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COMPARISON OF INDUCTIVE AND DEDUCTIVE CONTENT SEQUENCE ON STUDENTS' CHEMISTRY ACHIEVEMENT, ATTITUDES AND ACADEMIC SELF CONCEPT*

ÖĞRENCİLERİN KİMYA BAŞARI, TUTUM VE AKADEMİK BENLİK KAVRAMLARI ÜZERİNDE TÜMEVARIM VE TÜMDENGELİM İÇERİK YAKLAŞIMLARININ KARŞILAŞTIRILMASI

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ABSTRACT: This study compared the effectiveness of inductive (part-to-whole) and deductive (whole-to-part) content sequences on students' chemistry achievement, attitude toward chemistry and academic self-concept. 62 freshman students from a general chemistry course participated in this study. The course units were structure of atom and periodic table, chemical bonding, intermolecular attractions and properties of liquids and solids, and matter (stoichiometry). Each group studied the same course content with reverse order. The data were analyzed with MANCOVA. As a result of the analyses, it was found that students exposed to inductive content sequence achieved better than students exposed to deductive content sequence on essay type test when their science process skills, attitudes toward chemistry and academic self-concepts before the treatment, and pre-achievement were statistically controlled. However, there was found no significant difference on their attitudes toward chemistry, academic self-concepts, short answer test achievement and multiple choice test achievement after the treatment when the above stated confounding variables are statistically controlled.

KEY WORDS: *Inductive and deductive content sequence, chemistry achievement, attitude, academic self-concept.*

ÖZET: Bu çalışmada, ders konularının tümevarımsal ve tümdengelimsel sıralanmasının öğrencilerin kimya başarıları, kimyaya karşı tutumları ve akademik benlik kavramları üzerindeki etkisini karşılaştırılmıştır. Çalışmaya 62 üniversite birinci sınıf genel kimya dersini alan öğrenci katılmıştır.Derste atomun yapısı ve periyodik tablo, kimyasal bağlar, moleküller arası çekim kuvvetleri ve sıvı ve katıların özellikleri ve madde konuları işlenmiştir. Veriler MANCOVA ile analiz edilmiştir. Yapılan analiz sonunda, öğrencilerin bilimsel işlem becerileri, ön bilgileri, ön tutum ve akademik benlik kavramları kontrol edildiğinde tümevarımsal sıraya göre konuların işlendiği grubun tümdengelimsel sıraya göre konuların işlendiği gruba göre klasik sınavda daha başarılı oldukları ortaya çıkarken, tutumlarında, akademik benlik kavramlarında, kısa cevaplı ve çoktan seçmeli test başarılarında ise anlamlı bir fark bulunamamıştır.

ANAHTAR SÖZCÜKLER: *Tümdengelimsel ve tümevarımsal konu sıralaması, kimya başarısı, tutum, akademik benlik kavramı.*

1.INTRODUCTION

Several models of meaningful learning have been proposed by both educators and psychologists for many years. Constructivist ideas have been favoured by most of the science educators to explain the process of meaningful learning. Constructivists [1,2,3] mainly underline the effect of prior knowledge on meaningful learning. According to Ausubel [4], meaningful learning occurs when a learning task is related to what learner already knows. Thus, the learner makes an intellectual link between the newly learned material and that previously stored in his or her cognitive structure. For a meaningful understanding of the science concepts the sequence of learning material should be organized in such a way that the learner could form internal associations of knowledge. In other words, the sequence of subject matter presentation should make learner

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to organize his/ her experiences in terms of preexisting mental structures or schemes. Therefore, the sequence of subject-matter presentation is one of the most important aspects affecting students' learning.

Inductive (part-to-whole) and deductive (whole -to-part) approaches are two of the varying methods of content organization [5]. According to inductive approach, the content of the subject- matter is sequenced from particular concepts to general concept. Specifically the chapters related to each other are organized in a way that the most prerequisite knowledge to the general concept is presented firstly. In contrast, according to deductive approach the content of the subject matter is organized from general concept to the particular concepts.

