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Research Article

Analyzing Process of Problem Solving with Group via Statistical Discourse Analysis*

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Abstract

The aim of this research is to examine the effects of various variables (cognitive flexibility, school achievement, physics course success, gender, popularity, family income level) and communication that occur between students in the problem solving process of the high school students. The research, which was designed according to the mixed research approach, was carried out with 80 tenth grade students determined by high school education and purposive sampling. It is given in research; the problem form was obtained by cognitive flexibility scale and observations, the discourses obtained from the observations were coded, and the data obtained from the other variables were categorized. Problem solving situation is coded with rubric in accordance with ordinal variable. Data is analyzed by modelling with multi-level sequential logistic regression and sequential logistic regression analysis. Findings showed that obtaining a creative solution to the problem is related to the success of the physics course related to solution of the problem rather than the general academic achievement, it is related to cognitive flexibility level, gender, family income level. The higher the level of cognitive flexibility and the level of family income, the higher likelihood of reaching creative solutions. The probability of women reaching creative solution is lower than men. The number of discourses and rudely disagreeing discourses in schools with low achievement levels are higher than those of successful schools. While presenting suggestions that are modelled as descriptive in reaching creative solutions, discourse of ignorance is meaningful variable; approval, politely disagreeing, rudely disagreeing are not meaningful variables.

Keywords

Dynamic multilevel analysis • Statistical discourse analysis • Problem solving

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To be knowledgeable today, to do a job in a fault-free manner in accordance with their stages are not enough. Information is changing rapidly, expertise is changing, and changes are taking place at a dizzying pace. In order for people to succeed, they are expected to be productive, be creative, critical thinking, collaborating effectively, problem solving, effective communication, knowing how to access the information they need, being flexible, being easy to adapt, taking responsibility, taking initiative, sustaining their inner motivations. Today, one of the outstanding skills is the ability to present problem-solving, creative solutions to problems.

Human is social. Nowadays, accumulation of knowledge has increased considerably. Coping as a group with a problem can be more effective than coping individually. Shaw (1981) defines the group as "two or more people affecting each other and interacting with each other" and the common point of groups according to the author is "the interaction of group members" (p. 9). Groups perceived "us" concept against "those" concept (Turner, 1987). Intimacy groups provide adaptation needs of the group members, task groups provide success needs of the group members, social groups provide the needs of identity needs of the group members (Johnson et al., 2006). Individual work in groups or working in groups can affect group members in different ways. In other words, group influence can create collective positive situations like unity of force or social facilitation; or negative situations as polarization, social withdrawal, self-esteem, etc. (Myers, 2017).

In order to understand the social effects of group processes, two models are suggested in the field writing: social communication approach and social integration approach (Baron & Kerr, 2003). In order to understand the social effect within the group according to the social communication approach, it is necessary to analyse the communication between the members of the group, in other words, "Who said to whom, what situation or effect? According to the social integration approach, the preferences of the group members are transformed into a single collective side belonging to the group, which is formulated in some processes belonging to the group." Different combinations of group processes can be mathematically modelled. The results obtained from the mathematical model can be tested by comparing the actual results with the group. Today, approaches to social integration are known as social integration models (Laughlin, 2011).

Data is analysed by Dynamic Multilevel Analysis-DMA. In many cases where consecutive discourse takes place, it can be analysed how pre-condition variables affect the final state of discourse. Chiu and Khoo (2005) used DMA when studying problem solving in small groups in mathematics, while studying the interaction of certain characteristics of students with discourse in the problem solving process. Chiu (2008) also used this method in mathematics lessons to influence small creativity in the

interaction of certain characteristics of students and discourses in the process and Chiu (2008) used this method in the lessons of mathematics in the effect of more correct contributions (through discourse) to problem solving in small groups, Gottman et al. (2003, as cited in Chiu & Khoo, 2005) have used this methodology in how discourses influence matrimonial conflicts, Farran and Son-Yarbrough (2001, as cited in Chiu & Khoo, 2005) used this method in the influence of discourses on preschool games.

DMA is based on regression analysis. The analysis is carried out in three steps. These include: a) determination of time intervals by means of breakpoints, b) obtaining multi-level logits, and c) testing. Differences between groups can be modelled over time intervals using DMA (also known as a hierarchical model). It is used in special cases in which the effect of variables on sample unit, session, and time intervals is examined. It is used in situations where the relationship between the DMA outcome variable and a group of explanatory variables identified at different stages of the analysis (Chiu & Khoo, 2005).

The statistical analysis of sequential group processes with sequential speech should come from three difficulties. The first, the effects of group members' behaviour on each other are nested data between groups and in terms of time, they are changing. Second, the affected variable (result variable) is categorical. The third, the events are similar to the previous event, they are the continuation of each other, sequential; so variables depend on the variables of the last order (serial correlation) (Chiu, 2008).

Ordinary Least Squares (OLS) based regression cannot overcome these difficulties. Standard error of regression coefficients cannot be estimated when ordered least squares based regression is applied in nested data sets. Sequential least squares based regression is not effective in discrete/categorical data and may produce biased results. Also, if the time-series correlations are not properly modelled, the remains calculated in the regression model can be related in a serially. This will lead to ineffective parameter predictions and uncertain standard error predictions. However, it can be used to identify DMA breakpoints, test group and time period differences, test serial correlations, and model direct or indirect effects (Chiu, 2008).

In this study, the demographic variables that students have and the effect of the discourse of problem solving task on problem solving are examined.

Method

Research Model

Explanatory sequential design was used in this research. Research in exploratory sequential design begins with the acquisition of qualitative data. Following this stage, the quantitative stage of research based on quantitative data is begins. (Cresswell & Plano Clark, 2014; Creswell, Plano Clark, Gutmann, & Hanson, 2003). As the first

step in the research, the discourse of the students who solve the problem is analyzed and coded. Following this stage, the discourses were modelled by quantitative method.

