topic were handled separately. For example, each of the four propositions given for the Numbers had a different form of proof. The forms of proof were adapted from the proof clusters of Harel and Sowder (1998). This was also true for the proposals in geometry, probability and algebra. No special array was used for coding vectors. For example, inductive proposal in input vectors was 4, algebraic one was 3, perceptual one was 2, and visual one was 1.

The output vectors specified the classification of learning styles that Kolb (1984) created. In the output vectors, 4 diverging, 3 converging, 2 assimilating and 1 accommodating were determined. The total number of neurons in the output vectors was 1.

In addition, SOM-Ward (Self Organizing Map) clustering algorithm based on artificial intelligence was used to investigate the relationship between students' tendency towards the types of mathematical proof and the learning styles they have. With this program, it was aimed to visualize the numerical data obtained from students' answers. The students were clustered according to their orientation to the forms of proof, and the relations between the formed clusters were presented visually. In addition, it was visually understood which learning style students have and also these students had a tendency to a specific proof method.

Population and Sample

The population of the research was composed of middle school students who study in private and public schools in Denizli and İzmir. In the qualitative data collection process of this study, criterion sampling method was used as the purpose sampling. The sample of this research was determined as the 8th grade students of two private and two state schools in Denizli and also the 8th grade students of a private and a public school in İzmir. Participants consisted of 180 students.

In the selection of the students who participated in the research, it has been determined that they were the 8th grade students as the basic criterion. In accordance with this basic criterion, answers to questions based on mathematical expressions and answers to the inventory were taken in accordance with the volunteerism of the 8th grade students who were studying in 2016-2017. 45% of the participants were male students and 55% were female students.

Data Collection Process

By coding process, inductive proposal was taken 4, algebraic one was taken 3, perceptual one was taken 2, and visual one was taken 1. The adaptation of the learning style inventory of Kolb to Turkish was used as a material for determining the learning style of the students. As a result of the validity and reliability study conducted by Gencel (2007). the reliability coefficients of the four dimensions of the inventory has varied between 0,71 and 0,84. The output vectors specified the classification of learning styles that Kolb (1984) created. By coding process, 4 diverging, 3 converging, 2 assimilating and 1 accommodating were determined.

Table 1. Coding examples from students' rankings

S	Number				Geometry				Probability				Algebra				Learning Style
S1	1	2	3	4	2	3	1	4	1	4	2	3	1	3	4	2	3
S2	3	2	4	1	3	1	4	2	1	2	3	4	3	2	4	1	3
S3	4	3	1	2	2	4	3	1	1	4	2	3	1	4	2	3	4
S4	3	1	2	4	3	2	1	4	4	3	2	1	4	3	2	1	4
S5	1	2	4	3	3	4	2	1	4	3	2	1	4	3	2	1	2
S6	3	1	2	4	2	4	1	3	1	2	3	4	4	2	3	1	2

Table 2. Average Weights of Proof Methods by Students

S	Gender	Visual	Perceptual	Algebraic	Inductive	Learning Styles
S1	2	3,5	2,5	2,25	1,75	3
S2	1	2,25	2,5	3,5	1,75	3
S3	2	2,75	2,25	1,75	3,5	4
S4	2	1,75	2,25	3,5	2,5	4
S5	1	1,75	2,25	2,75	3,25	2
S6	1	2,5	3	2,25	2,25	2

In order to generate sequence averages, each of the four different sequences given for the four distinct areas of mathematic has been studied, and in each case, the number of proof methods are collected in order. Finally, four different proof methods are divided into 4 for reference, and then the value for creating a hierarchical order is removed from 5. With the data entered into the ViscoverySOMine program in a hierarchical way, the resulting maps are easier to interpret. For example, when the first student creates a visual proof method; the first order for the number field, the third order for the geometry field, and the first order for probability and algebra, and finally there is a total of 1 + 3 + 1 + 1 = 6. Because it has four proof methods, it has a value of 1.5 when divided by 4. In general, this is a low value for the method of visual proof selected in the first order; it is desired that the answer given in the first order is higher than the answer given in the last order. Therefore, a hierarchical system was created and the number 5 was taken as a basis and the value was removed from 5. The values in the table show the sequence averages. In the given example, when the average that the first student gives to the visual proof is calculated, the result is 3.5.

