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Öğrencilerin Fen Bilimleri Dersinde Kullanılan Öğretim Teknikleri Tercihlerinin Ölçeklendirilmesi

Scaling of Students' Instructional Techniques Preferences used in Science Lessons

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Öz

Bu araştırmanın amacı, ortaokul öğrencilerinin fen bilimleri dersinde başarıları açısından en yararlı olacağına inandıkları sekiz öğretim tekniğini ölçeklendirmektir. Bu kapsamda uzman görüşlerine göre teknikler belirlenmiştir. Araştırma verisi devlet okullarında öğrenim gören 221 altıncı sınıf öğrencisinden toplanmıştır. Araştırmada sınıflama yargılarına dayalı ardışık aralıklar yöntemiyle ölçekleme yapılmıştır. Öğretim tekniklerinin (uyarıcıların) ölçek değerleri hesaplanarak yorumlanmıştır. Ayrıca, Spearman-rho sıra korelasyon katsayısı kullanılarak erkek ve kızların ölçek değerleri arasındaki ilişki belirlenmiştir. Öğrenciler fen bilimleri dersinde başarılarına en büyük katkıyı yapan teknik olarak birinci sırada deney tekniğini tercih etmişlerdir. Deney tekniğini sırasıyla soru-cevap, gösteri, eğitsel video, gezi-gözlem ve grup çalışması tekniği takip etmektedir. Öğrenciler büyük grup tartışması ve eğitsel oyun tekniklerinin ise fen bilimleri başarılarına en küçük katkıyı yaptığını belirtmişlerdir. Korelasyon analizi kız ve erkeklerin farklı tercih sırasına sahip olduğunu göstermiştir. Sonuçlara göre; öğrenciler başarıyı çoğunlukla uygulamalı öğretim tekniklerine bağlamaktadır. Öğretim tekniklerinin değeri nasıl uygulandıklarına bağlıdır; bu durum genellikle öğretmen ve öğrenciler arasındaki ilişki tarafından belirlenir. Bundan sonraki çalışmalarda öğretmen yeterliliği, öğrenme konusu ve tekniklerin kullanılma sıklığı gibi konuların araştırılmasının öğrencilerin teknik tercihlerine daha açıklayıcı bir değerlendirme getireceği beklenmektedir.

Anahtar Kelimeler: ölçekleme, sınıflamalı yargılar, ardışık aralıklar yöntemi, fen bilimleri, öğretim teknikleri.

Abstract

The purpose of this study was to have secondary school students scale eight instructional techniques that they believe would be the most beneficial in terms of science achievement. Within the scope of this purpose, techniques were determined according to expert opinions. Data was collected from 221 sixth grade students from several public schools. In this research successive intervals scaling method depends on categorical judgments law was carried out. Scale values of instructional tecniques (the stimuli) was calculated and commented. Also, relationship between scale values of males and females determined by using Spearman-rho rank order correlation coefficient. The students preferred the experiment in the first order as the technique that made the biggest contribution to their achievement in the science lessons while large group discussion and educational play made the smallest. The experiment technique was followed by question-answer, demonstration, educational video, trip-observation and group study technique. The correlation analysis indicated that females and males had different rank of preferences. According to results; students mostly link success to hands-on instructional tecniques. The value of instructional techniques depends on how they are implemented, which is often determined by the relationship between teacher and learners. It is expected that this research will lead to a more explanatory evaluation of technique preference of students, particularly given the likely emergence of research on topics like teacher competency, learning topic and the frequence of utilization of the techniques.

Keywords: scaling, categorical judgments, successive intervals method, science, instructional techniques.

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Extended Abstract

Introduction: Many researches have been conducted to reveal that instructional methods and techniques affect science achievement. (Daluba, N. E.,2013; Ganyaupfu, 2013; Ergul, N. R. & Kargin, E. K., 2014; Arslan and Zengin, 2015; Chibabi, et all, 2018). An effective science teaching, teachers need to choose instructional technique not only appropriate for the lesson and the subject but also appropriate for the student. In common practice we can evaluate students' success by an exam. We can decide how much they learned by assesing the scores. It is also important what the students have been thinking about instructional techniques in which they are involved in science classrooms so that teachers can respond to student ideas in an accurate techniques.

Purpose: The instructional techniques are considered as a variable that determines success. In this case, students may attach more importance to some instructional techniques than others, so they can prefer one tecnique more than the other. In this research, the rank of preference of students in terms of instructional techniques' contribution to their achievement in the science lesson was investigated. What were the secondary school students' rank of preference of instructional techniques used in science lessons? This question formed the problem question of the research. The purpose of this study was to have secondary school students scale eight instructional techniques that they believe made the most important contribution to their achievement in science. The aim of the scaling is to produce a better quality and more objective scale by applying some statistical analysis to obtained data sets from observers' judgments or participants' reactions (Turgut and Baykul, 1992). Also it was aimed to scale instructional techniques based on categorical judgments of students by gender. When the literature was examined, it was found that the students' preferences of instructional tecniques wasn't been studied for science lessons. It was believed that knowing the rank of preference of instructional techniques based on students' views could be a guide for teachers.

Method: In this research, eight instructional tecniques were determined according to expert opinions. Data was collected from 221 sixth grade students from public schools in Turkey. In this study, instructional tecniques' influence over success are determined by applying the successive intervals method depends on categorical judgments law was carried out. Algebraic solutions were conducted by using condition D, applicable to the incomplete data matrix. When observers may not put a stimuli to any class, in this case, scaling could be made with incomplete data matrix (Torgerson,1958; Turgut & Baykul, 1992). Using five-points scale, students were asked to categorize their rank of prefers of the instructional techniques in terms of their importance for the science achievement. The students were asked to place eight instructional techniques to ranked categories from 1 to 5 point. After that, scale values of instructional tecniques (the stimuli) was calculated using Excel programme. When the internal consistency coefficient calculated for condition D solution (note that K is number of stimulus and n is number of category), it was attained that there was a difference of 0.052 between the expected and observed values. In this way, it could be said that there was a small amount of error which point out the scale values are reliable. Also, it was investigated whether the scale values varied by gender. The relationship between scale values of males and females determined by using Spearman-rho rank order correlation coefficient.