Working group

The study was carried out by eighty 10th grade students who were studying in high school (science high school, anatolian high school, vocational and technical anatolian high school and private anatolian high school) in different success levels within the borders of the municipality of Ankara. In the selection of the high school to be implemented, TEOG (transition from primary education to secondary education in Turkey) formed in 2015 (because are it is the exam year in which 10th grade students are placed) is considered to have minimum base scores, easy accessibility and allowing schools for video recording. With this aspect, sampling has become purposive sampling. The schools and some characteristics of the 10th grade students participating in the schools are shown in table 1.

Table 1
Demographic Characteristics of Research Participants

		Science High School	Anatolian High School	Vocational and Technical Anatolian High School	Private Anatolian High School	Total
Gender	Female	14	7	16	8	45
	Male	6	13	4	12	35
TEOG Percentiles and Base Points		%0.12 496.671	%7.08 420.695	%30.17 337.780	%17.25 395.181*	
Class size		35	36	33	26	
Income Rate	0-1000 TL	0	0	2	0	2
	1001-2000 TL	4	1	15	1	21
	2001-3000 TL	8	7	3	0	18
	3001 TL and high	8	12	0	19	39
Physics Achievement	50-59.99	0	1	5	2	8
	60-69.99	0	6	6	4	16
	70-84.99	4	9	8	6	27
	85-100	16	4	1	8	29
Cognitive Flexibility	High Level Cognitive Flexibility	1	6	7	9	23
	Medium Level Cognitive Flexibility	13	12	6	11	42
	Low Level Cognitive Flexibility	6	2	7	0	15

* The minimum scores of the students accepted by private schools are not announced. For this reason, it is written based on the information given by the school administration.

Data Collection Tools

The data of the study were obtained through “Information Form”, “Problem Form”, “Video Record” and “Cognitive Flexibility Scale”.

Information form: It is the form in which the family income level of the pupils, the names of the group colleagues with whom they would like to work together (to determine pupil popularity); school type (such as science, anatolian high school, etc.), level of achievement and classroom knowledge are recorded.

Problem form: It is the form in which the problem for the students to present a creative solution is written and it is given one for each group. The group has created a solution by debating and transferred the response to this form. The question on the form is:

> You will open an open-air restaurant in the penthouse of a shopping mall. You want to run the restaurant 365 days of the year. However, there is no roof of the restaurant area where you can use it. You are only allowed to use umbrellas. In terms of customer satisfaction, you decided to use an umbrella. However, the penthouse is very much exposed to strong winds. The umbrellas used are frequently reversed. How do you create a solution for preventing the umbrellas from reversing? How should the design of the umbrella that does not reverse be? You can draw your design. Describe what the information about "physics" you are using in your design.

While these problems are created, "Secondary Education Physics Curriculum" and "Physics course annual plan" are taken into consideration. Practices were made in November, 2016. Given that students cannot hypothetically think about a subject without knowledge and cannot offer a creative solution, the problem is addressed by taking into account the achievements of this unit. The basic information to be used in the problem that is asked to the students is the "Bernoulli Principle". The problem is broached to seven field experts. Five of the seven specialists are physics teachers who attend classes at the 10^{th} grade level and each has a postgraduate degree. The two experts are the faculty member of "Department of Physics Education". In view of the opinions received, the problem has taken its final form.

Video record: It is essential to record the discourses in quality in the research. In order to be able to conduct the research, both the permission of Ankara Provincial Directorate of National Education (dated 10/10/2016 and numbered 14588481-605.99-E.11025666) and the permission of parents of each student participating in the survey were received. The students solved the problem in groups of four people. Five groups were formed in each of the four schools. In total, discourses of 20 groups and 80 students were recorded.

Cognitive flexibility scale: Information on cognitive flexibility was obtained using the Cognitive Flexibility Scale, developed by Martin and Rubin, adapted to Turkish by Çelikkaleli (2014). The scale was developed for adolescents studying at high school level. The scale consists of 12 items. The items are structured in six categories and Likert type. 2, 3, 6 and 10 are scored reversely. As a result of the factor analyses made during the Turkish version of the scale, the scale showed a single factor structure. The reliability coefficient for internal consistency is .74. The test retest reliability is .98.

Resolution of Data

The problem solving process of the groups is coded in five categories according to the quality of the solution found. A creative solution is coded as "4". The expected solution is coded as "3". Understanding the problem but putting forward an inexact solution is coded as "2". Other answers, which means all answers irrelevant to the solution of the problem is coded as "1". Unanswered is coded as "0". This coding process for the solutions was made by three specialists who work as physics teachers in the field and have master's level education in physics education. Consistency between the coding of the experts was determined by the Krippendorff Alpha coefficient to be consistent at .78 (Krippendorff, 2004, pp. 222–223). Participants of the study were coded both scored and categorized according to their preference (popularity). Cluster analysis was performed on scores for constructing the coding and three categories were obtained. These three categories are; high, medium and low. The ANOVA test was conducted between the scores of the three categorized groups to determine the correctness of the categories. Families with an income rate of 3001 TL or more are coded as "4", students with an income rate of 2001-3000 are coded as "3", those with an income level of 1001-2000 TL are coded as "2" and those with an income level of 0-1000 TL are coded as "1". The cognitive flexibility scale scores were cluster analyzed. According to the results of cluster analysis three groups were formed. Students are coded as "3" with a high level of cognitive flexibility, "2" at a medium level and "1" at a low level. The ANOVA test was performed between the scores of the three groups to determine the correctness of the categories.