Findings and Comment

Students were asked to rank their proposals so their first proposal was closer to their thinking. The order of these proposals was used to train and test the artificial neural network. Students were asked to explain the mathematical language or interpretation of the criterion they consider when they had ranking the proposals.

The content of the students' verbal expressions was used to predict the learning styles they had, and the individual results in the inventory were compared with those estimates. The student who says 'Formative-based representation is more reliable' has assimilating learning style. On the other hand, the students who says 'I prefer to solve the mind instead of solving the formula' has diverging learning style.

While we had been attempting to create an artificial neural network model by using the toolbox, the values in the input vector and the output vector were fixed. The network itself generated the calculation map between the input and output vectors. The Levenberg-Marquardt algorithm was used; this algorithm was chosen to reduce the error rate. Since the values in the intermediate layer were determined by the designer, the results were found to give the best end result, and a 16x13x1 neural network model emerged.

The data obtained from the ranks collected from the students were divided into two groups for testing the network; 80% train the network and 20% test the network. The process began with the randomly selected middle layer value. The toolbox itself specified the weight matrices. The model was tested by comparing the results obtained in the output vector with the estimated results. The process was repeated until the lowest error was obtained in the model generated by the backpropagation.

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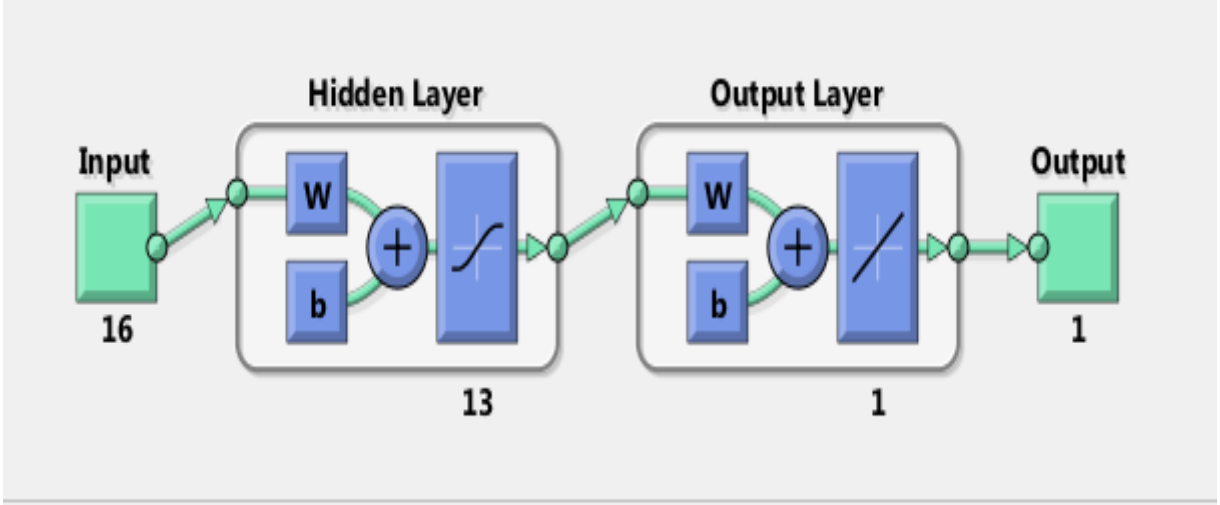

Figure 1. Artificial neural network modeling

The error rate was found to be 1.09, and it seems to be seen in the training phase in the model. According to the figure, there was enough consistency between the results produced by the model we created and the estimated learning styles.

