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# THE EFFECTS OF CONCEPT CARTOONS AND ARGUMENTATION BASED CONCEPT CARTOONS ON STUDENTS' ACADEMIC ACHIEVEMENTS

**Feyzi Osman Pekel**

**Abstract.** *Although "Reproduction, Growth, and Development in Living Things" (RGDLT) is a core topic in the Turkish science curriculum, it is known that students have difficulties in understanding. Integrating concept cartoons and argumentation into the teaching of this unit has the potential to promote students' interest and understanding. This research is the first to compare the effects of concept cartoons and argumentation-based concept cartoons on students' academic achievement in teaching sixth grade RGDLT subjects. The research was performed with two experimental groups and one control group in a secondary school in Turkey. A quasi-experimental research design was used in the research. Analysis of the post-test results revealed that the success of the group using concept cartoons was higher than the control group, but more importantly, the success of the group using argumentation-based concept cartoons was higher than the group using concept cartoons. The results of this research indicate that the academic achievement of students can be increased significantly when concept cartoons and argumentation-based concept cartoon activities are used in addition to the constructivist methods in teaching these subjects. The results of the research serve as a guide for teachers and researchers interested in teaching science and biology subjects.*

**Keywords:** *argumentation, biology education, concept cartoons, living things, quasi-experimental research*

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## Introduction

While every living thing on earth maintains its own life, it also works for the continuation of the ecosystem. Sustainable life on earth is only possible if students learn basic information about living things. However, the understanding that both children and adults develop about the natural world is quite different from that offered by the scientific community (Anderson et al., 2014). Research reveals that although students see different creatures in the written and visual media, they do not have enough information about how these creatures reproduce, grow and develop in their environment (Fancovicova & Prokop, 2011; Link-Perez & Schussler, 2013; Patrick & Tunnicliffe, 2011).

### *Learning Difficulties in Reproduction, Growth, and Development in Living Things Topics*

Research on Reproduction, Growth, and Development in Living Things *(RGDLT)* report that sixth and seventh-grade students could not give correct examples and they have a number of misconceptions (Taşdemir & Demirbaş, 2010), and seventh-grade students have misconceptions such as *"small animals reproduce by laying eggs", "only land mammals reproduce by giving birth", "only mothers with a small number of cubs take care of their offspring"* (Murat et al. (2011). In the experimental studies aimed to teach this subject better, Sinanoğlu (2017) reported that web-supported concept cartoons and conceptual change texts increased the academic achievement of the students in the experimental group, while reducing their cognitive load, but did not affect the permanence of the learned information.

Öztürk and Öztuna Kaplan (2017) as a result of their research in which they aimed to reveal the knowledge and alternative concepts of sixth-grade students about the factors affecting the growth and development of plants through drawings and interviews, as well as some misconceptions, they reported that the students mostly used water, sun, and fertilizer in their drawings, but none of the students used carbon dioxide. In other studies on teaching this subject, it was reported that students' academic achievement



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levels increased when inquiry-based learning activities (Çelik & Çavaş, 2012), multiple writing activities (Akçay et al., 2014), and 5E learning activities (Önder, 2011) were used.

The reasons why students have difficulty in understanding the RGDLT subjects in the science curriculum are stated in the literature as follows: Decreased interest in science lessons (Osborne & Dillon, 2008), abstract concepts, misconceptions, close pronunciation of concepts, cognitive terminology challenging the level of education, presentation of plants in the educational environment and media in a less interesting way than animals (Lampert et al. 2019), not using more efficient teaching activities in lessons (Stag & Verde, 2018), reproduction, growth and development mechanisms of living things differ (Güneş & Serdaroğlu, 2018). The fact that current secondary school students still have hesitations in deciding whether plants are alive (Amprasis et al., 2021), and that many students aged 10-12 do not clearly perceive that plants are alive (Maskour et al., 2019) shows how serious the problem is.

