ORIGINAL ARTICLE

Analyzing the Effect of Concept Cartoon Usage on Students' Cognitive Structures Developments and Science Achievements through Flow Maps

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ABSTRACT

In this study, the use of concept cartoons in a particle structure of matter unit was investigated using the flow map of 7th-grade students' academic achievement. The development of their cognitive structures and thoughts about concept cartoons was analyzed. 27 experimental and 27 control group students who were studying in the 7th grade participated in this research. The model of the study was "pre-test post-test control group model" from the experimental research models. Achievement test and concept cartoons developed by the researcher were used as data collection tools. As a result of this research, it was found that there was a difference between the post-test average scores in favor of the experiment group. The cognitive structures of the students were analyzed by the flow map technique, and there was a significant difference between the pre-test and post-test mean scores of the control group in the obtained data, but there was no significant difference in the correctness parameter. In the experimental group, there was a significant difference in the mean scores of size, integratedness, correctness, and richness parameters. When the opinions of the students on the use of concept cartoon were examined, it was revealed that the cartoons were thoughtful, funny, deficient in information, and different from each other. When the literature was examined, no research investigated the effect of concept cartoons on the academic achievement and cognitive structures of students and tried to reveal the cognitive structures of learners in a concrete way using flow map, which makes this study important.

KEY WORDS: science teaching; flow map; cognitive structure; concept cartoons; misconceptions

INTRODUCTION

Science and technology, which could be argued to be one of the essential requirements of the age in which we live, have been developed by individuals who have access to information and those who can use and produce information correctly. The most important feature of these individuals is that they have gained scientific attitudes and behaviors. For pupils to have more lasting attitudes and behaviors, knowledge must first be actively structured in their minds. To achieve these goals, pupils encounter many science-related concepts both in school and out-of-school settings, and sometimes they connect misconceptions in their minds to the learning process. When the cause of this situation is investigated, misconceptions are a primary cause. Concept cartoon is one of the techniques that help students to address wrong concepts. Concept cartoons can be described as a poster drawn in cartoon style containing different ideas about a scientific subject. Ideas are expressed in the form of arguments by cartoon characters, and then students in the class are expected to participate in discussions (Kabapınar, 2005).

Before entering any learning environment, students bring their own prior knowledge that they use to interpret and understand the new learning (Köse et al., 2003). Hierarchy in the cognitive structure is an important concept, and the hierarchy of building newly acquired knowledge, organizing, understanding, communicating, learning, and building more sophisticated information systems is a significant influence (Van Gigch, 1991). The cognitive structure is also defined as the linkage between concepts and the association of previous experiences. The individual achieves a solution using the information that exists concerning a different and new situation (Uçak and Güzeldere, 2006). For this reason, the higher the level of prior knowledge that an individual has, the quicker and easier it is to make a connection between concepts.

The student acquires knowledge when they incorporate the knowledge they receive from external sources through observation or experience. The theories of cognitive learning aim to reveal how information is processed in mind (Canpolat et al., 2004). The cognitive structures of the students can be investigated through methods and techniques such as word association tests, concept maps, structured grids, and V-diagrams. Flow maps are another technique that can reveal the cognitive structures of students. With the flow map, students' thought patterns are revealed in succession and correlated with each other by cross-links (Tsai, 2001). Flow maps reveal that cognitive structures of students as students are asked simple questions, and their answers are recorded sequentially (Tsai and Huang, 2001). The identification of cognitive structures that students have on concepts, the identification, and elimination of learning deficiencies and conceptual errors related to concepts has become an essential point for educators. As such, flow maps can be used as one of the techniques that serve to elicit cognitive structures of learners, to examine their development, and to detect misconceptions and conceptual relationships (Yiğit and Ceylan, 2015).

In this research, it was decided to use the concept cartoons in the teaching of 7th-grade students a particle structure of matter unit. Concept cartoons were created by the researcher. Cartoons were shown to the students in slides, and their thoughts were recorded. An achievement test was administered to measure the academic achievement of the students and was evaluated by the flow map technique. When the literature was examined, no research study was found that investigated the effect of concept cartoons on the academic achievement and cognitive structures of students or tried to reveal the cognitive structures of learners in a concrete way using flow maps, which makes this study significant.

Notably, the following five research questions guided this study:

1. Is there a statistically significant difference between the achievement pre-test scores of the students in the experiment and control group in the "particulate nature of the matter" unit?
2. Is there a statistically significant difference between the academic achievement post-test scores of the experimental and control group in the "particulate nature of the matter" unit?
3. Is there a statistically significant difference between the size parameter, correctness parameter, richness parameter, and integratedness parameter pre-test (IPRE) - post-test scores obtained from the flow maps that reveal the cognitive structures of the control group students?
4. Is there a statistically significant difference between the size parameter, the correctness parameter, the richness parameter, and the IPRE post-test scores obtained from the flow maps that reveal the cognitive structures of the students in the experimental group?
5. What is the opinion of the experiment group students about using concept cartoons in teaching?

METHODS

In this study, which used a semi-experimental design, the pre-test/post-test control/experimental group models were used as quantitative research designs to investigate the effect of concept cartoons usage on the academic success of 7th-grade students in a particle structure of matter science unit science (Karasar, 1999). The opinions about the concept cartoons of the experiment group students were analyzed by content analysis from the qualitative analysis methods. Content analysis is a systematic and repeatable technique in which individual words of a text are summarized by smaller content categories with secure rules-based coding (Büyüköztürk et al., 2011).

Participants

The population for this research was 7th-grade middle school students who were 12–13 years old and lived in the Mamak Province, Ankara. One of the classes was assigned randomly as an experimental group and the other as a control group, with simple unselected assignments. Of these students, 27 students constituted the control group and 27 of the experimental group.

