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An Examination of Mathematically Gifted Students' Learning Styles by Decision Trees

Matematik Alanında Üstün Yetenekli Öğrencilerin Öğrenme Stillerinin Karar Ağaçları Kullanılarak İncelenmesi

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Abstract

The aim of this study was to examine mathematically gifted students' learning styles through data mining method. 'Learning Style Inventory' and 'Multiple Intelligences Scale' were used to collect data. The sample included 234 mathematically gifted middle school students. The construct decision tree was examined predicting mathematically gifted students' learning styles according to their multiple intelligences and gender and grade level. Results showed that all the variables used in the study had a significant effect on mathematically gifted students' learning styles, but the most effective attribute found was intelligence type.

Key Words: mathematically gifted students, educational data mining, learning style, multiple intelligences

Öz

Bu çalışmanın amacı, matematik alanında üstün yetenekli öğrencilerin öğrenme stillerini veri madenciliği yöntemini kullanarak incelemektir. Veri toplama aracı olarak 'Öğrenme Stili Envanteri' ve 'Çoklu Zeka Ölçeği' kullanılmıştır. Araştırmanın örneklemi, 234 matematik alanında üstün yetenekli ortaokul öğrencisinden oluşmaktadır. Matematik alanında üstün yetenekli öğrencilerin öğrenme stillerini çoklu zeka alanları, cinsiyetleri ve sınıf seviyelerine göre tahmin etmek için oluşturulan karar ağacı incelenmiştir. Sonuç olarak tüm değişkenlerin üstün yetenekli öğrencilerin öğrenme stilleri üzerinde etkisi olduğu fakat en etkili değişkenin çoklu zeka alanı olduğu gözlenmiştir.

Anahtar Sözcükler: matematikte üstün yetenekli öğrenciler, eğitimsel veri madenciliği, öğrenme stili, çoklu zeka

Introduction

Understanding students' learning styles helps teachers to overcome learning difficulties, and assist them to invest in their capabilities (Fleming, 2007). Many scholars (Altun, 2010; Given 1996; Saban, 2004; Fleming, 2007; Babadoğan, 2000; Peker, 2003 etc.) stated that understanding students' learning styles can improve learning process. According to Gencel (2007), learning style is not the only agent that causes differences in learning; however it is accepted to be one of the most important components of the learning process. Boydak (2008, as cited in Demir, 2010) also emphasized that knowing our learning styles is as important as knowing our blood types.

Kolb (1984) defines learning style as a preferred way of gathering information, whereas for Dunn (1984), learning style is an individual way of absorbing and retaining information or

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skills. Focusing on different aspects, there are many kinds of models (e.g. Felder & Silverman, 1988; Honey & Mumford, 1986; Kolb, 1984; Grasha & Riechmann, 1982; Dunn & Dunn, 1993), which allow for the determination of students' learning styles. In the present study, due to widespread use, Kolb learning style model was preferred. This model is based on experiential learning theory, which is based on theories of Dewey, Lewin and Piaget.

In literature, it has been found that learning styles are associated with many variables. Multiple intelligences, gender and grade level were used in the present study. Gardner's theory of multiple intelligences (MI) is one of the proposals that has aroused more interest in the distinction of different human abilities (Chan, 2008). To date, Gardner has identified eight intelligences: verbal-linguistic, logical-mathematical, naturalistic, visual-spatial, musical, bodily kinesthetic, intrapersonal, and interpersonal (Gardner, 1993). Each person possesses all of these intelligences, but they typically differ in strength (Klein, 2003). Demir and Aybek (2014) and Can (2007), found significant relationships between several dimensions of learning styles and multiple intelligences. Narli, Özgen and Alkan (2011) also found by using rough set theory that intelligence areas together could explain learning styles at 0.794 level. However, there are some studies claiming that multiple intelligences and learning styles are the same things; whereas Gardner stated that they are different and a learning style could be related to more than one intelligence area. As for gender and grade level, a number of research studies was conducted on the relationship between learning styles and gender (Honigsfeld & Dunn, 2010; Altun & Yazıcı, 2010; Işık, 2011; Özer, 2010; Ok, 2009), and also there are many studies about relationship between learning styles and grade level (Altun & Yazıcı, 2010; Işık, 2011; Ok, 2009; Biçer, 2010).