Results: It was found that the students stated that experiment technique had the largest contribution to their science achievement, while large group discussion and educational play had the smallest. Experiment technique which was the students first preference was followed by question-answer and demonstration technique respectively. Five stimuli found with the lowest scale values (from bottom to top) as; educational play, large group discussion, group study, trip-observation and educational video techniques were not sufficiently distinguished from each other by the students. According to the correlation coefficient, which was 0.64, indicated that females and males had different preferences. Experiment technique was preferred as the first technique by both males and females. Female students preferred demonstration and question-answer techniques as second and third techniques. Male students preferred question-answer as second most preferred technique while trip-observation had the third place. Least preferred techniques were trip-observation for female students and large group discussion for male students.

***Conclusions and Suggestions*:** Teachers may have difficulties making decision about which instructional technique will be appropriate for the student. At this point, it is necessary for the teachers to communicate with the students and be aware of their interests, needs, learnings, likes and dislikes. In scientific development in teaching, it is important to receive feedback from the student regarding the teaching process. As investigated in this research, it is believed that knowing preferences of the students on instructional tool and techniques could be a guide for teachers. According to results; students mostly link success to hands-on educational tecniques like experiment. The results demonstrated that all students had a consensus over experiment, question-answer and demonstration techniques, which were seen as the most important techniques while educational play was seen as the least important. Those findings could be connected to frequent utilization of experimental activities in schools. The least preferred stimuli were (from bottom to top) group study, trip-observation and educational video. However, those stimuli could not be distinguished from each other. The value of instructional techniques depends on how they are implemented, which is often determined by the relationship between teacher and learners. It is expected that this research will lead to a more explanatory evaluation of technique preference of students, particularly given the likely emergence of research on topics like teacher competency, learning topic and the frequence of utilization of the techniques.

1. Introduction

Science education plays a key role in the growth and development of countries. There is a growing scientific knowledge, theories and technologies on science education as on every field. For many decades scientists has efficient and creative academic writings and researches on instrucitonal strategies, methods and tecniques. Linn & Eylon (2011) critisized that although award-winning and effective science teachers have always made every effort to succeed in the new assignment, it is disheartening to see them struggle to develop equally creative approaches for the new topic. Also, it takes years of listening to students and testing alternative responses to develop powerful approaches for teaching complex science topics. Teachers need time working with varied students to appreciate the many intuitive and culturally-relevant ideas that they bring to science lessons. For teachers developing strategies to respond to student ideas it generally requires some experimenting.

For effective science teaching, teachers need to choose instructional technique not only appropriate for the lesson and the subject but also appropriate for the student. In common practice we can evaluate students by an exam. We can decide how much they learned by assesing the scores. But beyond the scores it is also important what the students have been thinking about tool, technique or method in which they are involved in science classrooms so that teachers can respond to student ideas in an accurate technique. In a research Schmidt and et all (2017) investigated how variety of learning activities employed in science classrooms, including laboratory and other activities and may influence the engagement of high school students on multiple dimensions (behavioral, cognitive and affective engagement). In order to explore students' these three engagement patterns and the influence of learning activity on these patterns they gathered students' views. They believed that may support science teachers in making more informed decisions about instruction. They listed 10 learning activities which six of them were not examined because of the low level of usage that they have identified through videotapings. They worked with 12 classrooms 13 teachers and 244 students. In this study it was found that students experienced much more frequent pleasurable engagement in laboratory activities relative to other learning activities (lecture, individual work, test and quizes). But also, students exhibit both universally low engagement more frequently than expected when they are doing labs. Getting a correct feedback from students is closely related to the variety of techniques that were utilized. Glynn, Bryan, Brickman, Armstrong (2015) investigated that students wanted more hands-on activities, labs, field trips and collaborative projects in science lessons. In the research, it was indicated that students who were motivated to learn science pursue science learning goals, such as good science grades and science careers, by engaging in behaviors such as asking questions in class, seeking advice, studying, participating in study groups, and enrolling in advanced science courses. By implication, students could think that instructional technique and methods which they were motivated make contribution to their success in science lessons. In a research carried out by Corliss & Spitulnik (2008), preferences of instructional technique of science class students at secordary school were investigated. It was found that two-thirds of students at science lesson in a local middle school reported that they preferred learning by doing virtual experiments with dynamic, interactive visualizations of global climate change compared to learning from textbooks, teachers or peers. Only 5% selected learning by reading or studying and 3% selected learning from the teacher. Most of them report that doing projects (often with peers), testing ideas (often in science museum), and exploring conundrums (often with the encouragement from teachers) have been their most effective means of learning. Linn & Eylon (2011) stated that students tend to believe that activities with uncertain outcomes, involving collaboration, and personal initiative lead to more learning than do more tradational school activities. Students can learn better and be more successful when they do the work themselves. In many resarches students' achievement was being connected with the instructional techniques utilized in science lesson (Ganyaupfu, 2013; Ergul, N. R. and Kargin, E. K., 2014; Arslan and Zengin, 2015). In a research conducted by Daluba (2013), it was investigated the effect of demonstration tecnique of teaching on students' achievement in agricultural science in secondary school in Kogi State. Using purposive random sampling technique 480 students in the twelve intact classes constituted the sample for the study. The result of study revealed that demonstration method had significant effect on students' achievement. Chibabi, et all (2018) conducted a research to determine the effect of laboratory method of teaching on senior secondary school students' achievement and retention in Biology. The study concluded that laboratory method of teaching revealed significant difference of the achievement is an effective approach of teaching biology at the senior secondary school level. However, using mostly preferred tecniques by students can increase their achievement levels.