Data Sources

An achievement test was used as one of the data collection tools. To build on the results of this achievement test, semi-structured interviews were used to identify the opinions of the experimental group students about the use of concept cartoons.

Before beginning the development of the achievement test to be used in the research, the annual plan and learning outcomes of the particulate nature of the matter unit of the 7th-grade science course were examined. A questionnaire was prepared by the researcher based on the stated learning outcomes with 35 items consisting of four multiple choice answers. The test was administered to 166 8th grade students as a pilot study. The pilot study's test was analyzed for reliability, and 10 questions were removed from the test. The KR-20 reliability coefficient was calculated as 0.85, and this value indicated that the final version of the achievement test had a high degree of reliability.

As stated, a semi-structured interview technique was used in this study. This methodology involves prepared questions but allows for the flexibility to rearrange and discuss questions during the interview (Ekiz, 2009). For example, "Do you think the concept cartoons have a teaching feature?" "Should the concept cartoons be used in other lessons and if yes, which lessons?" "What contribution did concept cartoons make to you during the process?" "What is the difference between concept cartoons and other techniques?" During the interview, the interviewer was able to add or build on some questions according to the progress of the interview.

Process

The academic achievement test was administered to the control and experimental group students as a pre- and post-test. The pre-tests for both the experimental and control groups were offered at the beginning of the unit, and then both groups were taught the particle structure of matter science unit by the same teacher.

Academic achievement test

The 25-item, multiple-choice test prepared by the researcher was administered using a voice recorder for each student. The voice recordings of each student facilitated the examination of each student's test using the flow map technique. Through this examination, the researcher was able to determine misconceptions. After all the students in both the experiment and control groups completed their pre-test, the content teaching phase of the study began. For both groups, content was prepared according to ordinary daily plans prepared according to the 5E model. The 5E Learning Model, for constructivism, was developed by Roger Bybee in the 1970s. It is made up of five dimensions; these are: Engage, explore, explain, elaborate, and evaluate (Bıyıklı and Yağcı, 2014). In the experimental group, concept cartoons were included as an addition to this content.

Concept cartoons

The concept cartoons that constituted the basis of the work were developed by the researcher. A total of 20 concept cartoons were prepared to cover the course content. A professor who is a specialist in the subject area was asked about the validity of the cartoons according to their achievements and their suitability with the students' level. Figure 1 shows an example concept cartoon.

In these cartoons, up to four different characters were used: Oktay, Ata, Asya, and Öykü. The researcher created the stories and speech bubbles, and then the cartoons were drawn on a computer by a graphic artist. The concept cartoons were presented in a slide presentation to the experimental group of students in different sections of the 8-week course. Since the 5E method was chosen as a model for the coursework, the presentation of the cartoons was usually carried out in the elaboration section. At the end of the unit, a semi-structured interview was conducted to determine students' thoughts on these concept cartoons. The control group was not shown any cartoons, as they experienced a traditional teaching style.

Creating flow maps

Before and after the 8-week course, the achievement test was administered. Each student was recorded and analyzed one-by-one. The flow map technique was used to analyze each sound recording. As the test covers the whole unit, it was observed that the number of sentences which the students expressed about the subject increased. Expressed sentences were noted in the lower line, with crossed and direct links between them, and calculations were made in the flow map technique. Four parameters are calculated in this study. The flow map method could measure the following dimensions of the learners' cognitive structure outcomes: Size (direct linkages or number of ideas), richness (recurrent linkages), integratedness (proportion of recurrent linkages or association density), and correctness (misconception rate) (Tsai, 1998). Figure 2 shows an example of analysis by a flow map of student K21's voice recording (K21 is the code for student number 21 of the control group).

The sentences that the student expressed during the interview were written one under the other, and linear connections between them were established. Among the key concepts related to the subject, cross-links were established with the first sentence in which the concept took place. In the above figure, key concepts are shown as underlined. The "size" parameter, which is one of the flow map parameters, gives the number of sentences expressed by the student. The size parameter value for this student is 8. The "correctness" parameter is the number of misconceptions of the student. The bold cues are the cues that wrong student ideas and its numeric value are 4. The number of cross-links this student has established is 7. The integratedness parameter is calculated by the formula of richness/(size + richness). According to this formula, the wealth parameter value is calculated as 7/(7 + 8) = 0.46. According to this information, when considering the whole unit, the student has a weak academic knowledge of this subject. The student did not have many connections between the concepts in the cognitive structure and did not have enough knowledge of the particulate nature of the matter unit.