When the studies on RGDLT are examined, it is seen that the application of different techniques and activities has a positive effect on student achievement in general. It is understood that the use of concept cartoons or argumentation activities in teaching different science subjects has also a positive effect on student achievement in general. However, no study has been found on how the use of concept cartoon activities and argumentation-based concept cartoon activities in teaching the same subject affects student achievement. This research was aimed both to increase the academic achievements of students and to determine the effects of concept cartoons and argumentation-based concept cartoons in the teaching of RGDLT subjects.

### *Concept Cartoons*

Concept cartoons were first created in the 1990s to reveal students' ideas about a topic, to challenge their thoughts, and to support the development of their understanding (Naylor & Keogh, 2013). A concept cartoon consists of a worksheet prepared for a specific topic, in which three or more characters voice their thoughts in speech bubbles, one of which is scientifically correct, and the others that contain the most common misconceptions of students. In this activity, students are expected to answer the questions "Which of the characters do you think is correct? Why do you agree with this character and not with the others?", and to discuss their answers by comparing with those of their classmates. Concept cartoons were reported to make students more active in the lessons due to their visual and interesting features, improve their reasoning skills and self-confidence (Naylor & Keogh, 2013), increase learning through increasing students' participation and motivation (Pekel, 2019). They act as catalysts for argumentation without the need for any special help or teacher treatment in managing the argumentation process (Naylor & Keogh, 2013). In addition, while argumentation works best on socio-scientific issues; concept cartoons give better results not only in socio-scientific subjects but also in other scientific subjects (Kabapınar, 2009; Taşlıdere, 2013; Türkoğuz & Cin 2013). In addition, it has been reported that concept cartoons encourage students to participate in classroom discussions, lead them to think and reason about the subject, increase student success, initiate inquiry processes, and increase the quality of argumentation by giving them the chance to participate in scientific discussion (Evrekli & Balım, 2015; Naylor & Keogh, 2013). In the present research, worksheets containing concept cartoons were used both to increase student achievements and to determine the effect of concept cartoons on students' academic achievement.

### *Argumentation*

Argumentation is determined in the literature as; a form of scientific discussion (Dawson & Venville, 2013), a way of understanding the relationships between claims and data by considering their reasons (Jimenez-Aleixandre & Erduran, 2008); an appropriate instrument for learners to improve their conceptual understandings (Erduran et al., 2015); a process in which students learn to construct arguments containing data, claims, reasons, and backings, an effective instrument that provides students to question, justify and evaluate claims (Erduran et al., 2004). On the other hand, it was emphasized that teachers have important duties in creating the necessary conditions to facilitate argumentation (Jimenez-Aleixandre & Erduran, 2008; Dawson & Venville, 2013) since science lessons do not sufficiently include the activities necessary to facilitate argumentation (Taşlıdere, 2013; Türkoğuz & Cin, 2013). The use of concept cartoons and argumentation activities not only increases students' interest in science lessons (Er & Kirindi, 2021; Naylor et al., 2007) but also facilitates the elimination of misconceptions (Akamca et al., 2009).

Although most of the studies in which concept cartoons and argumentation were used reported increasing student achievement, the number of research examining the effect of concept cartoons, and argumentation on


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gender is few. Kubiatko et al. (2021) reported that the evidence in the literature on the effect of knowledge on gender is mixed and varies according to studies. Therefore, an answer was sought to the question of whether the methods used in this study affect the academic achievement of students in RGDLT subjects in terms of their gender. As can be understood from the above studies, argumentation and concept cartoons are mentioned as effective learning activities that positively affect students' academic achievement and individual development in science education. For this reason, concept cartoon activities were used in one of the experimental groups and argumentation-based concept cartoon activities were used in the other.