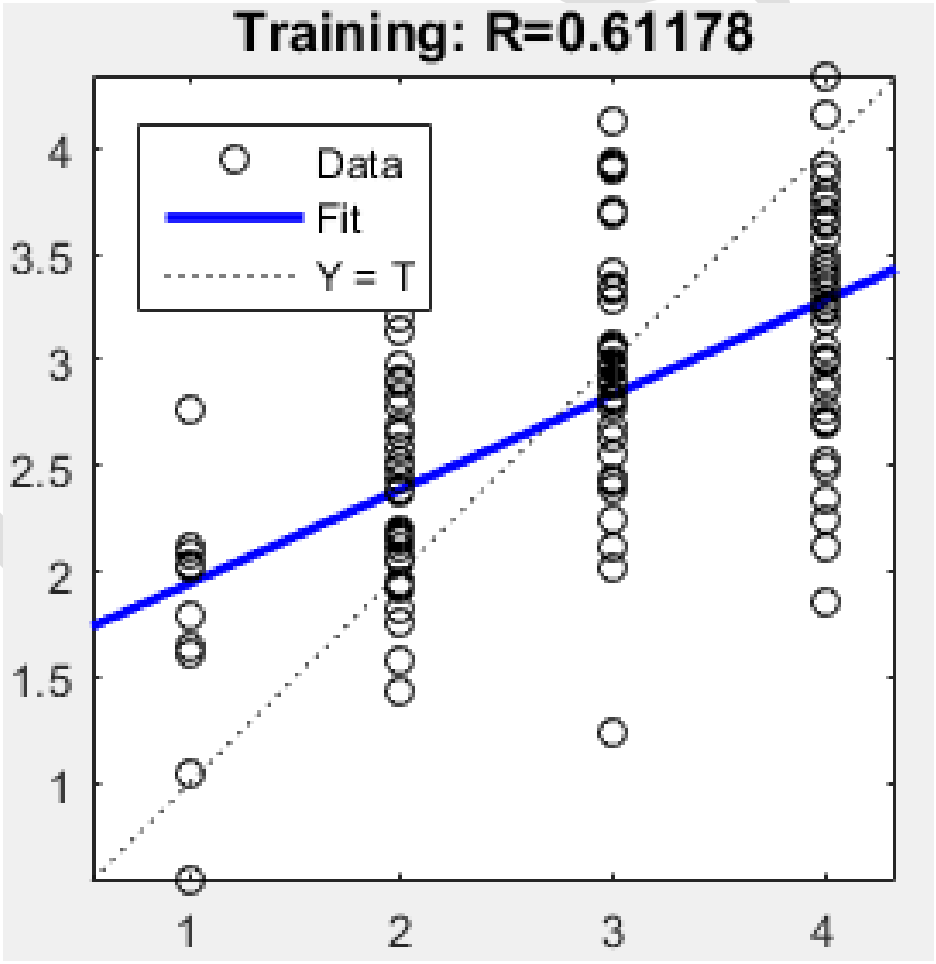

Figure 2. Model's Training Phase

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In a Special Version of the Artificial Neural Network, the SOM-WARD Program, the Resulting Map of Neurons Training:

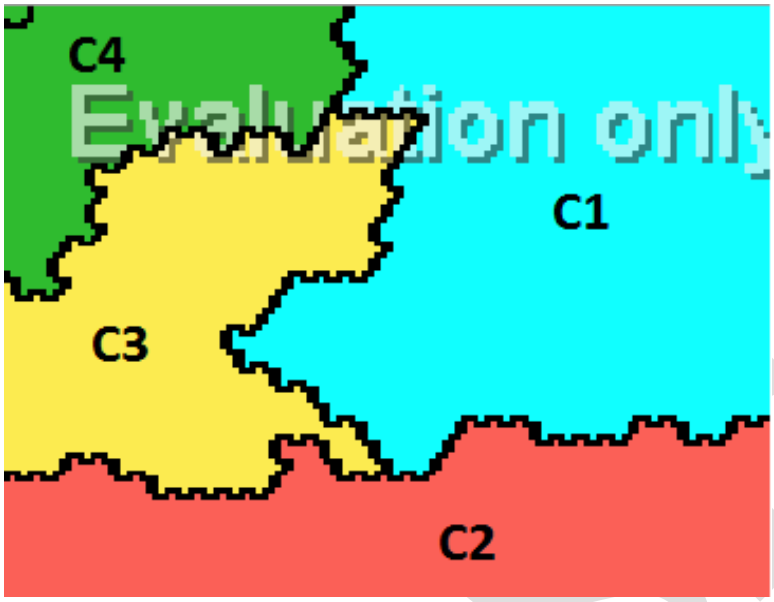

Figure 3. Finding clusters of SOM-WARD Program

In the Kohonen plate divided into 4 clusters after training, the parameter value of how each proof form influences clusters was given; these values vary from 1 to 4, which reveals the excess of the degree of influence to 4. The parameters actually represent the median values of the clusters and the parameters for this work are in the following table.