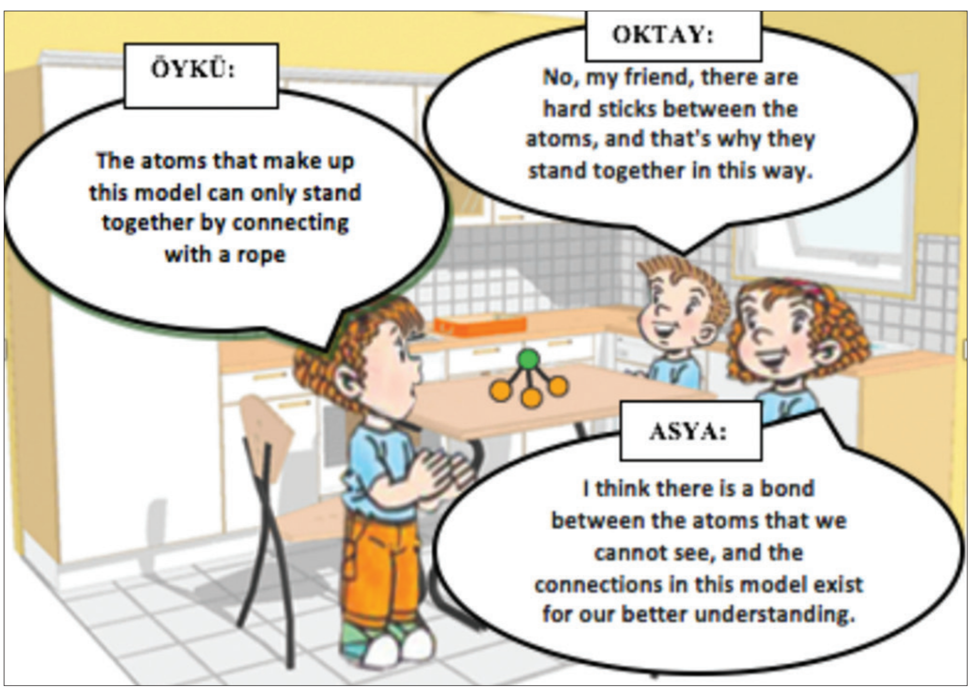

Figure 1: A concept cartoon developed by the researcher

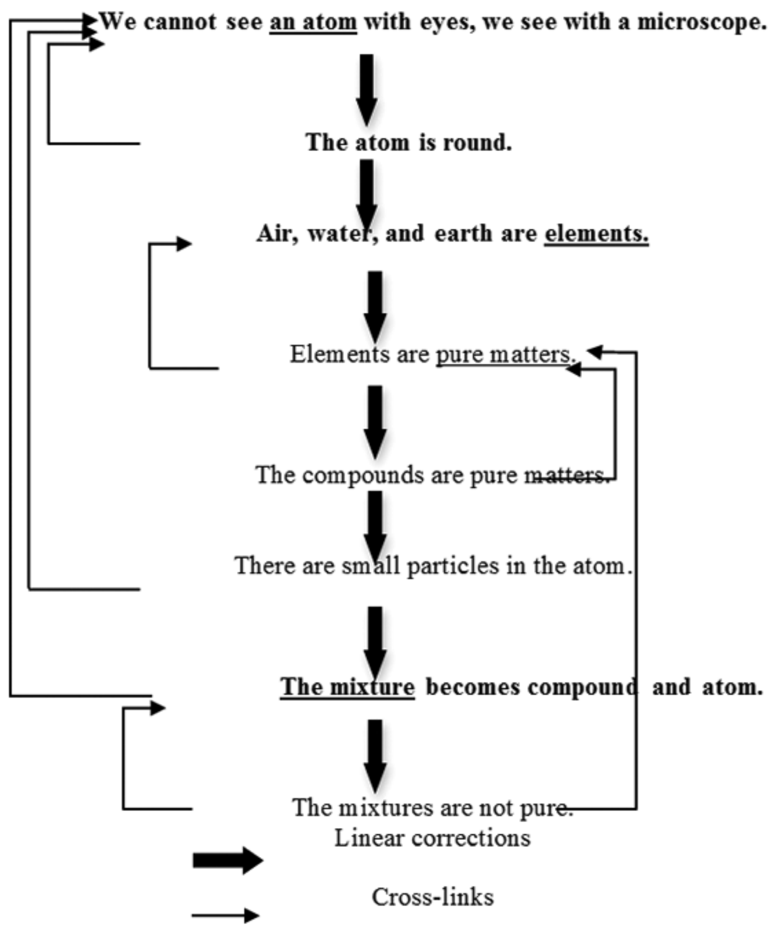

Figure 2: Analysis of the post-test flow map of K21 coded student

Analysis of Data

The quantitative data obtained from this study were assessed using SPSS version 22 and Microsoft Excel programs. Reliability calculations of the academic achievement test were made using the KR-20 formula in the Excel program. This type of reliability will increase if the measured properties of the test items are similar (Büyüköztürk et al., 2011).

To examine the effect of concept cartoons on the academic achievement of the students, the Kolmogorov–Smirnov Test was used to test whether the pre-test scores of the experimental and control groups showed a normal distribution. The results of the analysis did not show a normal distribution. For this reason, the Mann–Whitney U-test, which is a non-parametric analysis method, was conducted to compare the pre-test of the academic achievement test experiment-control group.

The responses of the students in the experimental group and the control group to the academic achievement test were analyzed using the flow map technique. Pre-test and post-test scores of size, richness, integratedness, and correctness parameters were obtained. Since these scores are the scores of the students' cognitive structures, each group was evaluated within itself. The Wilcoxon Signed-rank Test was used because the achievement test scores did not show a normal distribution to compare the pre-test post-test scores obtained from the flow maps of the experiment and control groups.

The opinions about the concept cartoons of the experiment group students were analyzed by content analysis from the qualitative analysis methods. In this direction, five themes were created by the researcher.

Findings

Findings obtained from sub-problems of this study are given below.

1. Is there a statistically significant difference between the achievement pre-test scores of the students in the experiment and control group in the "particulate nature of the matter" unit?

As Table 1 shows, $\rho < 0.05$ indicates that the pre-test success scores of the control and experimental groups do not show a normal distribution. According to these results, it was decided to apply Mann–Whitney U-test to compare the success pre-test scores of control and experiment group.

The Mann–Whitney U-test analysis results, which were conducted to compare the average scores of the students in the experimental and control group from the academic achievement pre-test, are given in Table 2.

According to the results of the analysis in Table 2, there was no significant difference between the control group and the experimental group students' average of achievement pre-test scores (U = 320.00, $\rho > 0.05$). When the mean ranks are taken into consideration, it was seen that the students of the experimental group had higher success pre-test scores than the control group students.

2. Is there a statistically significant difference between the academic achievement post-test scores of the experimental and control group in the "particulate nature of the matter" unit?

First, it was examined whether the academic achievement post-test scores of the experimental and control groups showed a normal distribution and the analysis was carried out by the Kolmogorov–Smirnov Test. The results of the analysis are shown in Table 3.