### *Research Aim and Research Questions*

In science teaching, it is crucial for teachers to know which activities give better results in teaching a particular subject. Thus, teachers can increase the success of their students more by using activities that are reported to give better results in teaching a subject. Therefore, the aim of this study was to examine the effects of different learning materials (concept cartoons and argumentation based-concept cartoons) on the academic achievement of students in the teaching of the RGDLT unit. Accordingly, answers to the following research questions were sought:

1. Is there a statistically significant difference between the pre-test achievement scores of the *Argumentation-based Concept Cartoons* (*ABCC*) group, *Concept Cartoons* (*CC)* group, and *Control* group?
2. Is there a significant difference between the pre and post-test achievement scores of the ABCC group?
3. Is there a significant difference between the pre and post-test achievement scores of the CC group?
4. Is there a significant difference between the pre and post-test achievement scores of the Control group?
5. Are there significant differences between the post-test points when the post-test achievement scores of the three groups were compared?
6. Are there significant differences between the post-test achievement scores of the three groups in terms of gender?

## Research Methodology

### *Research Model*

The present research was based on a quasi-experimental research design. Non-equivalent pre-test - post-test control group design was used in the research. Johnson and Christensen (2014) determined the pre-test-post-test control-group design as "a research design in which one of the groups was randomly assigned as the experimental group and the other as the control group before the research and pre-test and post-test were applied to both before and after the research". The research was conducted in a science course with three groups consisting of sixth-grade students. Before the treatment, each group was randomly assigned and named; Control group, the Concept Cartoons (CC) group, and the Argumentation-based Concept Cartoons (ABCC) group. While the individuals in the Control group were taught using the activities of the existing curriculum, additionally learners in the CC group received worksheets including concept cartoon activities and students in the ABCC group received argumentation-based concept cartoon activities. The research data were gathered from the result of academic achievement tests which were conducted to the students in three groups before the treatment as "pre-test", and after the treatment as "post-test". The research was conducted in 2018- 2019, during the teaching of the RGDLT unit.

**Table 1**
*Experimental Design of the Research*

| Groups | Pre-test | Treatment | Processing time | Post-test |
|---|---|---|---|---|
| Control | Achievement test | Activities based on current curriculum | 4 weeks (12 course hours) | Achievement test |
| CC | | Concept cartoon-based activities | | |
| ABCC | | Argumentation-based concept cartoons | | |


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*Research Group*

The research group consisted of 76 sixth-grade students in three different classes of a public secondary school in Isparta City Centre in the spring term of 2018-2019. Of the students, 36 were girls and 40 were boys. Each of the sixth-grade classrooms was randomly assigned and named respectively as; Control group, CC group, and ABCC group. Of the 26 students in the CC group, 12 were girls and 14 were boys. However, of the 25 students in the ABCC group were 12 girls and 13 boys; of the 25 students in the control group, 12 were girls and 13 were boys. The permission of the school administration was obtained before starting the research. Consent of the students was obtained within the framework of the principle of voluntariness to participate in the research.

*Data Collection Tools*

*Achievement test*

In this research, a test consisting of 19 items developed by Sinanoğlu (2017) was used to measure the success of sixth-grade students in the RGDLT unit. This test was used as a data collection tool in the present research. In this study, the Cronbach's alpha coefficient, which shows the reliability of the measurement made using the achievement test, was calculated as .76. George and Mallery (2010) referred to the reliability coefficient between .70 and .90 as "good" values. The validity of the achievement test was approved by two science educators and two experienced science teachers. After that, it was decided to use as an achievement test in the present research.

*Concept cartoon worksheets*

Before the concept cartoons were prepared, related subjects and achievements were examined in detail. In addition, a list of students' misconceptions on related subjects was prepared by conducting a literature search. In addition, three experienced science teachers were interviewed, and their students were asked to learn about the misconceptions they encountered in the previous years about the unit. Thus, concept cartoons were prepared in the form of worksheets, taking into account the achievements and students' misconceptions related to the subjects. While only one of the four or five characters in each cartoon voices the scientifically accepted idea, the other characters voiced the ideas that contain possible misconceptions that students may have. Two faculty members who are experts in the field of science education and three experienced science teachers examined the prepared concept cartoons and were given the final form in line with the suggestions of the experts.