Science achievement has been subject to world wide investigations. In the PISA (Programme for International Student Assessment) survey which is conducted every three years by OECD (The Organization for Economic Co-operation and Development) focuses each year on one of the three subjects (reading skills, mathematics literacy and sciences literacy). The PISA test intends to evaluate the interests, attitudes and qualifications of the students in the age of 15, to determine the strong and improvable aspects of the education systems in different countries and to determine the policies to increase quality and achievement in education (OECD, 2017). As a result of scales applied to science teaching and learning within PISA, it has been revealed that some differences in the performance of students are due to different learning and teaching conditions in the schools (MEB, 2010). As it was indicated at the PISA reports that Turkey students performed relatively well in science high schools. However, by the technical high school their level of performance dropped considerably (MEB, 2016a). Most of the students in Turkey expressed that they had chance to make hands-on activities, experiments and observations. However, these results were not reflected in their performance of science tests. This may be due to the inadequate use of teaching methods and techniques or assessment approaches. In this case, it should be ensured that the teachers are more competent in teaching methods and techniques and in the areas of measurement and evaluation (MEB, 2010). When examined affective characteristics for scientific literacy level of student interest and motivation in Turkey seemed to be higher than the OECD average. However, the students in Turkey got more pleasure from science and science courses and saw themselves in science more sufficient according to the OECD average. Looking at the career plans of the students, the proportion of students who were waiting for a profession related to science was higher than the OECD average. However in PISA 2015, results performance of students in Turkey related to science literacy achievement tests were seen as lagging behind the OECD average. In other words, though students generally had a positive attitude towards the science, their achievements were low (MEB, 2016a). Another survey research TIMSS (the Trends in International Mathematics and Science Study) which is carried out by IEA (International Association for the Evaluation of Educational Achievement) to evaluate the 4th year and 8th year students in the participating countries. Differing from PISA, TIMSS is repeated every four years. TIMSS describes achievement at four international benchmarks along the science achievement scale: Advanced, High, Intermediate, and Low. There are clear difficulties on educating students to advanced level of science achievement world wide. In terms of percentage of students reaching benchmarks, on average, countries were able to educate 7% of their eighth-grade students to advanced level of science achievement and 29% of high level of science achievement (IEA, 2016). In Turkey, the science achievement of secondary school students has been increasing compared to the past years. The majority of Turkish students (59%) has been middle (31%) and upper level (28%) in international science proficiency levels. Almost half of sample has been still under the middle level and far behind the world average in science achievement. By the way teachers' participation in professional activities related to science (determining students' needs, using information technology, science teaching, skill development, etc.) has been far behind the world average (MEB, 2016b).

It was obvious that teachers were having difficulties determining students' preferences, needs and interests. At this point, it was necessary for the teachers to communicate with the students and be aware of the things they liked and disliked. First of all, Pugh, et all (2015) argue that teachers could and should communicate their love of science while being open and supportive of students. By doing this, it would be more easy to receive feedback from the student regarding the teaching process. When the literature was examined, it was found that the students' preference of instructional tecniques wasn't been studied for science lessons. As investigated in this research, it was believed that knowing students' rank of preferences of instructional techniques could be a guide for teachers.

Conceptual and Statistical Framework of the Law of Categorical Judgment

Scaling methods has been emerged in science field named psychophysics. Psychophysics reveals how physical magnitudes are perceived by human senses. Psychophysics science concerns with finding laws that determines the relationship (regression) between the physical values of stimuli and perceived psychological continuum (Turgut &Baykul,1992:9-10). The relationship between measured and perceived features of stimuli was shown at Figure 1.

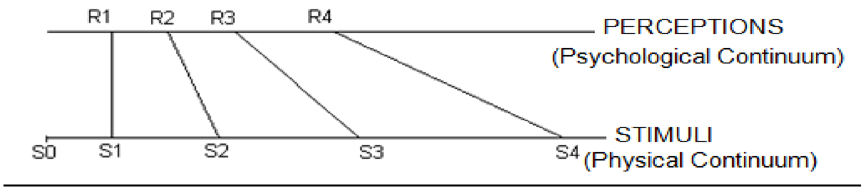

Figure 1. The relationship between measured and perceived features of stimuli

In the Figure 1, objects are present at physical (true) continuum as S1, S2, S3, S4... Sk and psychological continuum like R1, R2, R3… Rk. Sometimes objects have no counterpart on psychological continuum. Also, there can be many differences between values at psychological continuum. Scale development studies are being done using values of objects on psychological continuum. The difference between these values is investigated in such kind of scaling studies.

In scientific researches, measurement is necessary for determining the several features of entities and facts and making use of them efficiently (Ozcelik, 2010). It is difficult to measure human features directly with the social sciences like psychology, sociology and educational sciences. Thus, in the social sciences, indirect measurement is used. Measurement process is important for many aspects; first, it converts unobservable features to observable, judgments can be made about the features with the help of measurement. The accuracy of the judgments depends on the validity of measurements. However, scaling should be done to standardize or to enhance of any measurement result using simple instruments. Scaling methods basically based on two approaches: (1) approaches based on observer judgement (2) approaches based on subject responses. Approaches based on observer judgments are named shortly as judgement or stimulus-centered approach and approaches based on subject responses are named shortly as response approach. The purpose of scaling is to obtain qualified scale by applying statistical procedures to data obtained from observer judgments and subject responses. In scaling methods based on judicial approach, it is requested from observers to determine the relative status of a stimulus according to other ones, fairly. Scaling approach based on judge decisions comprises scaling stimuli in certain dimension based on observer or expert judgments. For example, if stimulus A is designated as greater than stimulus B it is concluded that stimulus A has grater effect than stimulus B with the respect to that particular attribute. The other approach based on subject responses purpose scaling not stimuli but responses. Developing attitude scale by Likert can be given an example of response approach (Torgerson, 1958; Turgut & Baykul, 1992; Tezbasaran, 2004).