According to Table 3, $\rho < 0.05$ according to Kolmogorov–Smirnov Test showed that the control and test group's academic achievement post-test scores did not show normal distribution. The Mann–Whitney U-test was applied to compare the mean scores of the students who did not have a normal distribution in the control group and the end of the academic achievement test, and the analysis results are shown in Table 4.

When Table 4 is examined, it is seen that there is a significant difference (U = 97.00, $\rho < 0.05$) between the achievement test scores of the students of the experimental group and the control group. When the mean ranks are taken into consideration, it is understood that the test scores of the students in the experimental group are considerably higher than the scores of the students in the control group. This finding indicates that the teaching with concept cartoons was effective in enhancing the success of teaching.

3. Is there a statistically significant difference between the size parameter, correctness parameter, richness parameter, IPRE, post-test scores obtained from the flow maps that reveal the cognitive structures of the control group students?

The interviews with the control group students were examined using a flow map technique; size, correctness, richness, and integratedness parameters were calculated and analyzed. In

Table 1: Kolmogorov–Smirnov Test results on pre-test achievement score of students of experiment and control group

Group	Kolmogorov–Smirnov		
	Statistic	SD	ρ
Control-Experimental	0.147	54	0.05

ρ<0.05

Table 2: Mann–Whitney U-test results of achievement pre-test scores according to groups

Group	n	Mean rank	Sum of ranks	U	ρ
Control	27	25.85	698.00	320.00	0.435
Experimental	27	29.15	787.00		

ρ<0.05

Table 3: Kolmogorov–Smirnov Test results on the distribution of the academic achievement post-test scores of the experimental and control group students

Group	Kolmogorov–Smirnov		
	Statistic	SD	ρ
Control Experimental	0.122	54	0.045

ρ<0.05

Table 4: Mann–Whitney U-test results according to the rank of academic achievement post-test scores

Group	n	Mean ranks	Sum of ranks	U	ρ
Control	27	17.59	475.00	97.00	0.000
Experiment	27	34.41	1010.00		

Table 5: Control group students flow map pre-test post-test points

Student	SPRE	SP	CPRE	CP	RPRE	RP	IPRE	IS
K_1	3	5	2	2	2	3	0.40	0.37
K_2	13	13	4	2	16	13	0.44	0.50
K_3	7	7	3	3	5	4	0.41	0.36
K_4	7	8	3	1	6	6	0.46	0.42
K_5	7	17	2	4	6	20	0.46	0.54
K_6	11	30	5	4	12	47	0.52	0.61
K_7	11	19	3	0	15	22	0.57	0.53
K_8	5	5	2	2	6	1	0.54	0.16
K_9	9	21	3	6	8	25	0.47	0.54
K_{10}	12	28	5	7	7	28	0.36	0.50
K_{11}	10	31	5	10	6	39	0.37	0.55
K_{12}	8	11	3	3	7	17	0.46	0.60
K_{13}	7	11	4	4	3	8	0.33	0.42
K_{14}	8	23	4	5	7	29	0.46	0.55
K_{15}	5	12	4	5	3	13	0.37	0.59
K_{16}	9	9	4	4	6	9	0.40	0.50
K_{17}	8	21	3	2	4	19	0.33	0.47
K_{18}	8	15	1	3	9	13	0.52	0.46
K_{19}	11	17	5	3	10	20	0.47	0.54
K_{20}	12	18	6	2	10	25	0.45	0.58
K_{21}	5	8	2	2	2	7	0.28	0.46
K_{22}	5	7	3	4	4	5	0.44	0.41
K_{23}	8	14	3	2	6	14	0.42	0.50
K_{24}	13	13	6	4	11	12	0.45	0.48
K_{25}	10	19	5	9	7	17	0.41	0.47
K_{26}	7	16	2	5	4	17	0.36	0.51
K_{27}	6	12	2	2	5	10	0.45	0.45
Kort	8.3	15.2	3.5	3.7	7	16.4	0.42	0.48

SPRE: Size pre-test, SP: Size post-test, CPRE: Correctness pre-test, CP: Correctness post-test, RPRE: Richness pre-test, RP: Richness post-test, IPRE: Integratedness pre-test, IS: Integratedness post-test

Table 5, the flow map scores of the control group students are given.

The size parameter pre-test (SPRE) scores on the flow map scores give the total number of ideas that students have about the subject before the application. When Table 5 is examined, it is seen that the greatest value belongs to the two K2 and K24 students. These students expressed their preliminary knowledge in 13 sentences. Size post-test (SP) scores were obtained as an 8-week application. When the scores are examined, it is seen that K11 had the largest SP value with 31 sentences; when the SPRE scores were compared, it was determined that the number of the statements that 22 students expressing their knowledge at the end of the process had increased.

The correctness parameter pre-test (CPRE) scores give the number of misconceptions that the control group has in the sentences that the students express about the subject before the application. When Table 5 is examined, it is seen that the greatest number of misconceptions in the preliminary information of the students were K20 and K24 with six errors. After the interviews with the control group students, the correctness post-test (CP) scores were obtained. When the CP scores are examined, K11 had the greatest value with 10 misconceptions. The CP scores increased for 10 students (K5, K9, K10, K11, K14, K15, K18, K22, K25, and K26) when compared with the CPRE scores.

The richness parameter pre-test (RPRE) scores give the number of cross-links, or relationships, between the statements the control group expresses before the application. According to Table 5, K2 had the highest number of points with 16 cross-links. The richness parameter post-test (RS) scores were obtained following the practice of the control group students. K6 scored 47, i.e., this student had established 47 cross-links between the sentences he expressed and correlated the cues with each other. Compared to RPRE and RS scores, the number of cross-links produced by the control group students seems to increase after the application.