Studies comparing the effectiveness of inductive content sequence over deductive content sequence on students' achievement, attitude and academic self-concept are not common in science education literature. Sakmyser [6] compared the effect of two learning sequences on high school students' achievement to teach chemical equilibrium. Although neither deductive nor inductive program was significantly more successful other factors including ability in algebra and reading affected the success of the students. Students with high scores on reading test performed significantly better on the deductive program than those who had low scores. On the other hand, students with high scores on the algebra test were significantly more successful on the inductive program than the students with low scores [6].

Other studies related to inductive and deductive method are mostly concerned with instructional methods rather than content organization. Herman and Hincksman's study (1978) whose aim was to test the effectiveness of inductive method over the deductive method in the field of chemistry teaching programmed instruction materials with the same verbal content were used As a result of the analysis of the experimental data by analysis of variance, the deductive group did not perform significantly better on the delayed retention test[7]. Hall (1976) compared the effectiveness of inductive model and growth model in which the teacher select physical event and provide a suitable sequence of subsequent experience serving to lead to further development of the concept. The result of oral test and achievement test indicated that the teaching scheme based on the growth model better promoted acquisition of the subject matter of the course but doesn't lead to more effective generalization of the idea of chemical reaction[8].Yore (1984) explored the effect of age and cognitive development of learners on student's achievement using structured inductive and semi- deductive instructional strategies on two different science topics. The result of this study indicated that age made a significant difference on achievement for both strategies. The effect of cognitive development was more noticable in the semi-deductive strategy[9]. Tobias(1973), Lahnston(1973) and Trope (1974) studied instructional methods of inductive and deductive [10, 11, 12].

Content sequence organization is one of the important variables affecting students' meaningful understanding of the science concepts. The concepts of atoms, periodic table, chemical bonding, intermolecular attractions and properties of liquids and solids, and matter (quantitative chemical relationships) are the basic concepts of general chemistry. These concepts are heavily related to other concepts of general chemistry. Therefore, meaningful understanding of these concepts by the students will determine their achievement, attitudes and academic self- concept on other subjects of general chemistry. The main purpose of this study is to compare the effectiveness of inductive and deductive content sequences on students' achievement, attitudes toward chemistry and academic self- concepts.

2. METHOD

2.1 Subjects

This study was conducted with 62 freshman students of a general chemistry course. This course was a part of a four-year teacher education program for the preparation of elementary school teachers. The chemistry class was randomly divided in to two groups based on inductive and deductive sequence of concepts. One of the groups consisted of 30 students was instructed by deductive content sequence, while the other group consisted of 32 students was instructed by the inductive content sequence.

2.2 Design and Procedure

A pretest-posttest experiment-control group design was used in this study. The course was scheduled as 3 hours a week. The study was conducted in the first 6 weeks of 14 weeks instruction. The same instructor having more than 25 years of experience has taught both of the inductive and deductive groups. This study was confined to the general chemistry course consisting of four units. The contents of the units were as follows:

Unit I: Structure of atom and periodic table: Dalton' atomic theory, discovery of electrons and protons, X-ray and radioactivity, electromagnetic radiation, quantum theory, Bohr atom model, modern quantum mechanics, quantum numbers, and periodic table.

Unit II: Chemical bonding: Metallic bond, ionic bond, covalent bond, covalent bond theories, valence shell theory, and molecular orbital theory.

Unit III: Intermolecular attractions and properties of liquids and solids: Intermolecular attractions, types of intermolecular attractions, gases, liquids, changes of states, vapor pressure, critical point, phase diagrams, liquid crystals, glasses, solid crystals, and determination of crystal structure.

Unit IV : Matter: atomic weight, mole concept, empirical and molecular formula, chemical formula, naming compounds, balancing chemical equations, yield, and limiting reactant.

Although the content of the subjects studied in each group was the same, the content of the subjects was given in the reverse order to each group. The inductive group followed the order of unit I, unit II, unit III, and unit IV, while the deductive group studied from unit IV to unit I oppositely.

The same textbook [13] and teaching materials (eg. projector) were followed in both the classes. In addition, same examples were given to both groups. Students' participation was mainly in the form of listening, taking notes and sporadic questioning. The instructor solved both algorithmic and conceptual problems in both groups.

Throughout the treatments, three observers (a chemistry expert, a curriculum developer and a science educator) observed both groups in order to ensure that the instructor implemented the study as intended.

Before the treatment, a 40-item multiple-choice achievement test, attitude scale toward chemistry, science process skill test and academic self-concept scale were administrated to both groups as pre-test.