Cluster	Description	Abs. Profil...	Frequency	Cinsiyet	Stiller	Görsel	Cebirsel	Algısal	Tümevarımsal
C 1		0,5884	37,79%	1,354	2,523	2,865	2,008	2,804	2,323
C 2		0,5926	29,65%	1,941	2,824	2,157	2,534	2,358	2,951
C 3		0,9233	16,86%	1,000	2,379	1,836	3,284	2,353	2,526
C 4		0,5416	15,70%	1,778	3,185	2,546	3,417	2,231	1,806

Figure 4. The parameters of the study

Through color scaling, how each proof form influences clusters was visually presented. The dark blue color indicated that the students in the surrounding area occupied the above proof in the last order; dark red indicates that the students in the area occupied the above proof in the first order.

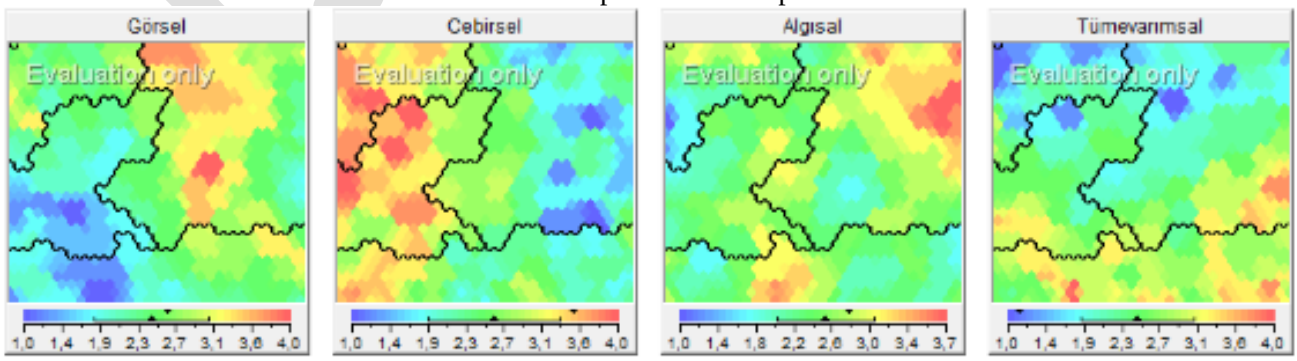

Figure 5. Distributions of students according to their tendency towards proof schemas

Can the effect of having 'diverging' learning style on students' rankings according to mathematical propositions be examined by artificial neural network model?

It is shown that the students have a 'diverging' style of learning in their orientation towards proof. Because there is a certain consistency between the results of the model and the estimated learning styles. In addition, with the help of the maps created as a result of SOM-Ward clustering, inferences were made about the relationship of students' proof orientation to their learning styles.

After the color scaling, when referring to the parameters given to the styles, the region that refers to the 'diverging' learning style (4) appears to be red. When the orientation of the students in the red regions is examined, it is observed that there are more algebraic orientations. Some parts of the red regions in the algebraic map correspond to the diverging learning style.