The quality of the communication in the problem solving process was made according to the categories that Chiu (2008) determined in his study. Discourses in group work; the student suggested a suggested an offer "1"; agree, "2" if the idea put forward in the discourse; "3" if it was politely disagree; "4" if it was rudely disagree; "5" if it was ignored, and "6" if it was except these codes. This coding has been done by three specialists. One of the specialists is an assistant professor who has received a bachelor's degree in physics teacher education, a master's degree and doctorate in the field of education management and many qualitative research experiences. Another expert is an associate professor who has completed his master's and doctoral studies in the field of educational sociology, which is a bachelor's degree guidance and psychological counselling. The third expert is a teacher in the Ministry of National Education who is in the field of teaching Turkish as a bachelor's degree, has a master's degree in Turkish teaching and continues to doctorate education in the same field. Experts coded 7652 lines of 80 students separately according to the above codes, in total 20 groups working in four members in four schools. Consistency between the coding of the experts was tested by the Krippendorff Alpha coefficient and consistency was determined at .82 (Krippendorff, 2004, pp. 222–223).

Below is an example of the communication that students make during the problem solving process.

Group X (an example from Science High School)

Student 1: Or we could make the umbrella a double storey. The pair, the top fabric, the top fabric will be flat; the bottom fabric will be wavy. (offering suggestions)

Student 2: Hıııı (outside of discourses)

Student 3: He will never see the top; in fact (politely disagree)

Student 2: We make it transparent. (offering suggestions)

Student 3: Customer (outside of discourses)

Student 1: It does not count. (politely disagree)

Student 3: But they do not allow you to build a roof. That way, you do it like this. From the top, the current is coming in one direction. From where? Let's say the wind, comes from here (shows with his pen on the notebook). (politely disagree)

Group Y (a sample from Private Anatolian High School)

Student 5: The umbrella is reversing because the pressure applies air pressure at the bottom. (outside of discourses)

Student 6: The umbrella is turning upside down because of high pressure to low pressure. To prevent this, we must use strong anchors against strong winds. (offering suggestions)

Student 7: But the anchors on the umbrella do not count. Again, we should have a nylon appendix on it. (After this saying student 6 started to laugh) (On the other hand, student 8 started to laugh.) (offering suggestions)

Student 5: Yes. Answer me. Okay, let's get the answer. (outside of discourses)

Student 7: Now umbrs and umbrellas (outside of discourses)

Student 8: Let's make holes in the umbrella to reduce the pressure. (offering suggestions)

Student 6: No. (rudely disagree)

Student 5: Logical. If we open the holes in the umbrella, the pressures on both sides will be equal. The umbrella does not reverse. I think it makes more sense. (agree)

Student 6: At the Umbrella ... (outside of discourses)

Student 5: But this time umbrellas can intake water. (politely disagree)

Student 7: When it rains. The umbrella is ... (Drawing shapes in the air with a pen) (outside of discourses)

Analysis of Data

Analysis of the data in the study was done by DMA. DMA is based on regression analysis. The analysis is carried out in three steps. These include: a) determination of time intervals via breakpoints, b) obtaining multi-level logits, c) testing serial correlation. Differences between groups using DMA can be modelled over time intervals (also known as a hierarchical linear model) (Chiu & Khoo, 2005). In addition, the data set was analyzed by ordinal logistic regression.

The Akaike Information Criteria (AIC) and the Schwarz Information Criteria (SC) are based on the DMA for determining the Lag Order Selection Criteria. The AIC statistic was first proposed by Akaiki (1973, as cited in Akdi, 2012, pp. 207–208). The most general state of the AIC statistics:

$$AIC(p, q) = -2\log(L(\hat{\theta}_n)) + 2k$$

When the number of variables affecting dependent (outcome / output) variables in regression or time series models is increased, the dependent variable is expected to be better explained. Adding new variables to the model is an effect to reduce the average of error squares. However, every variable that enters the model has a price. The formulation of AIC statistics shows this level. For a good model, this cost is expected to be small (Akdi, 2012).

Another criterion similar to the AIC criterion is the one proposed by Schwartz (1978, as cited in Akdi, 2012, p. 208). The SC statistic is shown as

$$SC(p, q)= n \ln(\hat{\sigma}_n^2) + k \ln(n)$$

It is suggested to take the SC statistic into account in modelling non-stationary series, although it generally has similar results with AIC statistic (Akdi, 2012).

Results

The analysis of the data showed that the exact solution was in two groups of high school graduates, one group of vocational and technical anatolian high school and two groups of private anatolian high school. The expected solution emerged from three groups of high schools, four groups of anatolian high schools, four groups of vocational and technical high schools, and three groups of private high schools. The only group that has come up with creative solutions is in anatolian high school. The creative solution has not been achieved in the most successful high school in the academic direction. From the academic point of view, in the second most successful high school creative solution emerged. The expected solution, which is the second best solution in private anatolian high school with vocational and technical anatolian high school which is less successful in academic direction, has been obtained as many

as the number in science education. When these results are obtained, it will be correct to think about the quality of exams made for high school students. To what extent do the questions asked during the exams take into account creative problem solving skills? Science high school students may be using classical problem solving styles that the current academic achievement scoring system rewards and may actually be considered more successful. If the existing academic achievement scoring system rewarded creative problem solving style, some of the students who were still studying in anatolian high school could go to the science high school.

It is observed discourses that in the science high school there are 1716 students in 5 groups 20 students, 1707 students in 5 groups 20 students in the anatolian high school, 2158 students in 5 groups 20 students in vocational and technical anatolian high school and 2071 students in 5 groups 20 students in the private anatolian high school. In science high schools, two groups had "inexact solutions" and three groups had "expected solutions". In these groups, the distribution of the discourses is realized as in figure 1.