The IPRE scores were calculated using the formula of richness/(size + richness) from the points that the control group students got before application. In Table 5, K7 had the highest correlation of 57 points, so the richness of the cognitive structure that the learner had about the subject was moderate. After the study, control group students' integratedness post-test (IS) scores, it was found that the highest IS rate was K6's. 61, who also had the highest RP score. It is seen that the richness of the cognitive structures of the students about the subject was revealed by the relationship rate and the richness parameter had an important role.

The size parameter

Since the control group did not show a normal distribution of achievement scores, the scores of the parameters obtained from the flow map were also conducted by the Wilcoxon Marked Rank Test, which is a nonparametric analysis method.

The results of the Wilcoxon Signed-rank Test on whether the control group students showed a significant difference between the pre- and post-test scores of the size parameters are given in Table 6. The analysis results showed that the control group students had a statistically significant difference ($z = 4.111$, $\rho < 0.05$) between the pre-test scores of the size parameter after 8 weeks of study. This difference observed when the rank average and sum of the difference scores are taken into consideration seems to be in favor of the positive rank for the post-test. Since the size parameter represented the number of sentences the students expressed about the topic, it was seen that the level of knowledge about the particulate nature of the matter unit of the students of the control group increased.

The correctness parameter

The control group's flow map's CPRE post-test scores were examined by Wilcoxon Signed-rank Test and the findings are shown in Table 7.

The results of the Wilcoxon Signed-rank Test are shown in Table 7 as to whether the control group the correctness parameter shows a significant difference between the pre- and post-test scores. There was no statistically significant difference ($z = 0.488$, $\rho > 0.05$) between the correctness parameter pre-post test scores of the control group at the end of the 8-week period. When the rank order and sum of the difference scores are taken into account, it is seen that this difference is favorable rank, that is, favoring the post-test, but there is not a remarkable difference. The correctness parameter represents the misconceptions in the statements expressed by the students. It has been seen that the misconceptions that the control group students have about the particulate nature of the matter unit of the substance cannot be removed in the course of teaching with the current program.

The misconceptions of the control group students were detected from the flow maps are given in Table 8.

In Table 8, misconceptions were identified in the pre-test and repeated in the post-test. According to this, 17 (62%) of the students had the misconception that "the compounds are not

Table 6: Pre-test and post-test the size parameters of control group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative ranks	0	0.00	0.00	*4.111	0.000
Positive rank	22	11.50	253.00		
Equal	5				

*Based on positive ranks, ρ<0.05

Table 7: Pre-test and post-test the correctness parameters of control group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative Rank	9	9.22	83.00	*0.488	0.626
Positive Rank	10	10.70	107.00		
Equal	8				

*Based on positive ranks, ρ<0.05

pure." The second most frequently encountered error after this misconception was found in 16 (59%) students with "atom is visible with microscopy/telescope/magnifying glass." It can be seen that in the control group students' misconceptions detected in the pre-test cannot be removed in the last test and new misconceptions emerged.

The richness parameter

The control group's flow map is the RPRE post-test scores were examined by Wilcoxon Signed-rank Test, and the findings are shown in Table 9.

The Wilcoxon Signed-rank Test results for the difference between the control group students' flow map the RPRE and post-test scores are given in Table 9. The results of the analysis showed that the control group had a statistically significant difference ($z = 4.018$, $\rho < 0.05$) between the pre-post test scores of the richness parameters of the students. When the rank averages and sums of the difference scores are taken into account, this difference appears to be in favor of the positive test, that is, the post-test. The richness parameter represents the cross-connections between students sentences For this reason, the results of the analysis show that the cognitive structures of the control group increase as the connections between the students' statements about the particulate nature of the matter unit are increased.

The integratedness parameter

The control group's flow map's the IPRE post-test scores were examined by Wilcoxon Signed-rank Test, and the findings are shown in Table 10.

The results of the Wilcoxon Signed-rank Test on whether the control group students showed a significant difference between the pre-test and post-test scores of the flow map the integratedness parameter are given in Table 10. The results of the analysis showed that there was a statistically significant difference ($z = 3.114$, $\rho < 0.05$) between the pre-test scores of the control group's integratedness parameters. This difference observed when the rank average and sum of the difference scores are taken into consideration seems to be in favor of the positive rank, i.e., the end test. The integratedness parameter is calculated using the formula of richness/(size + richness). If a student wants to get a high score from the wealth parameter, he must establish many cross-links between the sentences he says. The obtained data show that the relationship between the control group students' information about the subject is increasing.

4. Is there a statistically significant difference between the size parameter, the correctness parameter, the richness parameter, the IPRE, post-test scores obtained from the flow maps that reveal the cognitive structures of the students in the experimental group?

The interviews with the experimental group students were examined using flow map technique; the size, the correctness, the richness, and the integratedness parameters were calculated and analyzed. In Table 11, the flow map scores of the experimental group students are given.

The size pre-test (SPRE) scores on the flow map scores give the total number of ideas that the experimental group had about the subject 8 weeks before. When Table 11 is examined, it is seen that the greatest value belongs to the students with the codes of D1 and D8. These students expressed their preliminary knowledge in 15 sentences. The SP scores were obtained as a result of practice using concept cartoons in addition to the curriculum for 8 weeks. When the scores are examined, it is seen that the student with the code D19 has the greatest SP value with 37 sentences, that is, it expresses the opinions he has about the topic with 37 sentences at the end of the process. When SPRE-SP scores were compared, it was determined that the number of sentences in which 25 learners expressed their knowledge at the end of the process increased.