These relationships should be investigated for all kinds of student population (e.g. different school types, different ages). In addition, characteristics of gifted students are of increasing importance in recent years. Leikin, Karp, Novotna and Singer (2013) also discussed that characteristics of mathematically gifted students should be identified through careful systematic research. The present study aimed to examine mathematically gifted students learning styles by using a novel technique, data mining. This study may be one of the cases identifying characteristics of mathematically gifted students through the use of data mining.

Educational Data Mining

Data mining can be defined as application of different algorithms to identify patterns and relationships in a data set. It is similar to mining to obtain ore from the sand. That is, it can be considered that sand is data and ore is knowledge. Although it should be defined as knowledge mining, it is defined as "data mining" to emphasize large amounts of data by researchers in the area of knowledge discovery. Data mining has been used in different areas such as Marketing, Banking, Insurance, Telecommunication, Health and Medicine, Industry, Internet, Science and Engineering and recently, in the field of education known as Educational Data Mining (EDM).

A decision tree is a flowchart-like tree structure, where each internal node (nonleaf node) denotes a test on an attribute, each branch represents an outcome of the test, and each leaf node (or terminal node) holds a class label. The topmost node in a tree is the root node (Han & Kamber, 2006). During the construction of these trees, the data is split into smaller subsets iteratively. At each iteration, choosing the most suitable independent variable is an important issue. Here, the split, which creates the most homogenous subsets with respect to the dependent variable, should be chosen (Güntürkün, 2007).

Purpose of the Study

The aim of this study was to examine mathematically gifted students' learning styles according to their multiple intelligence types, gender and grade level. Unlike conventional methods to analyze data, data mining techniques were used to examine data. Compared to traditional statistical methods, data mining can (1) provide a more complete understanding of data by finding patterns previously not seen and (2) make models that predict, thus enabling people to make better decisions, take action, and therefore mold future events (Miner, Nisbet & Elder , 2009).

Method

Participants

Participants of this study consisted of 234 mathematically gifted students from four different Sciences and Arts Centers in two cities in Turkey. Convenience sampling was preferred because of its availability and the quickness. The participants were in grade 5 to 8. Distribution of the participants according to grade level and gender is presented in Table 1.

Table 1. Demographic characteristic of mathematically gifted students

		Grades					Total
		5th	**6th**	**7th**	**8th**		
Mathematically gifted	Male	43	53	34	15	145	234
	Female	37	29	16	7	89	
Total		80	82	50	22	**234**	

Instruments

All participants responded to a three-part questionnaire, including the 'Learning Style Inventory' (Kolb, 2005), and 'Multiple Intelligences Scale' (Selçuk, Kayılı & Okut, 2004).

Learning Style. Kolb's Learning Style Inventory (LSI) (version 3.1) (Kolb, 2005), adapted by Gencel (2007), was used to assess individual learning styles. The twelve-point questionnaire had four choices for each prompt, the students ranks the choices by similarity to their learning style. The scores collected for the inventory adapted by Gencel (2007) were

found to be reliable with a Cronbach Alpha coefficient of .76 for the concrete experience scale, .71 for the reflective observation scale, .80 for the abstract conceptualization scale, .75 for the active experimentation scale. In this sample, Cronbach's α coefficients for the learning style inventory scores were .73, .78, .70, and .81 respectively.

Multiple Intelligences. Multiple Intelligences Scale (Selçuk et al., 2004) was used to assess students' MI. The Multiple Intelligence (MI) Inventory used in this study has 80 items. The instrument used a 5-point Likert-type scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. The items aim to measure students' multiple intelligence preferences. The inventory includes 10 items for each of the eight intelligence domains: In this sample, Cronbach's α coefficients for the MI scores were .65, .78, .75, .73, .74, .84, .69 and .85, respectively.