Judgement approach includes evaluating the stimuli with the respect to some designated attribute. In this approach; specialists or observers define stimulative power of each stimuli with a method (paired comparison, categorical, absolute judgment, rank-order methods). Task of Observers during this process is comparing and denoting position of each stimuli in scaling with other stimuli as objective as possible. In conclusion; mean value of observer judgments for any stimulus is accepted as the scale of the stimulus (Torgerson, 1958; Turgut & Baykul, 1992). In this research, scaling method depends on categorical judgments law (based on Thurstone's general judgment model) was carried out. The law was developed for the case where the stimuli have been placed into categories which were ordered with respect to the attribute being investigated.

It is assumed that the proportion of times each stimulus is sorted to each category boundary is known. There are a number of procedures available for obtaining estimates of these proportions: sorting, rating and rank-order procedures (Torgerson, 1958). In this study the method of successive intervals, which is used as a sorting procedure, was carried out. This method was first applied by Saffir (1937) and was followed by Guilford (1938) and Attneave (1949). Saffir (1937) declared that this method was first mentioned by Thurstone (Turgut & Baykul, 1992). In the method of successive intervals numbers of K stimuli are supplied to number of N subjects. The subject's task is to sort the stimuli into m+1 pile so that the first pile contains those stimuli that are most positive with respect to the attribute; the second pile, the stimuli next most positive; etc. There is no requirement that the subject sort the stimuli so that the intervals between piles are equal. Often the piles may be identified with adjectives which progress from extremely positive to extremely negative. Also, this method is easy to utilize in the presence of large number of stimuli (Torgerson, 1958). The law of categorical judgement is based on certain assumptions. The assumptions are as follows; 1)Psychological continuum of the subject can be divided into a specified number of ordered categories or steps, 2)Owing to various factors, a given category boundary is not necessarily always located at a particular point on the continuum. Rather, it also projects a normal distribution of positions on the continuum. Again, different category boundaries may have different mean locations and different dispersions, 3)The subject judges a given stimulus to be below a given category boundary whenever the value of the stimulus on the continuum is less than that of the category boundary (Torgerson, 1954, Torgerson, 1958). For the categorical judgment situation, the following set of general equations was applied:

$$t_g - S_j = x_{jg} (\sigma_j^2 + \sigma_g^2 - 2 r_{jg} \sigma_j \sigma_g)^{1/2} \qquad (j= 1, 2, ..., n)\ (g= 1, 2, ..., m) \qquad (1)$$

where the new terms were defined as follows:

$m+1=$ number of categories

$t_g=$ mean location of the gth category

$S_j=$ scale value of stimulus j

$\sigma_g=$ dispersion of the gth category boundary

$\sigma_j=$ discriminal dispersion of stimulus j

$r_{jg}=$ correlation between momentary positions of stimulus j and category boundary g

$x_{jg}=$ unit normal deviate corresponding to the proportion of times stimulus j is sorted below boundary g

Equation 1 is the complete form of the law of categorical judgment; but it is not solvable in its complete form. In order to arrive at a workable and solvable version of the general equation, it is necessary to specify additional restrictions. For that purpose, there are conditions that were designated as A, B, C and D for scaling with categorical judgement law. B and D conditions are more utilizable due to their analytical solution (Torgerson, 1958). In this study algebraic solutions for condition D, applicable to the incomplete data case was carried out. These solutions are presented below.

When we assume that the variance of the discriminal differences is constant, the general equation of the law of categorical judgment reduces to equation 2 given below.

$$(j= 1, 2, ..., n)(g= 1, 2, ..., m) \qquad tg - Sj ==cxjg \qquad (2)$$

Since the scale is determined only to within a linear transformation, there is no loss in generality when we specify the unit of the scale so that c=1, we can write the two sets of equations involving categories g and g+1, respectively, as follows;

$$(j= 1, 2,...,n) \qquad tg - Sj = xjg \qquad (3)$$

$$tg+1 - Sj = xj,g+1 \qquad (4)$$

Subtracting equation 4 from equation 3, we have equation 5 given below;

$$(j= 1, 2,...,n) \qquad tg+1 - tg= xj,g+1- xjg \qquad (5)$$

If we specify the origin so that $t_1=0$, equation 5 enables us to solve for the t_g when given the theoretical values of x_{jg}. It is clear that there will be as many estimates of the difference ($t_{g+1} - t_g$) as there are pairs of filled cells in the g and (g+1) th columns of matrix X. The average is taken as the value wanted:

$$tg+1 - tg= \frac{1}{q} \sum_j^n (x_{j,g+1} - x_{jg}) \qquad (g=1, 2,....,m-1) \qquad (6)$$

where q is equal to the number of terms summed over. Given the differences between the boundaries, the values t'_g can be obtained by assigning an origin (say t_1=0) and adding the successive differences to obtain the remaining values. The scale values S_j can be obtained by translating the elements in each column to the common origin (t_1=0) numerically. Then a new matrix is constructed with estimate of S_j which is equal to ($t_g - x_{jg}$). The average of these estimates is taken as the value wanted:

$$(j= 1, 2,\dots,n) \qquad Sj= \frac{1}{q}\sum_{g}^{m}(t_g - x_{jg}) \qquad (7)$$

The scale values S_j can be obtained by assigning the origin (say S_1=0) and adding the successive differences to obtain the remaining values by linearly (Torgerson, 1958).

Purpose of the Study

In this study, it was aimed to scale 8 instructional techniques that students thought would be most beneficial in terms of achievement in science lessons. The scaling is an academic subject with the aim of putting basic principles and methods of "increasing from observations to measurements". In scaling methods it is aimed to convert qualitative data to quantative by identifying a zero point and unit (Gocer Sahin & Gelbal; 2016). In this research, our purpose was to scale the students' instructional techniques preferences as stimuli. Within this context, we pursued the following questions:

1) What are the scale values of instructional techniques calculated by successive intervals method?
2) Do these scale values vary by gender?