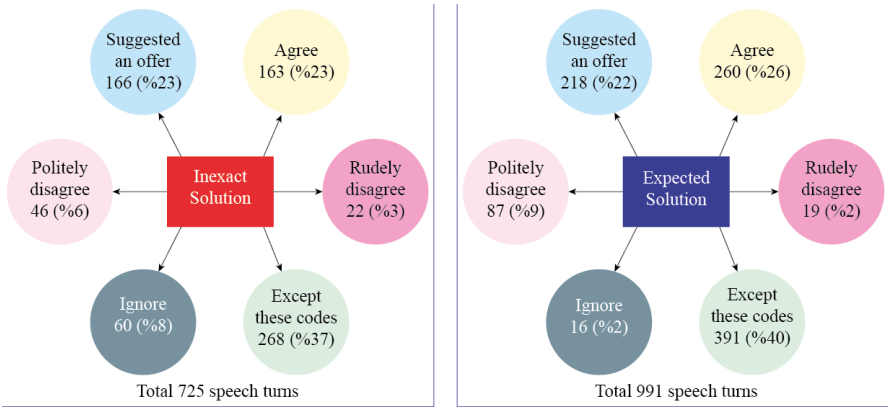

Figure 1. Distribution of discourses in science high schools.

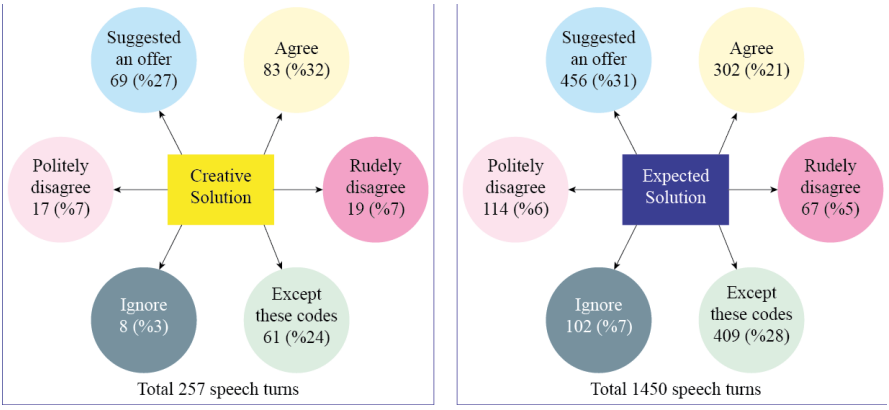

Figure 2. Distribution of discourses in anatolian high school.

According to Figure 1, it can be said that confirming as a percentage is a little too much in the expected response groups. In anatolian high school, the "expected solution" emerged in four groups and the "creative solution" emerged in a group. In these groups, the distribution of the discourses is realized as in Figure 2.

When Figure 1 and 2 are examined, it can be said that the suggestion rate in the anatolian high school is higher than those in the science high schools. In the vocational and technical anatolian high school, the "expected solution" in four groups and the "inexact solution" in a group emerged. In these groups, the distribution of the discourses was realized as in figure 3.

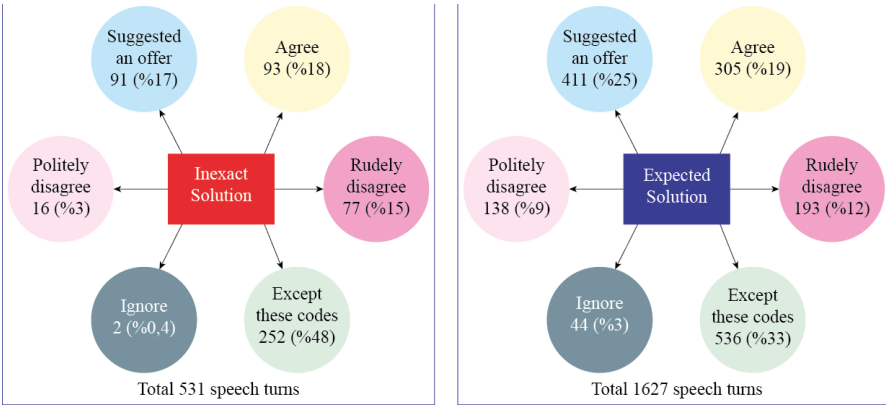

Figure 3. Distribution of discourses in vocational and technical anatolian high schools.

According to Figure 3, it can be said that the rate of rudely disagree in the group which gives a completely inexact solution is high and the rate of suggestion is low. When figures 1, 2 and 3 are evaluated together, it can be said that the rate of disagreement in vocational and technical anatolian high schools is higher than that of the anatolian high school and the agreement rate is lower. In the private anatolian high school, the "expected solution" emerged in the three groups and the "inexact solution" in the two groups emerged. In these groups, the distribution of the discourses is as shown in Figure 4.

According to Figure 4, it can be said that the rate of suggestion and approval in the group that gives the inexact solution in private anatolian high school is higher than the group that gives the expected solution. Despite the high rate of suggestion and approval, an exact inaccurate solution has emerged. Moreover, the suggestion rate of this group is higher than the suggestions of the other three groups. In this case, it can be interpreted that if less creative suggestions are approved, results with less creativity can be obtained. The rates of rudely disagreement in the private anatolian high school increased compared to the other two, which were more successful than

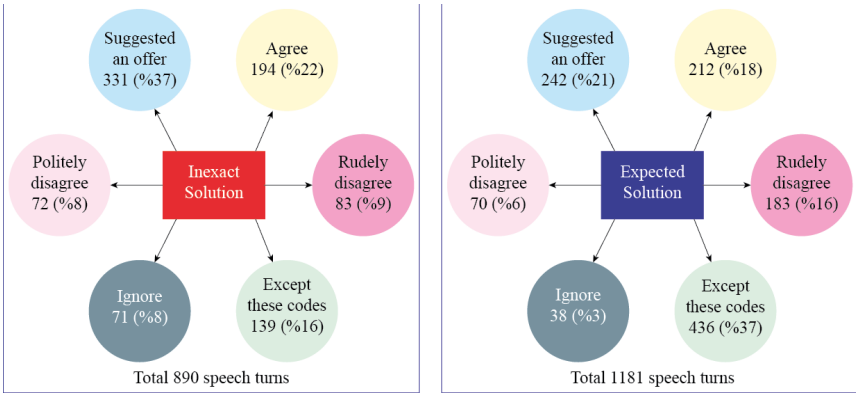

Figure 4. Distribution of discourses in private anatolian high schools.

the vocational and technical anatolian high school. In this case, it can be interpreted that the proportion of rudely disagreement in the groups with lower academic achievement increases.