Data Analysis

SPSS Clementine 10.1 was used to analyze data. Clementine is the SPSS enterprise-strength data-mining workbench built by IBM. It has been used to build predictive models and conduct other analytic tasks. It has a visual interface allowing users to obtain statistical and data mining algorithms without programming. In the present study, the decision three, a data mining technique, was used.

Findings

To investigate mathematically gifted students' learning styles according to their multiple intelligences, gender and grade levels, decision tree which is a classification technique of data mining was used. Decision trees work by recursively partitioning the data based on input field values. The data partitions are called branches. The root is split into subsets, or child branches, based on the value of a particular input field. Each child branch can be further split into sub-branches, which can in turn be split again, and so on. At the lowest level of the tree are branches that have no more splits. Such branches are known as terminal branches (or leaves) (Clementine 10.1 Node Reference).

In constructed decision tree the target variable is learning style. And independent variables are multiple intelligence, gender and grade level. Thus, we can examine mathematically gifted students' learning styles according to their multiple intelligence and gender and grade levels.

The represented tree is so large that the image of tree is minimized. To interpret the decision tree shown in Figure 1, it was divided into two parts (left part/right part) and these parts are enlarged to read easily (Figure 2 and Figure 3).

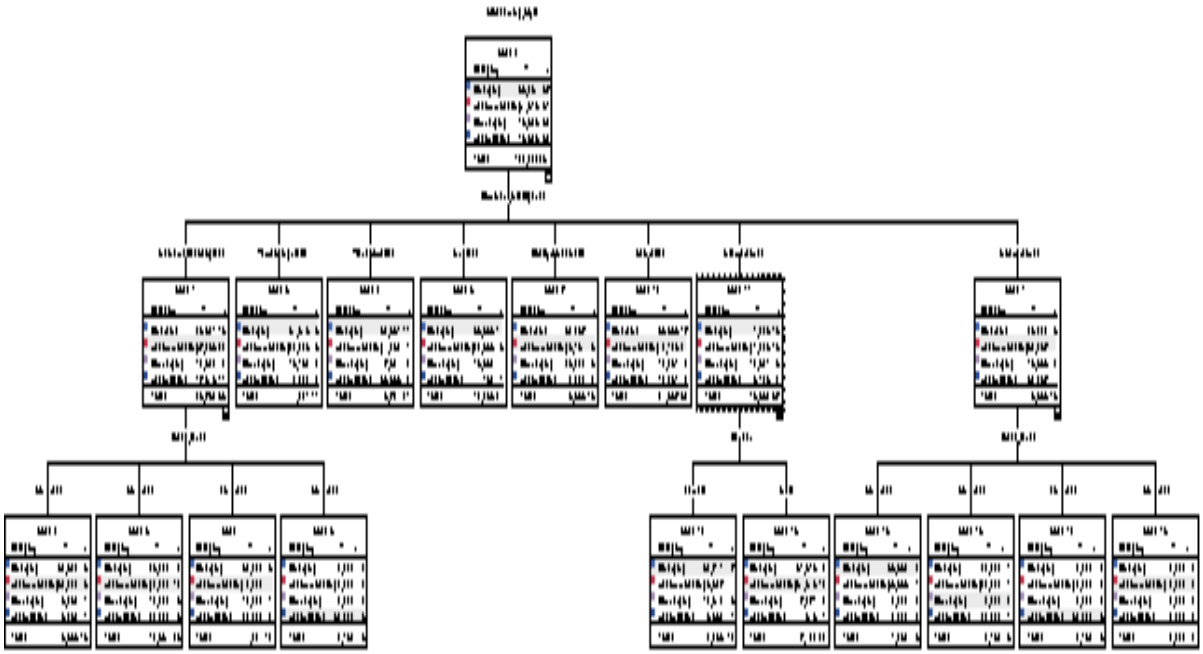

Figure 1. Mathematically gifted students' learning style decision tree

Figure 2 shows the left part of the tree for mathematically gifted students' learning styles, the top level is the root of tree contains all the records of attitude (N=234) (Node 0). It can be seen in Node 0 that the most frequently observed learning style is diverging but the ratio of accommodating is close to it, too. It can be said that most of the mathematically gifted students in this sample prefer feeling for grasping experience. But according to transforming experience they differ from each other. That is, some of them prefer watching, and the others prefer doing.