After the treatment, multiple choice achievement test, short- answer achievement test, essay type achievement test, attitude scale toward chemistry and academic self-concept scale were implemented as post-test to both groups.

2.3 Instruments

2.3.1 Multiple-Choice Achievement Test

In order to investigate students' achievement about the four units, a 40-item multiple choice achievement test was developed by the researchers. In developing this test, the instructional objectives for the four units in

different cognitive levels (knowledge, comprehension and application) were stated by the researchers. Each item of the test had one correct answer and four distracters. The items of the test were investigated by two experts in chemistry, a chemistry educator and a curriculum developer for face and content validity. The test was given to both groups as pre-test (MCPRAT) to examine students' prior knowledge before the treatment. Moreover, the same test was administrated to both groups as post-test (MCPOAT). The reliability of the test was found to be 0.84.

2.3.2 Short Answer Achievement Test

The test was developed according to the instructional objectives by two experts in chemistry. The test contained 41 short answered questions. The test validity was examined by five person, two experts in chemistry, a chemistry educator, a science educator and a curriculum developer. The test was scored by giving one point for each correct response to each item. The test reliability was found to be as 0.92. The test was given as a post-test to both groups in order to examine students' achievement about the concepts in five units.

2.3.3 Essay Type Achievement Test

10 essay type items covering the concepts of four units were constructed by an expert in chemistry according to the instructional objectives. The test included both questions investigating students' conceptual understandings and problem solving abilities. The test was controlled by a proffesor in chemistry and a curriculum developer for face and content validity. A detailed scoring key showing each step in solving questions and acceptible responses was prepared. The test was scored by the chemistry expert according to the scoring key.

2.3.4 Attitude Scale Toward Chemistry

The scale was developed by Geban and Ertepınar [14] to measure students' attitudes toward chemistry. This scale contains 15 likert type items (strongly agree, agree, undecided, disagree and strongly disagree). The reliability (Cronbach Alpha) was found to be 0.83. This scale was given to both groups as pre-test (ATCPR) and post-test (ATCPO).

2.3.5 Science Process Skill Test

In order to process students' science process skills including identifying variables, identifying and stating hypotheses, operationally defining, designing investigations and graphing and interpreting data, Science Process Skill Test (SPST) developed originally by Burns, Okey, and Wise [15] was used. The test was translated and adopted into Turkish by Geban, Aşkar and Özkan [16]. It contains 36 four-alternative multiple-choice questions. SPST was given to both groups before the treatment. The reliability of the test was found to be 0.85.

2.3.6 Academic Self-Concept Scale

In order to assess students' perceptions of their academic abilities, the academic self-concept scale developed by Brookover et al. [17] was used in this study. Senemoglu [18] adopted this test into Turkish and found the reliability coefficient as 0.80, 0.84. and 0.89 for three groups participated in her study. Şahin [19] used the scale in mathematics and social sciences and found the reliability as 0.79 for mathematics and 0.91 for social sciences. The scale consists of 8 items. This scale was administered as pre-test (ASCPR) and post-test (ASCPO) to both groups.

2.4 Analysis

The data was analyzed by multivariate analysis of Covariance (MANCOVA) which is a statistical technique for statistically equating groups on one or more independent variables. Moreover, means and standard deviations were given for all independent and dependent variables.

3. RESULTS

3.1 Descriptive Statistics

The means and standard deviations are presented in Table.1. for all dependent variables (multiple-choice post-test achievement (MCPOA), attitude toward chemistry after treatment (ATCPO), short-answer test achievement (SATA), essay type test achievement (ETTA), and academic self concept toward chemistry after treatment (ASCPO)) and independent variables (group, students' multiple-choice pre-test achievement (MCPRA), attitude toward chemistry before treatment (ATCPR), academic self-concept toward chemistry before treatment (ASCPR), science process skills (SPS)).