The CPRE scores give the number of misconceptions that the experiment group has in the sentences that the students expressed about the subject before the 8 weeks. When Table 11 is examined, it is seen that the greatest value of the number of misconceptions that exist in the students' preliminary knowledge belongs to 7 errors and D11 students. After the interviews with the students in the experimental group, the CP scores were obtained. When the CP scores are examined, it is seen that the D27 coded student has the greatest value with ten misconceptions. Besides, when the CPRE and the CP scores are

Table 8: The misconceptions which were identified in the control group's academic achievement pre- and post-test results that analyzed by flow maps

The misconception	Frequency (%)
Atom is visible with light microscope/telescope/magnifier	16 (59)
Water, air, fire, and earth element	2 (7)
The compounds are not pure	17 (62)
Al^{3+} is a multi-atomic ion	1 (3)
The mixtures are pure	13 (48)
Melting and dissolution are the same thing	3 (11)

Table 9: Pre-test and post-test the richness parameters of control group students Wilcoxon signed-ranks test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	3	5.83	17.50	*4.018	0.000
Positive rank	23	14.50	333.50		
Equal	1				

*Based on positive ranks, ρ<0.05

Table 10: Pre-test and post-test the integratedness parameter of control group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	7	7.57	53.00	*3.114	0.002
Positive rank	19	298.00	298.00		
Equal	1				

*Based on positive ranks, ρ<0.05

Table 11: Experimental group students flow map pre-test post-test points

Student	SPRE	SP	CPRE	CP	RPRE	RP	IPRE	IS
D_1	15	30	3	3	16	36	0.51	0.54
D_2	10	18	4	5	8	22	0.44	0.55
D_3	7	5	3	4	6	1	0.46	0.16
D_4	5	5	2	3	4	2	0.44	0.28
D_5	10	20	3	3	5	25	0.33	0.55
D_6	3	4	1	2	2	1	0.40	0.20
D_7	4	20	2	5	2	20	0.33	0.50
D_8	15	24	1	2	15	32	0.50	0.57
D_9	8	14	3	4	5	16	0.38	0.53
D_{10}	5	10	2	5	3	6	0.37	0.37
D_{11}	12	19	7	3	6	22	0.33	0.53
D_{12}	8	28	2	8	5	33	0.38	0.54
D_{13}	4	6	2	1	2	4	0.33	0.40
D_{14}	8	23	6	6	6	24	0.42	0.51
D_{15}	10	20	1	3	10	24	0.50	0.54
D_{16}	10	25	5	0	5	27	0.33	0.51
D_{17}	4	6	3	2	3	3	0.42	0.33
D_{18}	7	27	4	8	6	33	0.46	0.55
D_{19}	10	37	3	7	10	52	0.50	0.58
D_{20}	11	19	3	8	7	21	0.38	0.52
D_{21}	2	15	0	5	1	10	0.33	0.40
D_{22}	7	22	5	7	4	23	0.36	0.51
D_{23}	5	6	3	3	4	5	0.44	0.45
D_{24}	13	30	5	4	9	35	0.40	0.53
D_{25}	4	6	2	1	3	3	0.42	0.33
D_{26}	11	22	1	1	9	23	0.45	0.51
D_{27}	12	28	4	10	11	38	0.47	0.57
Dort	8.1	18.1	3	4.2	6.2	20	0.45	0.46

SPRE: Size pre-test, SP: Size post-test, CPRE: Correctness pre-test, CP: Correctness post-test, RPRE: Richness pre-test, RP: Richness post-test, IPRE: Integratedness pre-test, IS: Integratedness post-test

compared, it is seen that the CP scores are increased, that is, the misconceptions do not disappear at the end of the application.

The richness pre-test (RPRE) scores give the number of cross-links, or relationships, between the experimental groups that they expressed before 8 weeks. When Table 11 is examined, it is seen that D1-coded student has the highest RPRE score with 16 cross-links. Following the instruction using the concept cartoons with the students of the experimental group, the richness post-test (RP) scores were obtained. The student with the highest score of RP according to the obtained score is the student with 52 cross-link and D19 code. This student has established 52 cross-links between the phrases he has expressed and correlated the cues with each other. When the RPRE and RP scores are compared, it is seen that the number of cross-links of the students in the experimental group increased after the 8 weeks.

The integratedness pre-test (IPRE) scores were calculated from the scores of the experiment group students 8 weeks before using the formula of richness/(size + richness). When Table 11 is examined, it is seen that the highest the integratedness ratio belongs to the student with D1 code with 0.51 points and the cognitive structure richness that the student has about the subject is moderate. At the same time, it was found that the same student had the highest IPRE score. After the application, the integratednes post-test (IP) scores of the experimental group students were calculated using the same formula. It was found that the highest IP rate belonged to the student with the code D19 and 0.58, again having the highest IP score. It is seen that the richness of the cognitive structures of the students about the subject is revealed by the relationship rate and the richness parameter has an important role.

The size parameter

Since the experimental group did not show a normal distribution of achievement scores, the scores of the parameters obtained from the flow map were also conducted by the Wilcoxon Marked Rank Test, which is a nonparametric analysis method.

The results of the Wilcoxon Signed-ranks Test on whether the experimental group students showed a significant difference between the pre- and post-test scores of the size parameters are given in Table 12. The analysis results showed that the experimental group students had a statistically significant difference ($z = 4.347$, $\rho < 0.05$) between the pre-test scores of the size parameter after 8 weeks of study. This difference observed when the rank average and sum of the difference scores are taken into consideration seems to be in favor of the positive rank for the post-test. Since the size parameter represented the number of sentences the students expressed about the topic, it was seen that the level of knowledge about the particulate nature of the matter unit of the students of the experimental group which was using concept cartoons in lessons increased.

The correctness parameter

The experimental group's flow map's CPRE post-test scores were examined by Wilcoxon Signed-rank Test and the findings are shown in Table 13.

The results of the Wilcoxon Signed-rank Test are shown in Table 13 as to whether the experimental group the correctness parameter shows a significant difference between the pre- and post-test scores. There was no statistically significant difference ($z = 2.283$, $\rho < 0.05$) between the correctness parameter pre-post test scores of the experimental group at the end of the 8-week period. When the rank order and sum of the difference scores are taken into account, it is seen that this difference is favorable rank, that is, favoring the post-test, but there is not a remarkable difference. The correctness parameter represents the misconceptions in the statements expressed by the students. It has been seen that the misconceptions that the experimental group students have about the particulate nature of the matter unit of the substance can be decreased in the course of teaching with the using concept cartoons in lessons.