According to the level of cognitive flexibility in the research, the number of discourses to obtain a creative solution has been investigated. Table 2 summarizes the distribution of discourse according to the level of cognitive flexibility.

Table 2
Cognitive Flexibility Level-Distribution of Discourse and Solution Types

Distribution of Discourses	High Level Cognitive Flexibility	Medium Level Cognitive Flexibility	Low Level Cognitive Flexibility
Suggestion	542 (%26)	1124 (%27)	318 (%24)
Agree	413 (%19)	876 (%21)	323 (%24)
Politely Disagree	148 (%7)	276 (%7)	136 (%10)
Rudely Disagree	265 (%12)	305 (%7)	93 (%7)
Ignorance	67 (%3)	241 (%6)	33 (%3)
Out of Discourses	694 (%33)	1355 (%32)	443 (%33)
Total	2129 (%100)	4177 (%100)	1346 (%100)
Solution Types	Creative Solution Inexact Solution	Expected Solution Inexact Solution	Expected Solution Inexact Solution

Suggestion rates are close to each other at almost every level of cognitive flexibility. It can be said that the rate of submitting suggestions is slightly lower for students with low level of cognitive flexibility. At the same time, the agreement rate of the students with low levels of cognitive flexibility is higher than those with high and medium cognitive flexibility. Students with low levels of cognitive flexibility have a high degree of politely disagreement, while those with high levels of cognitive flexibility have a high degree of agree disagreement. Medium level cognitively flexible students are more ignorant than others.

Dynamic Multilevel Analysis (DMA) Results

It is investigated in this research that to what extent the level of cognitive flexibility of students, the quality of the discourse in the problem-solving process (suggestion, agreement, politely disagreement, rudely disagreement, ignoring) and certain characteristics of the students in the groups (student success, gender, student

Table 3
Predictive Variables in Hierarchical Ordinal Logistic Regression

Fixed Effect Model	Coefficient	Standard Error	Odds Rate	*t*	*p*
Suggestion π_1	0.03	0.85	1.03	0.04	0.97
School Type γ101	1.59	1.75	4.93	0.91	0.36
Group γ102	-0.05	0.6	0.95	-0.07	0.94
Gender γ103	1.19	1.75	3.31	0.68	0.49
Family Income γ105	-0.40	1.38	0.67	-0.29	0.77
Physics Achievement γ106	0.32	1.11	1.37	0.29	0.77
Popularity γ107	1.37	2.08	3.95	0.66	0.58
Cognitive Flexibilityγ108	0.62	1.31	1.85	0.47	0.64
Agreement π2	-0.04	0.89	0.96	-0.05	0.96
School Type γ201	1.62	1.89	5.07	0.86	0.39
Group γ202	-0.12	0.73	0.89	-0.16	0.88
Gender γ203	1.46	2.05	4.31	0.71	0.48
Family Income γ205	-0.45	1.49	0.64	-0.30	0.76
Physics Achievement γ206	0.29	1.17	1.33	0.24	0.81
Popularity γ207	1.35	2.27	3.88	0.59	0.55
Cognitive Flexibility γ208	0.63	1.43	1.89	0.44	0.66
Politely Disagreement π3	-0.02	1.33	0.98	-0.02	0.99
School Type γ301	1.50	2.95	4.49	0.51	0.61
Group γ302	-0.08	1.22	0.91	-0.07	0.95
Gender γ303	1.22	3.23	3.39	0.38	0.71
Family Income γ305	-0.25	2.22	0.78	-0.11	0.91
Physics Achievementγ306	0.23	1.78	1.25	0.13	0.90
Popularity γ307	1.39	3.79	4.05	0.37	0.71
Cognitive Flexibility γ308	0.52	2.17	1.69	0.24	0.81
Rudely Disagreement π4	-0.01	1.27	0.99	-0.01	0.99
School Type γ401	1.17	2.61	3.21	0.45	0.65
Group γ402	0.08	1.03	1.08	0.08	0.94
Gender γ403	1.33	3.08	3.78	0.43	0.67
Family Income γ405	-0.41	2.28	0.67	-0.18	0.86
Physics Achievement γ406	0.15	1.63	1.16	0.09	0.93
Popularity γ407	1.63	3.92	5.09	0.42	0.68
Cognitive Flexibility γ408	0.71	2.00	2.03	0.35	0.72
Ignoring π5	0.28	1.64	1.32	0.17	0.87
School Type γ501	1.85	4.82	6.38	0.38	0.70
Group γ502	0.28	1.85	1.33	0.15	0.88
Gender γ503	1.03	4.08	2.81	0.25	0.80
Family Income γ505	-0.44	3.76	0.64	-0.12	0.91
Physics Achievement γ506	0.33	2.80	1.39	0.12	0.91
Popularity γ507	1.66	5.01	5.28	0.33	0.74
Cognitive Flexibility γ508	0.59	3.52	1.81	0.17	0.87

popularity, family income level etc.) affect the students who solve the given physics problem in groups in a creative way. In DMA, data is divided into three levels. The first level constitutes the order (speech sequence) of the discourse of the students in the groups when they are solving the problem. The second level consists of breakpoints in the flow of discourses. The file divided into time periods according to these break points prevents the autocorrelation of the variables in the data file showing the time series feature. The third level consists of the characteristics of the students in the groups (student success, gender, student popularity, family income level etc.). Lag Order Selection Criteria in data file have been reviewed. According to the Akaike Information Criteria (AIC) and Schwarz Information Criteria (SC), the fifth delay point is the most appropriate delay point. Based on this information it was decided that the data file should be divided into five breaks and a total of six time periods. The results of the analysis of the variables thought to be effective in achieving a creative solution in the DMA result are summarized in Table 3.