Table 1. Means and Standard Deviations for Variables across Groups

Variables	Group	Mean	Standard deviation
ASCPR	Inductive	23,767	4,68
	Deductive	24,875	4,911
ASCPO	Inductive	26,200	4,396
	Deductive	25,969	4,403
MCPRA	Inductive	1,933	2,716
	Deductive	1,937	2,047
MCPOA	Inductive	8,667	5,803
	Deductive	9,375	6,899
SATA	Inductive	10,633	6,871
	Deductive	13,188	9,451
ATCPR	Inductive	51,000	9,889
	Deductive	57,938	10,552
ATCPO	Inductive	51,000	12,937
	Deductive	54,312	13,410
SPS	Inductive	22,517	4,771
	Deductive	21,071	5,490
ETTA	Inductive	56,200	17,850
	Deductive	45,906	19,376

N=62

Table 2. Correlations between Dependent Variables and Covariates

	Correlation Coeffiecients				
Covariates/Dep.	V ASCPO	MCPOA	SATA	ATCPO	ETTA
ASCPR	0,596**	0,441**	0,405**	0,393**	0,049
MCPRA	0,211	0,424**	0,344**	0,315*	0,088
SPS	0,262*	0,284*	0,406**	0,289*	0,184*
ATCPR	0,592**	0,387**	0,429**	0,573**	0,139*
GENDER	-0,032	0,057	-0,088	0,102	-0,049

*p<0.05, **p<0.01

3.2 Multivariate Analysis of Covariance (MANCOVA)

Differences among groups caused by confounding variables should be statistically equalized in order to be able to say that the differences between groups in dependent variables are occurred only as a result of the treatment. Students' pre-achievement, attitudes toward chemistry and academic self-concepts before the treatment, science process skills and their gender may be covariates affecting the dependent variables. Because there should be a significant correlation between these covariates and dependent variables, a correlation analysis was performed. The results of the correlation analysis are presented in Table 2.

As shown in Table 2. the covariates rather than gender were significantly correlated to the dependent variables. Therefore, the covariates other gender were used in the MANCOVA model.

In order to test the assumption that the relationship between covariate and the dependent variables must be equal for all groups (homogeneity of regression), the significance of covariate group interaction was investigated by entering these variables after the covariates and group. The result of this significance test for covariate group interaction is presented in Table 3.

As seen from Table 3, covariate group interactions didn't result in significant multivariate F. Therefore, homogeneity of regression assumption is satisfied for the MANCOVA model. Hence, covariate group interactions were excluded from the MANCOVA model.

The MANCOVA model for the study consisted of 5 dependent variables which are students' multiple choice post-test achievement, short answer test achievement, essay type test achievement, students' attitudes towards chemistry and academic self concept after the treatment. The independent variable included in the model was group. The covariates were students' multiple choice pre-test achievement, students' science process skills, their attitudes toward chemistry and academic self concept before the treatment. Table 4 presents the multivariate test of this MANCOVA model. As seen in Table 4, group resulted in significant multivariate F. This means that there was a significant difference between students' exposed

Table 3. Significance Test for Covariate Group Interaction

Covariates*Group	Hypothesis df	Error df	Wilks' Lambda	F	p
Group*ASCPRT	5	43	0,896	0,994	0,433*
Group* SPST	5	43	0,913	0,822	0,541*
Group* MCPRAT	5	43	0,838	1,659	0,165*
Group* ATCPR	5	43	0,812	1,992	0,099*

N= 62, *p> 0,05(not significant)

Table 4. Multivariate Tests of MANCOVA

Source of Variance	Wilks' Lambda	Hypothesis df	Error df	Multivarite F	p
MCPRA	0,833	5	52	2,083	0,082
ATCPR	0,733	5	52	3,781	0,005*
SPS	0,807	5	52	2,486	0,043*
ASCPR	0,793	5	52	2,710	0,030*
Group	0,738	5	52	3,685	0,006*

N= 62, $p < 0,05$

to deductive content sequence and students' exposed to inductive content sequence on the collective dependent variables of their multiple choice post-test achievement, short answer test achievement, essay type test achievement and their attitudes towards chemistry and academic self concepts after the treatment.

The part of interpreting a MANCOVA is determining what to do if a significant effect has been obtained. By far the most popular way of proceeding from a significant effect in MANCOVA is to perform univariate ANCOVAs for each of the dependent variables [20]. In order to decide which dependent variables were responsible for this significance the follow up ANCOVAs should be investigated. Table 5 presents the results of the follow up univariate ANCOVAs for each dependent variable.