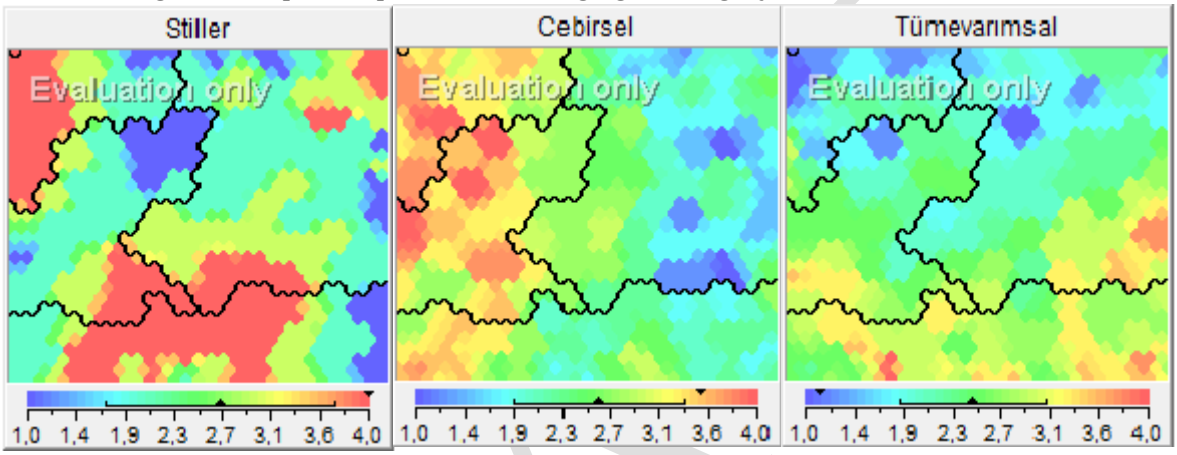

Figure 6. Algebraic and Inductive Proof Orientations Correspond to Diverging Learning Style which has 4 parameter in Styles Map

On the other hand, it is noteworthy that there are few inductive orientations; some parts of the blue regions in the inductive map correspond to the diverging learning style.

In the process of inferring from the verbal expressions of the students, attention was paid to the signs that might be related to the classical characteristics of the 'diverging' learning style. The person who has the 'diverging' style of learning needs to be able to see the whole first, so he gives importance to deduction. For this reason, some examples have been sought in the answers of students in terms of looking at mathematical judgment and propositions from a holistic perspective.
Ex1. I took into consideration the propositions in which mathematical expressions were used.
Ex2. Algebraicity = invariance = generality
Ex3. It's important for me to be based on the theory.
Ex4. I prefer using the process rather than using long sentences.

Since the person with the 'diverging' style of learning can make examinations on the material which would be learned or studied when sufficient time and opportunity is given, the students' opinions about the material which was used in the content of the propositions have been taken into consideration.
Ex. The use of biscuits shows that it has been well thought out. Most people don't like to think so much, but I do.

Because the person who has ‘diverging’ learning style likes to learn by doing, students' answers were sought for an expression about their movement.
Ex. If I'm going to tell someone, I've arranged for the easiest.

Since the person who has 'diverging' learning style gives importance to systematic planning, in the answers, attention was given to the students' information about individual solutions.

Ex. It's best for me to imagine that I'm on the football field because I've been dreaming about geometry questions first.

Since the person with the 'diverging' style of learning tends to make a logical analysis on his ideas, some expressions of the students were also sought in the answers of students in terms of making comments and evaluating their responses.

Ex. I chose this because I was more interested in examples of daily life, such as the football field example. But the football field in test process may not come to mind or we cannot look at it in that test time so I changed my decision and put the impression of the circle in the first place.

Since the person who has a 'diverging' learning style comes to the forefront with the decision-making aspect, the clarity of the points on which the students base their decision were sought in the answers.
Ex1. The solutions that will be most useful to me in the Teog exam are in the first place for me.
Ex2. I've sorted the order from the one I thought would be less likely to make a transaction error to the more one.

Can the effect of having 'assimilating' learning style on students' rankings according to mathematical propositions be examined by artificial neural network model?

It is shown that the students have an 'assimilating' style of learning in their orientation towards proof. Because there is a certain consistency between the results of the model and the estimated learning styles. In addition, with the help of the maps created as a result of SOM-Ward clustering, inferences were made about the relationship of students' proof orientation to their learning styles.

After the color scaling, when referring to the parameters given to the styles, the region that refers to the 'assimilating' learning style (2) appears to be light blue. When the orientation of the students in the light blue regions is examined, it is observed that there are algebraic orientations and perceptual orientations. Some parts of the red regions in the algebraic map and the perceptual map correspond to the assimilating learning style.