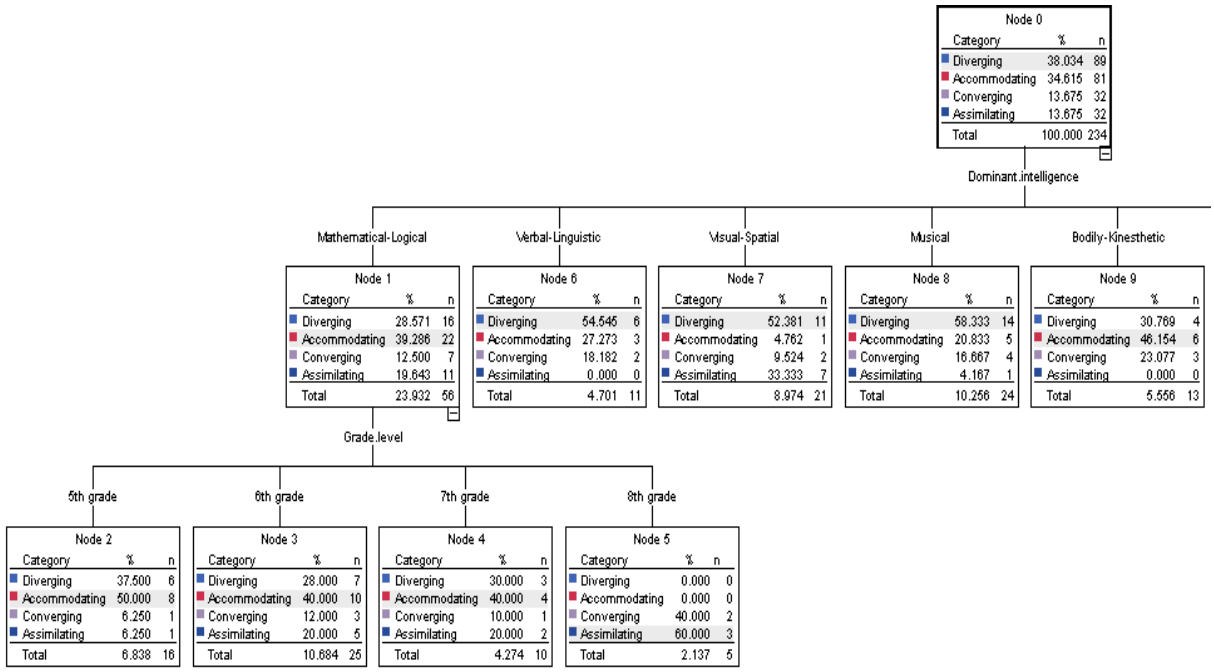

Figure 2 Mathematically gifted students' learning style decision tree (left part)

The second level represents the first partition of the data according to the most important factor suggested by the algorithm (Şuşnea, 2009). The C5.0 tree indicated that all of the independent variables have some sort of effect on learning styles but the most effective attribute is found to be multiple intelligences. In addition, the most observed dominant intelligences are mathematical-logical and naturalist while the least observed is verbal-linguistic intelligence.

As seen in Figure 2 and Figure 3, except from Node 1, Node 11 and Node 14, the other nodes did not divided into child node, and these nodes constructed terminal branches (leaves). If we examine the learning styles of the students in these nodes, we can see that most of the students, whose dominant intelligences are verbal-linguistic, visual-spatial or musical, are divergent thinkers while most of the students, whose dominant intelligence is bodily-kinesthetic or naturalist, are accommodator. This result showed that multiple intelligences might be compatible with learning styles. Because, as an interesting example from these nodes, individuals with accommodating style have the ability to learn from primarily 'hands on' experience. And, it is expected that individuals, whose dominant intelligence is bodily kinesthetic, want to use their whole body or parts of the body. To give one more example, an individual with diverging learning style have imaginative ability. So it may be related to visual-spatial intelligence.