According to the results in Table 3, the first level; ($p > .05$) were not significantly explanatory variables in terms of suggestion, agreement, rudely disagreement, politely disagreement, ignoring. Third level; ($p > .05$), the type of school in which the student was educated, the group in which the learner participated in the problem solving, gender, family income level, the physics achievement, popularity and cognitive flexibility level were not significant. According to these results, none of the research hypotheses were accepted. The 7653 lines of data obtained from 80 students are becoming a huge data file. As Chiu and Khoo (2005) point out, it is difficult to model such huge data. Chiu and Khoo (2005) have stated that different statistical techniques can be used to statistically model such huge data consisting of discourses. The advantages and disadvantages of the different models made by different methods of analysis are presented in the study as a table. One of the techniques that can be used is modelling with logistic regression.

Ordinal Logistic Regression Analysis Results

Özdamar (2013) stated that logistic regression analysis is used to determine cause-effect relationships with explanatory variables (such as gender, school type, level of cognitive flexibility) when the outcome variable (obtaining a creative solution in this research) is categorical. Ordinal logistic regression analysis was used in the study. Because of the resulting variable (a creative solution) is scored with the rubric. The results are coded as a creative solution emerges (4), an expected solution is obtained (3), a problem understanding state is only an inexact solution (2), an answer other than these (1) and unanswered (0). This situation corresponds to the ordinal scale structure.

Whether gender, school type, family income level, physics achievement, level of popularity, and level of cognitive flexibility were the explanatory variables to obtain a creative solution were determined by ordinal logistic regression analysis.

It has been determined that a supplementary log-log linked ordinal logistic regression model is appropriate for the analysis fit values (p>.05). From the Cox and Snell R^2 and Nagelkerke R^2 values obtained, it is understood that there is a relationship between the outcome variable (obtaining a creative solution) and explanatory variables (communication quality, gender, school type, family income level, cognitive flexibility level etc.). Estimates of the ordinal logistic regression are summarized in Table 4.

Table 4
Relations in Ordinal Logistics Regression Model[3]

		Estimation	Standard Error	Wald	*p*
Threshold Values	Problem Solving (inexact answer)	-0.70**	0.14	25.49	0.00
	Problem Solving (expected answer)	27.98**	0.23	15444.98	0.00
Explanatory (Predictive) Variables	Suggestion	-0.34**	0.08	16.88	0.00
	Agreement	-0.03	0.09	0.13	0.72
	Politely Disagreement	0.19	0.13	2.34	0.13
	Rudely Disagreement	-0.01	0.12	0.01	0.93
	Ignoring	-1.19**	0.16	52.98	0.00
	School type (science high school)	0.75**	0.11	46.25	0.00
	School Type (anatolian high school)	24.61	0.00		
	School Type (voc and tech. anat. sc.)	3.55**	0.17	452.24	0.00
	Gender (female)	-0.66**	0.08	70.57	0.00
	Physics Achievement (50-59,99)	-2.92**	0.16	350.21	0.00
	Physics Achievement (60-69,99)	-1.55**	0.12	172.09	0.00
	Physics Achievement (70-84,99)	-0.06	0.09	0.43	0.51
	Family Income Level (0-1000 TL)	-5.73**	0.30	358.18	0.00
	Family Income Level (1001-2000 TL)	-1.07**	0.14	58.12	0.00
	Family Income Level (2001-3000 TL)	-1.14**	0.12	96.66	0.00
	Popularity (high level popularity)	25.39	5475.09	0.00	0.99
	Popularity (medium level popularity)	3.83**	0.15	633.28	0.00
	Cognitive Flexibility (high level cognitive flexibility)	0.69**	0.11	37.49	0.00
	Cognitive Flexibility (medium level cognitive flexibility)	-0.29**	0.09	8.63	0.00

[3] Ordinal Logistics Analysis, the "creative response" in the outcome variable (achieving a creative solution) in regression analysis is based on the explanatory variables; 85-100 "in the success of the physics course", 3001 TL and above "in the family income level", low popularity "in the level of popularity", the level of the cognitive flexibility "low level of cognitive flexibility" was taken as a reference group and comparisons were made accordingly.
**$p < .01$

When Table 4 is examined, it is understood that the quality of communication in the problem solving process is a significant explanatory variable. When the quality of communication in problem solving is examined, it has been determined that there is a negative explanatory variable in reaching a creative expression of suggestion and ignorance. School type variable is an explanatory variable at a meaningful level. Science and vocational and technical anatolian high school are explanatory variables in positive direction. The students who are enrolled in these schools are more likely to reach the

creative circle than the students who have studied at the private anatolian school. The gender variable is an explanatory variable at a meaningful level. It seems that a creative solution of being a woman is a negative explanatory variable in reaching. In this case it is more likely that the men in the reference group will reach a creative solution.

The success of the physics course is an explanatory variable at a meaningful level. The success of the physics lesson is 50-59.99 with 60-69.99, which is a negative directional explanatory variable in reaching a creative solution. The falling of the success of the physics lesson falls to the possibility of reaching creative solution. The level of family income is a meaningful explanatory variable. Having family income between 0-1000 TL, 1001-2000 TL and 2001-3000 TL is a negative change in reaching a creative solution. Since the reference group is 3001 TL and above, it can be said that "the increase in the level of family income increases the likelihood of reaching the creative solution". Popularity is an explanatory variable at a meaningful level. Being medium popular is a positive change in reaching a creative solution. Being medium popular increases the likelihood of reaching a creative solution, while being highly popular does not. The variables that students in the group have (physics course success, popularity, gender, school, etc.) are related to their creative solution.