*The Experimental Procedure*

The RGDLT unit was taught for 12 lesson hours, three hours a week, as stipulated in the curriculum. The research was fulfilled with sixth-grade students of a public secondary school in Isparta City Centre in the spring term of the 2018-2019 academic year. Teaching activities were completed simultaneously in 4 weeks in all three groups.

In the control group, students were taught based on the activities in the coursebook, in line with the achievements and explanations, as stipulated in the curriculum, without any preliminary research. These teaching activities were based on constructivist teaching strategies determined by the curricula. The main difference between control and experimental groups was that control group education facilities do not include concept cartoons or argumentation activities.

In the CC group, a concise briefing was given on the application of concept cartoons so that students would not be inexperienced in using and interpreting concept cartoons effectively. After this briefing, at the end of the previous unit, two different worksheets containing concept cartoons on *Reflection of Light and Interaction of Sound with Matter* were distributed to the students, and sample applications were made. The main difference between CC and ABCC groups was that classroom discussions in the CC group do not include argumentation activities.

In the ABCC group, after a preliminary briefing was given to the students about argumentation, two different worksheets containing argumentation-based concept cartoons on *Reflection of Light and Interaction of Sound with Matter* were distributed and sample applications were made. During this preliminary research, they were asked to use *data*, *warrants*, *backings,* and *rebuttals* while trying to prove their *claims*, since the purpose of argumentation is not to win the discussion but to reach scientifically correct information. In the ABCC group, concept cartoon


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activities, which were prepared in the form of worksheets in addition to the teaching methods in the control group, were carried out with small groups of five students after each of the sub-topics of the unit were processed. The groups were formed in a heterogeneous manner. The teacher distributed each worksheet to each student, and a reasonable time was given for all students to read and understand all the expressions in the cartoon.

Every student in the ABCC group individually performed the activities on his/her worksheet. Then, the students wrote the ideas that they agree and disagree with from the views voiced by each character on their own worksheet, using data, warrants, backings**,** qualifiers, and rebuttals**.** After that, group worksheets containing the same concept cartoon were distributed to each group, and the groups were asked to discuss with the group members why the statements made by each character in the cartoon were true or false, using data, warrants, backings, qualifiers, and rebuttals. So, each group performed argumentation activities in their group. Group discussions continued until a consensus was formed within the group. At the end of the discussion process, every group clerk took notes about agreed group thoughts on their group report paper. After this period, an electronic version of the related argumentation-based concept cartoon was projected onto the board via a projection device, and each group spokesperson presented the data, warrants, backings, qualifiers, and rebuttals for their group's idea. The groups were asked to express the opinions they agreed and disagreed with from the views voiced by each group spokesperson, using data, warrants, backings, qualifiers, and rebuttals. In this way, it was ensured that the students who explained the opinions of the other students expressed their reasons for agreeing or disagreeing with their opinions in the form of argumentation by justifying them. Students discussed whether presented statements are true using data, claims, warrants, and rebuttals. Students in other groups tried to refute the presented argument they do not agree or corroborate the argument using data, claims, and warrants in the process of their discussions. During this process, the teacher served as a counsellor during the discussion processes. When a debate is blocked teacher redirected the discussion. The teacher encouraged students to contribute discussions and explain the reasons for not supporting the claims and counterclaim. These discussions were continued until a consensus was reached in the class. The teacher made a general evaluation of the argumentation process following each session. In the discussion process, the teacher asked some questions to the students when necessary to reveal faulty/incomplete learning, and the students were also able to ask questions to the teacher during the evaluation process.