2. Method

Research Design

Observer judgements can be obtained from various disciplines, experimental procedures and guidelines. Within this research, judgements were obtained from students as observers. Students were asked to judge the preferences of instructional tecniques by ranking in terms of their contribution level to their science achievement. This research was a descriptive study and carried out in the form of survey design which aims to describe a past or present situation as it exists (Karasar, 1995; Frankell, Wallen ve Hyun, 2011). In the study generalization from sample to population was not used; current condition was put forth with real data.

Research Participants

The study was conducted in state schools located in the central district of a province in the Central Anatolia region of Turkey in the second semester of the 2010-2011 academic year. The research was carried out on the study group. A purposive random sampling method was used to recruit the research participants. In each of the school selected, classes in which the instructional tecniques being utilized at least once were included to the research. Because, it was not possible for students to had an idea about an unapplied technique. Data was collected from 232 sixth grade students. As a result of the examination of the data, some students' forms were not used in the study due to reasons such as including missing values or given the same technique two different values. When the individuals with these conditions were excluded, study group consisted of 221 students (113 females, 108 males).

Research Instrument and Procedure

During the process of preparing the data collection instrument, instructional tecniques for science lesson were designated by browsing relevant literature. Designated techniques coupled with "other" option and presented to four science instructors and they were asked to select the tecniques that were used at least one time by them. According to the expert views similar suggestions were combined. After that, experiment, large group discussion, educational play, question-answer, demonstration, trip-observation, group study and educational video techniques were selected. In this research 5-point scale was prepared. Students were asked to categorize their preferences of the instructional techniques in the light of contribution to their science achievement between 1 and 5 points (5= Strongly prefer, 4= Prefer, 3= Somewhat prefer 2=Unlikely prefer, 1= Never prefer). Students were asked to give 1 to 5 point to each technique in approximately 5-6 minutes.

Data Analysis

In this research scaling method depends on categorical judgements law was carried out. Algebraic solutions were conducted by using condition D, applicable to the incomplete data matrix. When observers may not put a stimuli to any class, in this case, scaling could be made with incomplete data matrix (Torgerson,1958; Turgut & Baykul, 1992). All the analysis were conducted using Excel programme. At the initial phase of the analysis frequency matrix F which has some incomplete data (0) was formed, showing stimuli and categories. Then cumulative frequency matrix Φ was constructed by addition of rows of categorical columns in matrix F. Division of cumulative frequency matrix by the column, which has number of observers gave the cumulative proportion matrix P. Matrix P is an (n x m) matrix whose elements give the proportion of times stimulus j was judged to be below the gth category boundary. Then matrix X which is an (n x m) matrix and its elements are the unit normal deviates corresponding to the elements of matrix P was prepared with the formula of normsters in Excel. Any cells of matrix P that contain proportions of zero or unity cannot be transformed into X values, and therefore the cells of matrix corresponding to such cells must be left vacant. Matrix F and Φ can be seen in Table 1, as well as matrix P and X can be seen in Table 2.

Table 1. Raw frequency (F) and cumulative frequency (Φ) matrix for for whole group

		Category Boundaries *g*				
	Stimuli *j*	1	2	3	4	5
The Raw Frequency Matrix F	1	0	4	19	77	121
	2	3	14	60	90	54
	3	0	14	43	69	95
	4	3	20	56	74	68
	5	2	13	43	72	91
	6	4	12	35	85	85
	7	10	10	39	61	101
	8	4	17	53	66	81
		Category Boundaries *g*				
	Stimuli *j*	1	2	3	4	5
Cumulative Frequency Matrix Φ	1	0	4	23	100	221
	2	3	17	77	167	221
	3	0	14	57	126	221
	4	3	23	79	153	221
	5	2	15	58	130	221
	6	4	16	51	136	221
	7	10	20	59	120	221
	8	4	21	74	140	221

Table 2. Cumulative proportion (p) and unit normal deviations (x) matrix for incomplete data

		Category Boundaries *g*			
	Stimuli *j*	1	2	3	4
Cumulative Proportion Matrix P	1	0.000	0.018	0.104	0.453
	2	0.014	0.077	0.348	0.756
	3	0.000	0.063	0.258	0.570
	4	0.014	0.104	0.358	0.692
	5	0.009	0.068	0.262	0.588
	6	0.018	0.072	0.231	0.615
	7	0.045	0.090	0.267	0.543
	8	0.018	0.095	0.335	0.633
		Category Boundaries *g*			
	Stimuli *j*	1	2	3	4
Unit Normal Deviations Matrix X for Incomplete Data	1	-	-2.095	-1.259	-0.119
	2	-2.209	-1.426	-0.390	0.692
	3	-	-1.527	-0.650	0.177
	4	-2.209	-1.259	-0.365	0.502
	5	-2.364	-1.492	-0.636	0.223
	6	-2.095	-1.458	-0.736	0.293
	7	-1.693	-1.338	-0.622	0.108
	8	-2.095	-1.310	-0.427	0.341

Then a matrix of differences between corresponding cells of adjacent columns was constructed. Then intervals between the columns of differences matrix X columns were estimated with $(t_{g+1})-t_g$ formula which is given in Equation 6. Calculated values of interval ranges can be seen in Table 3.

Tablo 3. Differences matrix X ($X_{j,g+1}-X_{jg}$) for whole group

Stimuli j	Xj2-Xj1	Xj3-Xj2	Xj4-Xj3
1	-2.095	0.836	1.139
2	0.783	1.036	1.082
3	-1.527	0.877	0.826
4	0.951	0.893	0.868
5	0.872	0.856	0.859
6	0.637	0.722	1.030
7	0.355	0.716	0.730
8	0.784	0.884	0.768
$\sum$	0.760	6.820	7.302
q	8	8	8
$\frac{1}{q}\sum_{j}^{n}$	0.095	0.853	0.913

After that t_g category boundary values were obtained from these interval values. It is assumed that upper limit of first interval is zero. So. the origin was set at t_1=0, then was cumulate the average differences as seen below in Table 4.