The misconceptions of the experimental group students were detected from the flow maps are given in Table 14.

According to Table 14, the sentences appear as the repeated misconceptions in the pre-test and post-test, 15 of the students (55%) have the misconception that "atomic microscope/telescope/

magnifier." The most common error after this misconception is that "the compounds are not pure" 13 (48%) were detected in the students. It is seen that some of the misconceptions detected in the pre-test of the experiment group are not eliminated in the post-test, and they have new misconceptions.

The richness parameter

The experimental group's flow map's the RPRE post-test scores were examined by Wilcoxon Signed-rank Test, and the findings are shown in Table 15.

The Wilcoxon Signed-rank Test results for the difference between the experimental group students' flow map the RPRE and post-test scores are given in Table 15. The results of the analysis showed that the control group had a statistically significant difference ($z = 4.079$, $\rho < 0.05$) between the pre-post test scores of the richness parameters of the students. When the rank averages and sums of the difference scores are taken into account, this difference appears to be in favor of the positive test, that is, the post-test. The richness parameter represents the cross-connections between students' sentences. For this reason, the results of the analysis show that the cognitive structures of the experimental group increase as the connections between the students' statements about the particulate nature of the matter unit are increased.

Table 12: Pre-test and post-test the size parameters of experimental group students Wilcoxon signed-ranks test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	1	4.50	4.50	*4.347	0.000
Positive rank	25	13.86	346.50		
Equal	1				

*Based on positive ranks, $\rho<0.05$

Table 13. Pre-test and post-test the correctness parameters of experimental group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	6	9.50	57.00	*2.283	0.022
Positive rank	16	12.25	196.00		
Equal	5				

*Based on positive ranks, $\rho<0.05$

Table 14: The misconceptions which were identified in the experimental group's academic achievement pre and post-test results that analyzed by flow maps

The misconception	Frequency (%)
Atom is visible with microscope/telescope/magnifier	15 (55)
Elements are not pure	4 (14)
The compounds are not pure	13 (48)
Al^{3+} is a multi-atomic ion	1 (3)
Melting and dissolution are the same thing	3 (11)

The integratedness parameter

The experimental group's flow map's the IPRE post-test scores were examined by Wilcoxon Signed-rank Test, and the findings are shown in Table 16.

The results of the Wilcoxon Signed-rank Test on whether the control group students showed a significant difference between the pre-test and post-test scores of the flow map the integratedness parameter are given in Table 16. The results of the analysis showed that there was a statistically significant difference ($z = 2.173$, $\rho < 0.05$) between the pre-test scores of the control group's integratedness parameters. This difference observed when the rank average and sum of the difference scores are taken into consideration seems to be in favor of the positive rank, i.e., the end test. The integratedness parameter is calculated using the formula of richness/(size + richness). If a student wants to get a high score from the wealth parameter, he must establish many cross-links between the sentences he says. The obtained data show that the relationship between the control group students' information about the subject is increasing.

5. What is the opinion of the experiment group students about using concept cartoons in teaching?

At the end of the 8-week process of teaching with concept cartoons, the students were asked their thoughts about the application, and the findings are shown in Table 17.

When we look at Table 17, it can be seen that the opinions of the students of the experiment group about the education about the concept cartoons are collected under five main themes, the students' opinions about each theme, the frequency, and percentages of these ideas.

DISCUSSION AND CONCLUSION

In this research, which examined the effect of concept cartoons on the academic achievement of students and the development

Table 15: Pre-test and post-test the richness parameters of experimental group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	3	3.67	11.00	*4.079	0.000
Positive rank	22	14.27	314.00		
Equal	2				

*Based on positive ranks, $\rho<0.05$

Table 16: Pre-test and post-test the integratedness parameter of experimental group students Wilcoxon signed-rank test results

Ranks	n	Mean rank	Sum of rank	z	ρ
Negative rank	5	18.00	90.00	*2.173	0.030
Positive rank	21	12.43	261.00		
Equal	1				

*Based on positive ranks, $\rho<0.05$

Table 17: The experiment group students' opinions on using concept cartoons in teaching

Theme	Code	Frequency (%)
Learning	I learned the unit better than the other units	18 (66)
	I did not have difficulty in learning	14 (51)
Availability of other lessons	Available in Mathematics course	9 (33)
	Available in English course	6 (22)
	Available in all of the courses	12 (44)
Eliminate missing and false information	I saw the information that I was missing.	5 (18)
	I have noticed/corrected my mistakes	9 (33)
Provide persisting	Concept cartoons provide persisting in learning	4 (14)
Being different/ funny	Concept cartoons are funny	23 (85)
	Concept cartoons are not funny	4 (14)
	They are used as a different activity instead of tests	7 (25)

of cognitive structures in science teaching, the scores of two groups' academic achievement pre-test were examined, and no statistically significant difference was found between the two groups. At the end of the 8-week teaching period, the students in the experimental group using concept cartoons were found to have higher academic achievement than the control group students. Based on these results, it can be stated that the teaching with the concept cartoons is more effective in enhancing academic achievement than the current program. Özüredi (2009), Eroğlu (2010), Evrekli and Balım (2010), Dereli (2008), and Erdağ (2011) have all noted that teaching with concept cartoons in academic studies has increased academic success.