In Node 1 most of the gifted students, whose dominant intelligences are mathematical-logical, are accommodator. Node 1 is divided into four nodes (Node 3, Node 4, Node 12, and Node 13) with respect to the input variable grade level. This situation may stem from the fact that as grade level increases, their experiences about mathematics may change. So, their ideas and learning styles may differ. And grade level may become critical for them. It is interesting that 8th grade students, whose dominant intelligences are mathematical-logical, are assimilator while most of the others are accommodator. Individuals with assimilating style are more interested in ideas and abstract concepts.

In Figure 3, the next split from Node 11 is made with respect to the gender. It means that gender has an effect on learning styles of students whose dominant intelligences are interpersonal. This situation may stem from puberty. Because interpersonal intelligence requires strong communication skill, and puberty may affect it. Node 12, one of the child nodes of Node 11, contains female students. Most of them have diverging learning style while most of male students in Node 13 are accommodator. In this case, it may be questioned why male students are accommodator, while female students are mostly diverger. According to Kolb learning style, diverging and accommodating learning styles have the same action (feeling/experiencing) to grasping experience but they differ in terms of transforming experience. An individual with diverging style prefers watching to transform experience while an individual with accommodating style prefers doing it.

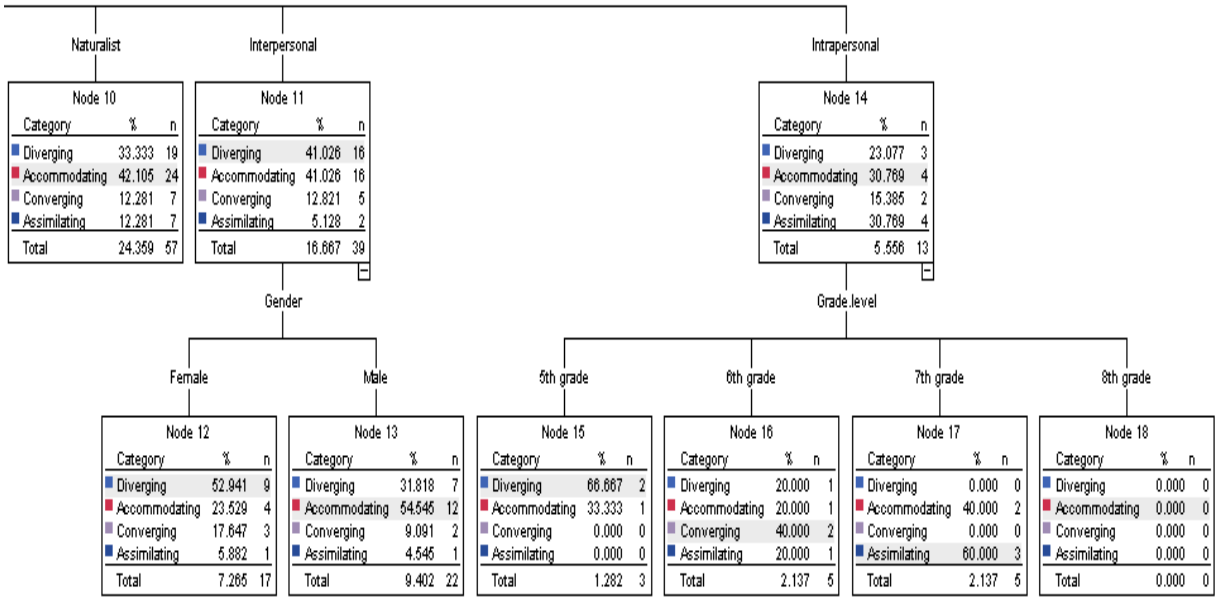

Figure 3 Mathematically gifted students' learning style decision tree (right part)

Besides examining both males and females whose dominant intelligences are interpersonal, the lowest rate belongs to assimilating learning style while accommodating ratio is the lowest in the other nodes mostly. It is an interesting result because as discussed below individuals with assimilating style Focus less on people, and more interested in ideas and abstract concepts.