Table 4. Category boundary values (t_g) for whole group

Category Boundaries	Values(t_g)
t1= 0	0
t2=t1+(t2-t1)	0.095
t3=t2+(t3-t2)	0.948
t4=t3+(t4-t3)	1.860

In order to determine the scale values of the stimuli, a matrix representing the Sj=$t_g - X_{jg}$ difference was generated using equation 7. Sj scale values were found by calculating the line averages of the obtained matrix. In order to easily interpret Sj scale values, a relative initial (zero) point is determined. For this, the value which equals zero is added to all the scale values. In order to determine the scale values of the stimuli, a matrix showing Sj values was formed in Table 5.

Tablo 5. Differences matrix ($t_g - X_{jg}$) for whole group

Teaching Techniques	Stimuli j	t1 - Xj1	t2-Xj2	t3-Xj3	t4-Xj4	$\sum$	$\frac{1}{q}\sum_j^n$ =Sj	Scale Value	Stimulus Order
Experiment	1	-	2.19	2.207	1.979	6.376	2.125	0.566	1
L.Group Discussion	2	2.209	1.521	1.338	1.168	6.236	1.559	0	7
Educational video	3	-	1.622	1.598	1.683	4.903	1.634	0.075	4
Educational play	4	2.209	1.354	1.313	1.358	6.234	1.559	0	8
Question-Answer	5	2.364	1.587	1.584	1.637	7.172	1.793	0.235	2
Demonstration	6	2.095	1.553	1.684	1.567	6.899	1.725	0.166	3
Trip-Observation	7	1.693	1.433	1.57	1.752	6.448	1.612	0.053	5
Group Study	8	2.095	1.405	1.375	1.519	6.394	1.599	0.040	6

In Table 5, row means of this matrix were used to calculate Sj scale values. In order to interprit Sj values easily an origin was determined by adding the value (1.559) that nullifies the smallest value of Sj to all scale values. So, “scale value” column was obtained. Also, Spearman's rank order (rho) correlation coefficient was calculated in order to determine whether the scale values varied according to gender. In addition, the line graphs for each problem were drawn and variation in the scale values was shown.

The Internal Consistency Analysis

Reliability in terms of internal consistency must exist within scale values of the condition D solution of categorical judgment law (Turgut and Baykul, 1992). Reliability was checked in order to find out if the scaling built on the obtained data meets those assumptions and if the observers were careful enough in making judgments. According to Torgerson (1958) one considering the internal consistency of scaling values should be considered the harmony between empirical cumulative proportion matrix P and theoretical cumulative proportion matrix P'. In order to determine internal consistency coefficient (ICC), the absolute values of P-P' were found and matrix of IP-P'I was prepared as seen in Table 6. Addition of this matrix gave the ICC was obtained. The magnitude of the difference between the matrix of P' ratios and the matrices P obtained by the norm normal deviation matrix Normsdag formula indicated how closely the observed pjk ratios are similar to the (expected) p'jk ratios obtained from the scale values. Then, ICC was calculated by equation 8 given below.

Table 6. IP-P'I Differences matrix

IP- P’I	1	2	3	4
1	0.480	0.003	0.029	0.032
2	0.052	0.023	0.062	0.119
3	0.442	0.016	0.009	0.044
4	0.052	0.050	0.071	0.056
5	0.031	0.035	0.050	0.043
6	0.029	0.034	0.002	0.043
7	0.014	0.042	0.002	0.073
8	0.042	0.045	0.062	0.012
Sum of Matrix	2.096			

(8) $$ICC = \frac{1}{K.n}\sum_{j=1}^{K}\sum_{g=1}^{n}\left|P'_{jg} - P_{jg}\right|$$

When the internal consistency coefficient calculated for condition D solution (note that K is number of stimulus and n is number of category), it was attained that there was a difference of 0.052 between the expected and observed values. In this way, it could be said that there was a small amount of error which point out the scale values are reliable.

3. Results

In this section, the results obtained from the answers of students were presented. In the first intance, students' preferences of instructional tecniques were scaled by processing the data collected from 221 participants. Results gathered using algebraic-type solution of incomplete data matrix of the D condition of successive intervals depending on 221 participants' categorical judgments which were shown in Table 7:

Table 7. Scale values and stimulus order of instructional techniques preferences

Stimuli *j*	Teaching Tool & Techniques	Scale Value	Stimulus Order
1	Experiment	0.566	1
2	Large Group Discussion	0.000	7
3	Educational Video	0.075	4
4	Educational Play	0.000	8
5	Question-Answer	0.235	2
6	Demonstration	0.166	3
7	Trip-Observation	0.053	5
8	Group Study	0.040	6

Analysis of Table 8 shows that first stimuli experiment (S_1) had the highest scale value. Stimuli with smallest scale values were large group discussion (S_2) and educational play (S_4) equally. In other words, students stated that experiment (S_1) had the largest contribution to their science achievement, while large group discussion (S_2) and educational play (S_4) had the smallest. Calculated scale values were presented as a line in Figure 2.