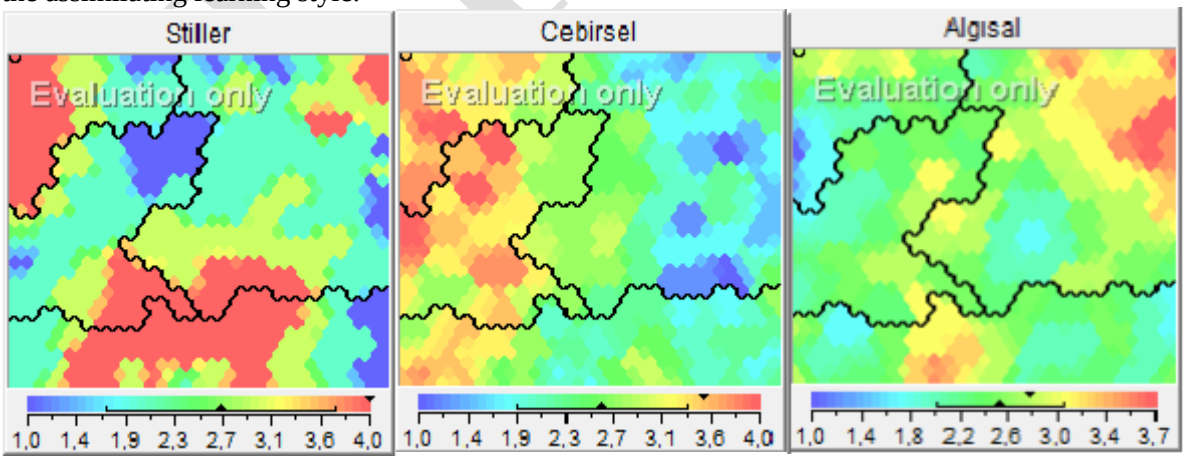

Figure 7. Algebraic and Perceptual Proof Orientations Correspond to Assimilating Learning Style which has 2 parameter in Styles Map

In the process of inferring from the verbal expressions of the students, attention was paid to the signs that might be related to the classical characteristics of the 'assimilating' learning style. The person who

has the 'assimilating' learning style gives an importance on abstract concepts and ideas. Therefore, mathematical concepts and expressions of abstract thinking were sought in the answers of the students.
Ex1. I've ordered it according to the logical.
Ex2. According to the scientific and equations.
Ex3. I have ordered from algebra-> model-> examples.
Ex4. The Pythagorean Theorem is consistent with this year's topic.
Ex5. Formulas and charts are more reliable than trial and error.
Ex6. The formula is easier to handle when dealing with larger numbers.
Ex7. One student argued that the best proposition that shows the accuracy of the mathematical judgment is the visual proposition B4, under the conclusion that "The diagonal of a rectangle is longer than each side of that rectangle."

'Because we have known the radius of the circle for a long time and it is easier to relate it to the diagonal subject', he referred to the concept of the radius of the circle and was able to connect with the subject by thinking abstractly.

For the student with an assimilated learning style, it is important to study mathematics by giving examples from daily life through the creation of conceptual models. Therefore, in the answers of the students, expressions about the use of concrete experiences in mathematical concepts were sought.
Ex1. There is no need to measure or mathematical process to compare lengths. This situation can be explained through the football field as mentioned in B2. We do not have to be on the field, we see on TV, we can imagine.
Ex2. One student argued that the best proposition for the mathematical judgment which is 'a number that is a multiple of 6, and a multiple of 3' is the perceptual A3 proposition. 'Because as long as real life examples are given, our memory forgets some concepts later. If the A3 method is used when learning, we immediately think of the object in question when we see it around us and we will not forget it' so he explained the importance of processing mathematical concepts with examples from daily life.

RESULTS, DISCUSSION AND RECOMMENDATIONS

In this study, we emphasized the existence of relationship between students' tendency towards the types of mathematical proof, and the learning styles. In the light of this information, it was aimed to examine the mathematical expressions of the 8th Grade students in the master's thesis by creating an artificial neural network model. In this section, the results, discussion, the limitations of the research and the suggestions that made in the light of the results are presented in this section.