Cognitive flexibility is an explanatory variable at a meaningful level. A high level of cognitive flexibility is a positive directional variant of a creative delivery; a medium level of cognitive flexibility is a negative directional variant. Having high cognitive flexibility increases the likelihood of getting a creative answer.

Discussion

The quality of the communication in the problem solving process in the research was used as one of the explanatory variables in order to obtain a creative solution. Discourse in the nature of communication are coded as presenting suggestions, agreeing suggestions, politely or rudely disagreement with the suggestions, suggesting ignorance, and finally out of the discourse. The explicability of the resulting codes on obtaining a creative solution is modelled. Suggesting and ignoring the suggestions in the ordinal logistic regression model is meaningful and variable; approval, politely disagreement, and rudely disagreement were not significant variables. The suggestion and approval at the beginning of the research will increase the likelihood of obtaining a creative solution; it is investigated that if they do not participate in the suggestion and ignore it they will reduce the possibility of obtaining a creative solution. But the results show that both presenting and ignoring the suggestion are a negative explanatory variable in reaching a creative expression. Offering suggestions and increasing the rate of ignoring reduce the probability of reaching a creative solution. Agreement and disagreement do not affect the likelihood of reaching a creative solution.

To be able to evaluate these results for the students who participate in the research and cooperate in a problem solving practice in groups they have formed with their chosen classmates, these results need to be evaluated separately in terms of both the effects on the group members of the group work and the contributions of the group members to the group creativity during the group interaction.

The social communication approach and the social integration models and the results obtained from the researches made up to now support some results of this research. For example, fewer discourse and less correct answers were expected from groups with lower academic achievement and cognitive flexibility, the results of this research show that the number of discourse, academic achievement and cognitive flexibility in groups formed from these students is higher than in groups with higher students; these groups also show that the expected solutions for probing can be reached in groups of students. Indeed, many researchers have pointed out that the average problem solving performance of an individual is both low in number and quality in problem solving performance with the group: There are numerous experimental research results that compare the performances of the participants measuring the individual performance with their performance measured in group work (Show, 1932, as cited in Laughlin, 2011); the results of research by Warnick and Senders (1980) show that witnesses' group-by-day event reports are more accurate than individual reports; Davis, Kameda, Parks, Stasson, and Zimmerman (1989) studied the social mechanisms that influence decision-making processes in the group; the research results of Laughlin and Adamopoulos (1980), Laughlin and Ellis (1986) show that groups are more effective than problem solving according to individual studies; so all these research results show that the groups perform much better in terms of both quantitative and qualitative individual performance. However, according to the group work done together, research findings show that the participants in the group session are more creative when they are working alone: For example, Paulus, Larey, and Ortega (1995) found that the ideas they produced while participating in the research alone were quantitatively more likely than the ideas they produced when trying to solve the group problem, in a probing-based brain storm laboratory study of participants alone and in groups of four; it also shows that it is more specific in quality. As a matter of fact, the results of this research show that students who have high academic achievement and cognitive flexibility and participate in the research in the science department perform poorly individually in performance of group problem solving.

The interaction of several minds can prevent the group avoiding cognitive prejudices, and more importantly, can lead to the generation of qualified ideas (McGlynn, Tubbs, & Holzhausen, 1995; Myers, 2017). However, the findings of Laughlin and Ellis (1986) show that there is an inverse correlation between the number of proposed solutions for probing group members and the number of collectively proposed

solutions in the group. More specifically, as the number of proposals increases in the group, the possibility of merging in a common solution decreases. As a matter of fact, the results of this research demonstrate that complete or creative solution cannot be achieved in groups with high number of discourses and high number of proposals (science, technical anatolian and private anatolian school).

When the descriptive statistics (frequencies and percentages) were examined, the group members with low level of cognitive flexibility had a high rate of not approving the proposal of the previous speaker and not attending politely; it is understood that the group members with high or medium cognitive flexibility have a high rate of disapproval of the previous one and a low rate of roughly not participating in this opinion. When it is thought that the creative solution is obtained from the group with high cognitive flexibility; the results of this research show that the path to creative solution occurs when group members have a higher rate of disapproval of each other's ideas. This result shows that the probability of reaching creative or correct solution in groups with many affirmative, graceful discourses is falling. Compared with the discussion in Chiu's (2008) study; he found that the non-consent of his friend in the group increased his creative solution reach by 11%. Just as in the results of this research, Chiu (2008) found that in groups with high mathematics achieved student, the chances of getting creative ideas and reaching the right result are high. Although Chiu (2008) found that the micro-creativity of students who behaved rudely during the group interaction (rudely disagreeing, submitting suggestions) was between 15% and 9% less than polite behaviours (politely disagreeing/asking/expressing) found that it increased the rate of producing ideas by 60%.

The results of this research show that suggestion and ignorance are negative explanatory variables in reaching a creative solution. Some field surveys show that individuals feel more productive when producing ideas within the group (McGlynn et al., 1995; Wright, Lüüs, & Christie, 1990). Myers (2017) explains this by the desire of individuals within the group to provide disproportionate self-esteem. However, those who position themselves in the group against others create a sense of authority, dissociate from the group, and disrupt group unity. Thus, as the share of ideas in the group decreases, micro-creativity also falls (Chiu & Pawlikowski, 2013). Chiu (2013) states that in class discussions, students are influenced by the current status of participating in the debate or speaking. The most important determinant of the current status of the student is his/her academic success. Students participating in class discussions disproportionately disadvantaged students with high academic success, giving them the right to speak their ideas and supporting their ideas. It has been understood that if the academic achievement of the students is low, the group has less attention to their ideas and the group is listening to them less. As a matter of fact, the results of this research show that students with low cognitive flexibility and

popularity offer less suggestions and approve more and more politely the views of others. Academic success indicates that those who attend research from low schools usually do not agree with each other's ideas.