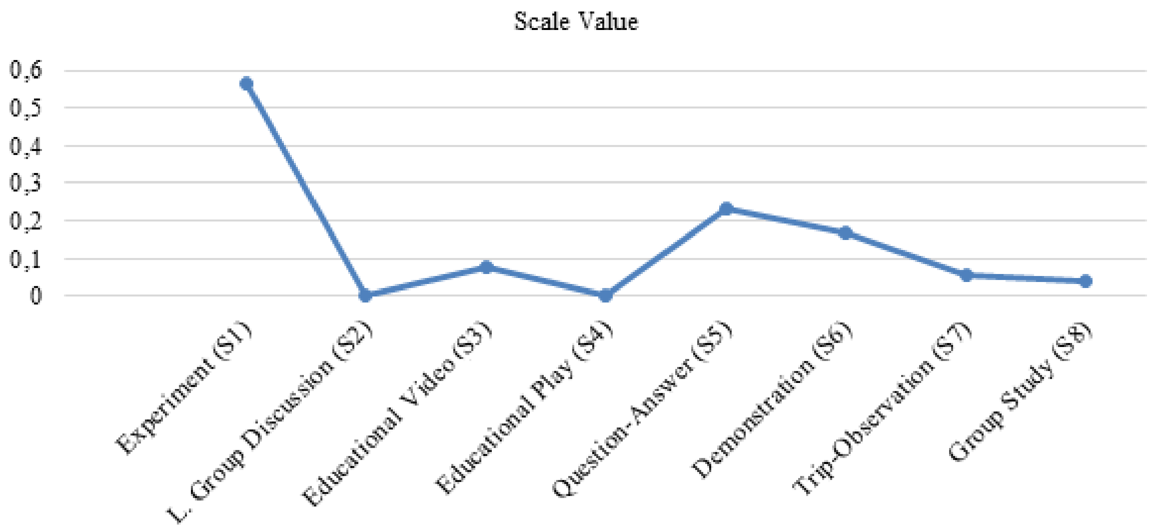

Figure 2: Displaying stimuli scale values on the line graph for whole group

According to Figure 2, experiment technique was followed by question-answer (S_5) and demonstration technique (S_6) respectively. Students taking science lesson gave these three techniques a fair distinction over remaining five techniques (large group discussion, educational video, educational play, group study and trip-observation) which have had smallest and closest scale values. Largest difference between scale values existed between experiment (0.551) and large group discussion (0.000) and educational play (0.000). Therefore, the experiment technique was distinguished from the large group discussion and educational play techniques. Five stimuli found with the lowest scale values (from bottom to top) as; educational play (S_4), large group discussion (S_2), group study (S_8), trip-observation (S_7) and educational video (S_3) techniques were not sufficiently distinguished from each other by the students.

The instructional technique which contributed to the achievement of the students in the second place was the question-answer technique. There was a difference of 0.317 between question-answer and experiment. The demonstration technique was preferred as the third technique. However, there was little difference between question-answer and demonstration techniques. So, those stimuli could not be distinguished from each other.

In the second problem of the study, it was examined whether the scale values vary according to gender. Relationship between scale values of males and females determined by using Spearman-rho rank order correlation coefficient. The correlation coefficient which was 0.64 indicated that females and males had different preferences. Calculated scale values were presented as a line graph in Figure 3.

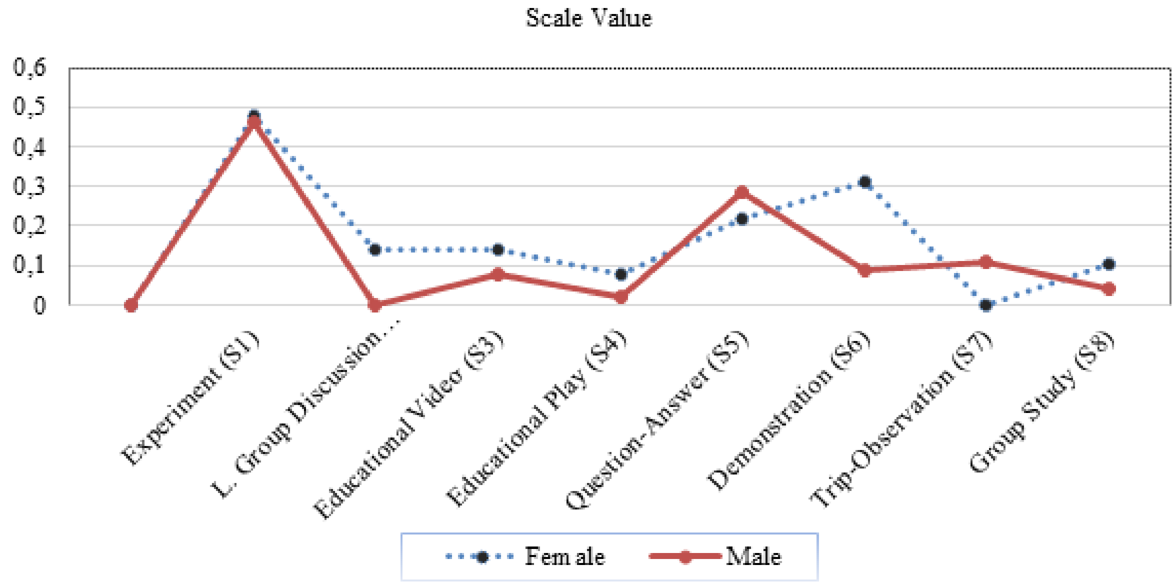

Figure 3: Displaying stimuli scale values on the line graph for gender

According to the Figure 3, experiment technique was preferred as the first technique by both males and females. Female students preferred demonstration and question-answer techniques as second and third techniques. In fact, this line-up was completely opposite of scaling done with respect to whole group. Male students preferred question-answer as second most preferred technique while trip-observation had the third place. Question-answer technique had a distinction of being in the first three preferred techniques for males and females. While trip-observation technique was the least preferred technique for the females, it ranked third for the males. Least preferred techniques were trip-observation for female students and large group discussion for male students.