It has been stated that the preliminary knowledge and cognitive structures existing in a subject may be revealed by flow maps in previous studies (Oskay and Dinçol, 2011; Tsai, 1998; Tsai and Huang, 2002; Wu and Tsai, 2005). In this study, flow maps and cognitive structures related to the subject were investigated. A statistically significant difference was found between pre-test and post-test scores of the size parameters of the control group and test group students. According to this result, it can be said that the number of sentences expressed by the control and experiment group increased after the application, that is, the level of knowledge belonging to particulate nature of the matter unit was increased in the cognitive structures of the students in both groups. However, the number of sentences expressed in the experimental group was higher and more meaningful.

One of the parameters calculated in the flow maps is the richness parameter. It was seen that there was a statistically significant difference between the pre-test and post-test scores of the students in the control group and the pre-test and post-test scores of the students in the experiment group among themselves. According to these results, it can be said that the students of both groups have more connections after the application of the information they have about the subject. Tsai (1998) stated that a student's cognitive network would be richer and more complex as the level of knowledge and understanding of a student increased. It can be said that richer links are established in the cognitive networks of the experimental group students.

Another parameter that is computed through flow maps is the integratedness parameter. When the pre-test-post-test scores of the integratedness parameters of the control group and the experimental group were examined, it was seen that there was a statistically significant difference among the groups themselves. As the level of knowledge students have about a topic increases, the relationship of information in cognitive structures increases. In this case, it can be said that an improvement is observed in the cognitive structure of both groups and the number of bonds established increases. Anderson and Demetrius (1993), Tsai (1998), Tsai (2000), Tsai (2001), Bischoff and Anderson (2001), Tsai and Huang (2002), Wu and Tsai (2005), and Selvi and Yakışan (2005) in their studies, the number of connections in the cognitive structures of the learners increased, their knowledge was more easily structured in their minds, and more meaningful learning took place.

There was no statistically significant difference between the control group's pre-/post-test correctness parameter scores calculated by the flow map in the study. For this reason, it can be argued that the control group students who are educated with the current program did not change their misconceptions. It was found that there was a statistically significant difference between the pre-/post-test of the correctness parameter scores of experiment group who were taught with concept cartoons. According to this finding, it can be said that the concept cartoons had an effect on the misconceptions of these students. They were given the opportunity to visualize difficult concepts to understand them better and make them more concrete. As a result, these students reduced their concept confusions. In many national and international studies, it has been stated that concept cartoons are a successful alternative technique in determining misconceptions (Çiğdemtekin, 2007; Yıldız, 2008; Demir, 2008; Ekici et al., 2007; Burhan, 2008).

In this study, similar mistakes were detected in the students from both the experimental and control groups, for example, the concept of "atom." Both groups reported that the atom is visible with a microscope/telescope/magnifier. Similar misconceptions have been noted in other studies (Duran et al., 2011; Say, 2011; Ekim, 2007; Griffiths and Preston, 1992). For these students, the following misconceptions have been determined regarding the concepts of "element, compound, and molecule;" the elements are not pure, the compounds are not pure, air, water, soil, and fire are elements. Similar studies have been found in the literature and have shown the same results (Çakır, 2005; Say, 2011, Çakmak, 2009; Yavuz, 2005; and Sökmen and Bayram, 1999). For the main concepts of "mixture, homogeneous mixture, heterogeneous mixture, and solution" melting and dissolving were the same, mixtures misconceptions were detected. Their students mostly used the melting concept instead of the solution concept. These misconceptions support Çalık et al., (2006), Abraham et al. (1992), Ebenezer and Erickson (1996), Kabapınar (2001), and Say (2011)'s studies. These students' misconceptions about the concepts of "anion, cation, and chemical bond" in students were seen in them reporting Al^{3+} contains three aluminum atoms. This study's findings were supported by various studies found in the literature (Butts and Smith, 1987; Boo, 1998; Taber, 1994; Öztürk Ürek and Tarhan, 2005; and Coll and Taylor, 2001). For example, Uslu (2011) found that 7th-grade students confused the anion and cation concepts.

This study's experiment group students' thoughts about concept cartoons were taken, and some of the students stated that concept cartoons were more instructive and not difficult to learn. In the studies performed by Ekim (2007), Durmaz (2007), and Özüredi (2009), they examined the opinions of students about concept cartoons and showed that they had better thoughts about learning concept cartoons. Students have stated that concept cartoons can be used in Mathematics, English, and all lessons. In Eroglu (2010) and Özüredi's (2009) studies, students were asked their opinions about concept cartoons, and it was seen through feedback received that the cartoons could be used in subsequent units. About concept cartoons, some of the students stated that they saw what was missing and some of the others noticed/corrected their mistakes.

In the studies of Ekim (2007) and Özüredi (2009), they have done group work with the students and showed that the concept cartoons have corrected coursework and students' misinformation about the current subject. Some students think that concept cartoons helped provide information permanence. Kılınç (2008), Eroğlu (2010), and Ekim (2007) reached similar results. Finally, concept cartoons were seen as both fun and not fun by students as well as some commented they appreciated a different activity instead of solving the test. Similar results have been obtained in other studies that cartoons are fun, motivating, and provide a different technique (Özalp, 2006; Durmaz, 2007; Keogh and Naylor, 1999; İnel et al., 2009; Erdag, 2011).

In this study, where concept cartoons were used as a different technique in science teaching; the effects of cartoons on the academic achievements and cognitive structures of the students, as well as the opinions of students about concept cartoons were investigated. When students' achievement tests were assessed, the flow map technique was used to demonstrate their cognitive skills in the subject. When the findings were evaluated, it could be said that concept cartoons increased the academic achievement of the students. In the evaluations made with flow maps, the cognitive structures that existed in the students and which were reconstructed at the end of the process have been examined. Along with this, misconceptions of the students have been determined, and these attempts were made to address these misconceptions using concept cartoons. Misconceptions of the experimental group were addressed; however, those of the control group were not. Evaluating the flow maps and the cognitive structures of the students in this study contributes to the literature regarding the academic achievement of students in science and warrants further study.

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