The problem used in the research was chosen in the context of physics. For this reason, in addition to general academic achievement in the survey, achievements of physics students of the students have been included as a variable. Physics achievement has increased the chances of achieving a creative solution. In other words, the physics course did not show the same effect as the student's overall achievement status. In the study by Chiu (2008), groups of students with high mathematical grades showed higher micro-creativity. In this respect, the research is similar to the results of the research conducted by Chiu on the basis of the success of the course.

There are also significant changes in the results of the research that investigates the relationship between creativity and success. Research shows that low level relationship between achievement and creativity (Erdoğdu, 2006; Kara, 2011), positive and meaningful relationship (Anwar, Aness, Khizar, Naseer, & Muhammad, 2012; Ayverdi, Asker, Öz Aydın, & Sarıtaş, 2012; Florence, Mark, & Samuel, 2015; Gautam, 2017; Jenaabadi, Shahidi, Elhamifar, & Khademi, 2014; Naderi, Abdullah, Aizan, Sharir, & Kumar, 2010; Nami, Marsooli, & Ashouri, 2014; Niaz, Núñez, & Pineda, 2000), that there is a strong relation (Yeh, 2004), that there is no relation (Balgiu & Adîr, 2013; Olatoye, Akintunde, & Yakasai, 2010; Tatlah, Aslam, Ali, & Iqbal, 2012) and negative and meaningful relationship (Olatoye, Akintunde, & Ogunsanya, 2010). According to Gautam (2017), academic success is positively and significantly related to the different dimensions of creative thinking (flexibility, fluency, originality and total creativity). Chauhan and Sharma (2017) found that creativity is an important variable that determines the academic achievement of students. Gajda, Karwowski, and Beghetto (2017) conducted a meta-analysis of the relationship between creativity and academic achievement. The research results show that there is a positive and medium relationship between creativity and achievement.

According to the results of this research, the creative solution emerged in the group of students with a high level of cognitive flexibility. In the groups formed by the students with medium and low level cognitive flexibility, the expected solution resulted in an inexact solution. In this case, a high level of cognitive flexibility increases the likelihood of reaching a creative solution, while a decrease in the level of cognitive flexibility decreases the likelihood of reaching a creative solution. It is possible to find research supporting this result in the field. It is clear that the high level of creativity in the literature has a high level of cognitive flexibility (Chen et al., 2014); flexible thinking; (Barbey, Colom, & Grafman, 2013; De Dreu, Nijstad, & Baas, 2011; De Dreu, 2007), and the ability to create new ideas and use multiple

ideas to use an idea. Cognitive flexibility is also associated with creative performance (Guilford, 1967, as cited in Lim, 2013); Hill (2008) that individuals with a high level of cognitive flexibility are able to use their abilities more effectively and are aware of multiple ways of solving a problem.

As a result of the research, it was determined that the probability of women reaching a creative solution is lower than that of men. There are researches that reach a different result as well as researches that have compatible results with this situation in the field. Determining that boys' flexibility scores are higher than females (Öncü, 2003), which determines the level of creativity of females to be higher than that of males (Ayverdi et al., 2012; Gülel, 2006), determines that male students have higher creativity capacity in scientific creativity (Özdemir, 2013), found that there is no relationship between creativity and gender (Baer & Kaufman, 2008), determining whether creativity does not differ from being male or female (Temizkalp, 2010; Topoglu, 2015), and that creativity is a predictor of academic success of the variables of creativity and gender have found that there are associations (Naderi, Abdullah, Aizan, Sharir, & Kumar, 2009; Naderi et al., 2010). Ai (1999) found that the flexibility dimension of creativity for male students is related to 6 different subject areas; for the female students, the detail dimension of creativity was found to be related to 4 different academic subject areas and the fluency dimension was related to science and mathematics. Candrasekaran (2013), Olatoye et al. (2010) found that there was no significant relationship between creativity and academic achievement in their research by gender.

In this research, as the level of family income increases, the probability of reaching a creative solution is increased. The results of the literature show that the positive family conditions predict the creative problem solving activities directly in mathematics and science (Cho & Lin, 2011), the higher the income level and socioeconomic level of the families, the higher the creativity level of the children (Ayan, 2017; Can Yaşar & Aral, 2010; Mangır & Aral, 1991; Kiper, 2016) showed that there is no relationship between income level and creative behavior (Akıllı, 2012). When the results obtained from the literature and the results of this research are considered together, it can be said that the family conditions, the income level supports the creativity of the individual.

Significant results were obtained in the Ordinal Logistics Regression, when the results of the research were modelled with the MDA meaningful results could not be obtained. As pointed out by Chiu and Khoo (2005) in their studies of analysis method, discourse analysis can be modelled by different analysis techniques. In this analysis, very high level iterations have been made when modelling with the MDA It is often preferred in statistical science that the analysis results in as low a repetition as possible. In the ordinal logistic regression, the result is obtained with 100 iterations determined

by statistical software as the default option. The data file obtained in this study is a file containing a large amount of data. Increasing the number of variables has a cost as stated in the "analysis of data" of this work under "heading" in the AIC description. Numerous variables and a large number of data makes analysis difficult. In this study, it was understood that ordinal logistic regression technique was obtained for the data set. However, which technique will yield more functional and non-biased results can be determined by using more of the similar analyses to be used.

According to the results of the research;

- Teachers should encourage their students to engage in creativity-enhancing activities for teaching creativity in gender-free teaching activities, focus on communication among students, and especially improve the quality of interaction in group work, encourage students to make good suggestions in group work, and work on their ideas recommended.
- In the future research about the dialogues, the researchers should compare the different data sets with different methods in the modelling, the different types of communication (analysis of the discourse), the different codes (proposal, approval, politely disagree, rough participation, ignoring, asking, explanation, objection, direction, direction change etc.).

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