4. Discussion, Conclusion and Suggestions

Within this study, 6th grade students teaching technique preferences in science lesson was obtained by scaling based on classification judgements. Calculations based on scaling of algebraic solutions of missing data matrix D with successive intervals showed that most contributive technique for students' achievement was experiment (S_1). Consistent with this finding; Gurdal & Yavru (1998), Bayram & Ersoy (2014) put forth that the experiment technique had positive effect on student views. Chibabi et all (2018) investigated that the laboratory method had significant effect on students' achievement in Biology. Studies of Can & Dikmentepe (2015), Boyuk, Erol & Koc Senol (2016) pointed out students had positive attitude towards experiments conducted within science lessons and they easily had a grasp on the topics. Those findings could be connected to frequent utilization of experimental activities in schools. In Turkey results for the PISA 2006 survey, students indicated that in the majority of science lessons had been applied practical activities and had the opportunity to experiment and observe. This ratio was higher for secondary school students than for high school students (MEB, 2010). Moreover, teachers are eager to use experiment technique in their lessons (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013; Boyuk, Demir and Erol, 2010; Roth & Garnier, 2006; Roth, Garnier, Chen, Lemmens, Schwille, & Wickler, 2011) and frequently utilize these experiential activities (Dindar & Yaman, 2002; Taskaya and Surmeli, 2014). By the way labs often provide some "entertainment value" to students, either by demonstrating a novel phenomenon or by providing the opportunity to socialize with peers; but in these situations, students do not see the activity as important or as requiring the investment of effort (Schmidt et all, 2018). Kang, Windschitl, Stroupe, & Thompson (2016) described most of the lab activity they observed as the low-demanding, disconnected variety, but when teachers planned tasks to be demanding, students were more engaged. All these findings explain why the experiment is most preferred.

Research results showed that experiment technique was followed by question-answer (S_5) and demonstration (S_6) techniques respectively. Consistent with that result in the studies conducted by Dindar & Yaman (2002) and Taskaya & Sürmeli (2014) science teachers utilized question-answer technique more common than demonstration technique. Similarly, in the PISA 2006 survey, students indicated that the majority of the science courses were interactive (MEB, 2010). In another study conducted by Kurtuluş & Çavdar (2011) it was found that students desired experiment and demonstration techniques in learning combined with teacher-centered question-and-answer techniques. Daluba (2013) investigated that the demonstration tecnique had significant effect on students' achievement in agricultural science in secondary school. So, the results of students' rank of preferences are consistent with the literature.

Educational play (S_4) and large group discussion (S_2) were the least preferred techniques with equal scales. Despite that result, when literature was studied, educational play and large group discussion techniques had positive effect on learning, academic success and attitude of the students (Bayat, Kilicaslan & Senturk, 2014; Sasmaz Oren & Erduran Avci, 2004; Saracaloglu & Aldan Karademir, 2009; Ulucınar Sagır & Kılıc, 2013). In this study, the smallest scale values observed in educational play and in large group discussion were thought to be caused by incorrect, ineffective and insufficient utilization (Dindar & Yaman, 2002; Tosun, 2011) of these techniques in the lesson. Also, it could be said that not all learning topics were compatible with educational play (Bayat, Kilicaslan & Senturk, 2014).

Findings of the study showed that rest of the least preferred stimuli were (from bottom to top) group study (S8), trip-observation (S7) and educational video (S3). However, those stimuli could not be distinguished from each other. Teachers' lack of information on these learning techniques was thought to cause difficulties on effective utilization during lessons. Aksu & Doğan (2015) studied a scaling research in mathematics lesson and found that (from bottom to top) role play, group study and discussion tecniques had the smallest scale values. Students stated that those tecniques were the least beneficial for themselves in mathematics lesson. It was also reported that students considered question-answer and demonstration tecniques which had the biggest scale values as the most important two methods to be successful in mathematic lessons.

Both female and male judgements similarly pointed that experiment was the most preferable technique. This finding of the study was similar to findings of Yesilyurt, Kurt & Temur (2005) and Can & Dikmentepe's (2015) findings, which pointed out that attitude towards science experiments, did not differ according to gender. Consistent with this result, in an experimental study conducted by Chibabi et all (2018) female and male students have been affected as the same way from experiment tecnique. It was found that the mean scores of achievement of both male and female students was increased in Biology lesson using Laboratory method of teaching. Experiment technique was well distanced from other techniques. So, it might be said that teacher's utilization of experiment technique, which provide learning through doing and experiencing must have been constant in the light of preferences of students.

Least preferred techniques were trip-observation for female students and large group discussion for male students. May be because these techniques are time consuming, teachers do not utilize them as frequent as the others. Despite statements of science teacher candidates said they would conduct trips when they became teachers (Balkan Kiyici & Atabek Yigit, 2010) study showed that in real life they didn't prefer trip and observation technique (Simsek, Hirca & Coskun 2012). It is recommended that at least occasional utilization of trip-observation and large group discussion techniques may had diminish this difference between males and females. Besides that, correct and frequent utilization of educational play technique which had the lowest scale value for both males and females on suitable topics is also recommended.

Teachers may have difficulties making decision about which instructional technique will be appropriate for the student. At this point, it is necessary for the teachers to communicate with the students and be aware of their interests, needs, learnings, likes and dislikes. In scientific development in teaching, it is important to receive feedback from the student regarding the teaching process.. As a result, utilization of techniques like experiment, question-answer and demonstration which address different senses of students is recommended to be kept utilized. This study was carried out in order to investigate the preferences of the students for instructional techniques in science lesson. Preferences of students for instructional techniques can be influenced by many factors. For instance, teacher competency, learning topic, utilization frequency of techniques, student interest, etc. These factors were not addressed in this study. For instance, learning topic affects the value of instructional techniques. So, in further researches, variables like teacher's ability and competency, instructional techniques based on learning topic can be taken in the account. Study can be repeated by adding new techniques such as lecturing, brainstorming, drama being utilized in science lessons. In addition, there are some limitations of the study. First due to incompatibility of a spesific learning topic with all the instructional techniques; further researches can be done. For instance, in the light of a future experimental design study to be carried out with the same learning topic, comparisions of different instructional techniques in science would likely contribute to the results.

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