As for Node 14, it covers the students, having mostly accommodating and assimilating styles with equal proportions. The last division of the decision tree occurs in this level, in Node 14. Division with respect to grade level generates the terminal nodes Node 15, Node 16, Node 17, and Node 18. According to Gardner, intrapersonal intelligence involves having an effective working model of ourselves. So this division with respect to grade level may be significant because of its relationship with age. That is, the age may be critical for intrapersonal intelligence. Interestingly all of the grade levels consist of different styles. It should be deeply analyzed, too. For instance, to tell it by majority, Node 15 consists of fifth grade students with diverging style. Node 16 consists of sixth grade students with converging style. Node 17 consists of seventh grade students with assimilating style. However there is nobody in Node 18 containing eighth grade students. It means that in this sample there is no eighth grade gifted student whose dominant intelligence is intrapersonal.

Discussion and Conclusion

One of the most significant advances in education has come from a considerable amount of research done in the area of learning styles, which recognizes that the students in classrooms have variety of different learning profiles (Vaishnav, 2013). And, it is inferred from related literature that effective learning is considerably related to students' learning styles, and learning styles also can be influenced by a wide variety of factors. It is thought that findings

of this research will be able to give opinion about some characteristics of students to researchers, mathematics educators and parents, besides contributing to the literature.

The created decision tree covers abundant information to be used for observing learning style profiles of mathematically gifted students. The results revealed that, in general, most of them have diverging learning style and accommodating respectively. It can be said that most of the mathematically gifted students in this sample prefer feeling for grasping experience. But according to transforming experience they differ from each other. That is, some of them prefer watching, and the others prefer doing. Constructed decision tree also revealed that all of variables used in this study have some sort of effect on mathematically gifted students' learning styles but the most affective attribute was found to be dominant intelligence type. In addition, the most observed dominant intelligences are mathematical-logical and naturalist while the least observed is verbal-linguistic intelligence. Some of dominant intelligences were found to be related to gender and grade level factors to determine mathematically gifted students learning styles. In literature it is pointed out that there are statistically significant differences in terms of learning styles according to grade levels (Altun & Yazıcı, 2010; Işık, 2011), and the others reached opposite results (Ok, 2009; Biçer, 2010). Some of the studies in literature asserted that gender has impact on learning styles (Honigsfeld & Dunn, 2010; Altun & Yazıcı, 2010; Işık, 2011) and the others reached opposite results (Özer, 2010; Ok, 2009).

As a result, the overall findings of the present study provided evidence for data mining techniques can contribute to the development of education. The results and the method of this study may open new perspectives. In this regard this study covers some suggestions to the educators to show where to look at and how to design the plans especially for students with special needs. According these results, it may be advised to educators that they should take heed to students' personal attributes, including relationships between them. Because the educators may have a students' personal information survey done at the beginning of year and it may guide the process of plan curriculum planning. Using student profiling through data mining will be the new competitive strength for the researchers, scholars, teachers, educators etc. in education sector. Educators can benefit from data mining by using each data collected from students, educational environments or educational databases. Educators can develop these results by increasing the sample size and using much more attributes. Thus, the rules can be generalized and used in educational environment.

Limitations and Suggestions for Further Studies

The sample size was an important limitation of this study. Data mining is also related to large amounts of data, which includes the millions in general. So the results can be more generalizable with increased number of data. But, it is difficult to reach large amounts of data without using databases in educational studies. Another limitation of this study is the fact that only self-report measures were used. Observations and interviews can contribute to better identification of students' attributes.

As a result of the present study, suggestions can be summarized as follows: First of all, increasing the sample size of the study may give more generalizable results. Similar studies may be done at different types of schools, in different cities, with different age groups. By this means, conclusions containing more comprehensive information can be reached. Both more and different variables, which might be considered to associate with gifted students or learning styles, can be used. In addition, it might be beneficial to compare the achievements of this research with other classification techniques of data mining and traditional statistical methods. And different attributes can be searched by the same techniques as well.

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