4. DISCUSSION, CONCLUSION AND SUGGESTIONS

The main purpose of the study was to compare the effectiveness of inductive and deductive content sequences on students' chemistry achievement, attitude toward chemistry and academic self-concept. The results of the study indicated although students exposed to inductive content sequence achieved higher than the students exposed to deductive content sequence, there is no significant difference between their short answer test achievement and multiple-choice test achievements. This result may be caused by that students took partial scores from the essay type questions. It was possible to observe the steps of student problem-solving processes and their explanations to question while scoring essay type test items. In inductive content sequence student might have been able to recognize the relationships between the subject of the units while constructing general objects on the specific subjects. Hence, students could easily

Table 5. Results of Univariate ANCOVAs

Source	Dependent Variable	df	MS	F	p	Etta square (Effect size)	Power
MCPRA	MCPOA	1	120.417	3,959	0,052	0,07	0,50
	SATA	1	67,933	1,385	0,244	0,02	0,21
	ATCPO	1	55,526	0,472	0,493	0,008	0,10
	ETTA	1	2,60.10-2	0,000	0,993	0,000	0,05
	ASCPO	1	16,872	1,606	0,210	0,03	0,24
ATCPR	MCPOA	1	20,004	0,658	0,421	0,01	0,13
	SATA	1	110,467	2,253	0,139	0,04	0,31
	ATCPO	1	1630,113	14,000	0,000	0,20	0,96
	ETTA	1	1328,958	3,925	0,052	0,07	0,50
	ASCPO	1	127,089	12,097	0,001	0,18	0,93
SPS	MCPO	1	86,076	2,830	0,098	0,05	0,38
	ASATA	1	474,758	9,681	0,003	0,15	0,86
	ATCPO	1	451,121	3,874	0,054	0,07	0,49
	ETTA	1	381,047	1,125	0,293	0,02	0,18
	ASCPO	1	21,831	2,078	0,155	0,04	0,29
ASCPR	MCPO	1	61,745	2,030	0,160	0,04	0,29
	ASATA	1	34,369	0,701	0,406	0,01	0,13
	ATCPO	1	9,923	0,085	0,771	0,002	0,06
	ETTA	1	303,414	0,896	0,348	0,02	0,15
	ASCPO	1	71,033	6,761	0,012	0,11	0,72
Group	MCPO	1	0,604	0,020	0,888	0,000	0,05
	ASATA	1	48,022	0,979	0,327	0,02	0,16
	ATCPO	1	3,525	0,030	0,863	0,001	0,05
	ETTA	1	2264,179	6,688	0,012	0,11	0,72
	ASCPO	1	39,203	3,732	0,058	0,06	0,48

show the relationships between concepts in essay type questions. On the other hand, in deductive content sequence students might have had difficulties in establishing relationships between subjects in their cognitive structures.

The analysis of the data showed that there was no significant difference between students exposed to inductive content sequence and the students exposed to deductive content sequence on their attitudes toward chemistry. and academic self-concepts that are in affective domain Most of the students participating in this study didn't take any chemistry course or only took one or two chemistry courses until the treatment began. Since attitude and academic self-concept are variables formed as a result of experiences taking place for a long period of time, the six weeks of treatment might not be enough to change students attitudes and academic self concepts.

Table 6. Adjusted Means of Dependent Variable Among Groups

Dependent Variable	Group	Adjusted Mean
MCPOA	Inductive	8,990
	Deductive	9,332
SATA	Inductive	11,075
	Deductive	13,137
ATCPO	Inductive	52,452
	Deductive	51,996
ETTA	Inductive	58,629
	Deductive	45,563
ASCPO	Inductive	27,014
	Deductive	25,1999

According to the results of this study while instructing the subjects related to each other the sequence of content presentation is an important variable affecting students meaningful understanding. In this study, in inductive content sequence subjects were presented from the concept of atom to matter, while in deductive content sequence a reverse order of subject were presented. In this study, inductive content sequence was effective in establishing relationships between concepts in students cognitive structures. However, other studies in different content areas should be conducted to compare the effectiveness of these two content sequences. It can be suggested that in order to investigate the effectiveness of these two content sequences of students' attitudes toward chemistry and academic self concepts, further studies taking longer time periods by using different samples having chemistry background could be replicated

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