Results and Discussions

The training field is closely involved with the functions performed by the human brain. The mechanism of the brain, the potential it contains and the changes in the brain that are felt during the learning process are important for the field of education; but it is not always possible to carry out meaningful studies. On the other hand, the findings obtained provide various information about the students. This information is included in the different learning styles of students and the differences in learning stages. This information can be changed with each new finding (Keleş, & Çepni, 2006). It is recommended to use artificial intelligence techniques in order to deepen the student's learning process (Özdemir, & Kazu, 2010).

In this study, which was conducted by producing a feed backward-propagated neural network model, it was aimed to examine the students' orientation towards proof. Consistency between the results of the model created using the toolbox and the estimated learning styles were sufficiently observed.

In a study of Kaplan and Özdemir (2014) in the literature, the suggestion that learning styles might be effective in students' orientation to proof and that activities should be reproduced accordingly was the basis of the thesis study and this article. As a matter of fact, the results obtained reveal the relationship between students' orientation and their learning styles.

- ✓ Those in the symbolic (algebraic) scheme of proof act solely on outcome. They ignore the relationship between concepts. They perform the verification process without thinking about why the symbols used in the proof should be used (Liu, 2013). When the maps in the study are examined, it is seen that the students in the red regions of the algebraic map-the students who prefer the algebraic proposition in the first place have assimilating and diverging learning styles. It was commented that the explanations of the algebraic proof scheme were in harmony with the defining characteristics of assimilating and diverging learning styles. These features include the need to see the whole, focus on decision-making, focus on abstract concepts and ideas, and make requests to process information.

- ✓ Those in the intuitive (perceptual) proof scheme provide insight into the accuracy of proof by suggesting their intuition; trust their feelings. However, they do not use certainty in explaining their accuracy (Liu, 2013). When the maps in the study are examined, it is seen that the students in the red regions of the perceptual map-the students who prefer to perceive the first order in the rankings have an assimilating learning style. It has been commented that the explanations of the perceptual proof scheme are compatible with some features of the assimilating learning style; like creating conceptual models.

In the literature, parallel and non-parallel studies have been mentioned about the students' perspectives on proof. In a study that showed that the perspectives of proof as well as mathematical competences were important for students' success, secondary school students used the experimental method (including inductive and perceptual proof schemes) more than other forms of proof (Heal, & Hoyles, 2000). In this thesis, the students put forward the propositions that are algebraic and perceptual. The fact that the red areas on the algebraic map occupies a large area and the red and green areas on the perceptual map are large shows this result.

- ✓ There was no significant relationship between the students' tendency to prove. In inductive predisposition, algebraic predisposition, perceptual predisposition and visual predisposition are linear independent.

According to the literature, it was not possible to determine the result in another study to determine the most convincing type of propositions based on algebraic, inductive, perceptual and visual proofs. Because there was diversity in students' evaluations about propositions (Liu & Manouchehri, 2013). The high color diversity and distribution in the maps obtained in this thesis shows that there is a difference in the students' orientation towards proof and therefore there is diversity in their approach to proof types.

Recommendations

Since the role of high-level thinking is important in commenting on proof-based questions, this study can be tried and developed through 8th grade students who are above the grade average. Success level factor can be taken as variable.

While preparing activities based on proof of assimilating learning style, algebraic and perceptual propositions can be used more frequently than propositions that show the accuracy of mathematical judgments. In the activities prepared for the student who has diverging learning style, the propositions showing the accuracy of the judgments should include those with algebraic features.

According to the study of Duran, Doruk and Kaplan (2017), it was emphasized that the classroom environment should be arranged in order to produce arguments for students; activities have a great role in creating a classroom environment in which students can question, conduct research, and communicate to share ideas. In this thesis, it has been seen that the role of learning styles in the students' orientation towards proof is changing according to each student. It was thought that other factors might be effective in students' orientation to mathematical proof; such as the readiness of students. Therefore, curriculum, student readiness and learning styles may be used to determine the standards of activities.

The use of the artificial neural network model in the field of primary school mathematics teaching can be expanded and even educators and those with a knowledge of artificial intelligence can work together. A more specific topic can be selected in mathematics and a model can be formed on this subject in order to reveal the students' thinking structures. In determining this topic, the subjects that are based on abstract thinking can be selected.

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