### *Data Analysis*

In the present research, since the sample size was not sufficient for parametric analysis ($n < 30$), the non-parametric tests were used in the analysis of the data, regardless of their normal distribution. In this framework, Wilcoxon Signed-rank Test was used to analyse whether the teaching conducted in the control and experimental groups created a statistically significant difference within the groups. Whether there was a statistically significant difference between the academic achievements of the groups was analysed through the Mann Whitney *U*-test. In addition, The Kruskal Wallis *H*-test was used to determine whether there was a statistically significant difference between the scores of the three groups.

## Research Results

Findings related to each problem of the research were presented in order. The first question of the research was whether there was a significant difference between the three groups in terms of pre-test achievement scores. Kruskal Wallis Test analysis was performed to reveal whether there was a statistically significant difference between the pre-test achievement scores of all three groups. Table 2 depicts the Kruskal Wallis analysis results about the first question of the research.

**Table 2**
*The Kruskal Wallis Pre-Test Analysis Results of the Three Groups*

| Group | $n$ | $\bar{X}$ | Mean Rank | $df$ | $\chi^2$ | $p$ | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Control | 25 | 7.56 | 40.34 | | | | |
| CC | 26 | 7.42 | 38.00 | 2 | .287 | .866 | .01 |
| ABCC | 25 | 7.36 | 37.18 | | | | |


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When Table 2 was examined, it is understood that there was no statistically significant difference between the pre-test achievement scores of the three groups [$\chi^2$ (2) = .287, $p$>.05]. This result shows that the control and experimental groups were similar in terms of their pre-test achievements before the treatment. When the calculated effect size value ($\eta 2$ = .01) was evaluated according to Cohen (1992)'s scale, it was understood that it had a low effect level. These results indicated that the academic achievement scores of the control and experimental groups were similar before the treatment.

The second question of the present research was whether there was a statistically significant difference between the pre and post-test achievement scores of the ABCC group. For this purpose, the pre-test and post-test achievement scores of the ABCC group were compared through Wilcoxon signed-rank test in order to see if there was a statistically significant difference between them. The comparison results of the pre and post-tests of the ABCC group are shown in Table 3.

**Table 3**
*Wilcoxon Signed-Rank Test Results Regarding the Pre and Post-Test Scores of the ABCC Group*

| Post-test - Pre-test | *n* | Mean Rank | Sum of Ranks | *z* | *p* | Cohen's r |
|---|---|---|---|---|---|---|
| Negative Ranks | 0 | .00 | .00 | -4.396 | .001* | 0.62 |
| Positive Ranks | 25 | 13.00 | 325 | | | |
| Ties | 0 | - | | | | |

*$p$ < .05

When Table 3 was examined, it is seen that there are no students in the ABCC group whose achievement scores decreased after the treatment. After the treatment in this group, the achievement scores of all students increased. It was determined that the pre-test achievement mean score of the ABCC group increased from 7.36 to 17.16 after the treatment (Net increase=9.80 points). The mean rank value of the increasing achievement scores of the 25 participants whose achievement score increased after the training was determined as 13.00. A statistically significant difference was found between the mean scores of achievement points before and after the training of the participants in the research group ($z$=4.39, $p$< .05). When the calculated effect size value ($r$= .62) was evaluated according to Cohen (1992)'s scale, it was understood that it had a large effect level. These results showed that the teaching activities including argumentation-based concept cartoons significantly increase students' academic achievement in the teaching of the RGDLT unit.

The third question of the research was whether there was a significant difference between the pre and post-test achievement scores of the CC group. Hence, the pre and post-test achievement scores of the CC group were statistically compared through the Wilcoxon Signed-Rank Test.

**Table 4**
*Wilcoxon Signed-Rank Test Results Regarding the Pre and Post-Test Scores of the CC Group*

| Post-test - Pre-test | *n* | Mean Rank | Sum of Ranks | *z* | *p* | Cohen's r |
|---|---|---|---|---|---|---|
| Negative Ranks | 0 | .00 | .00 | -4.479 | .001* | 0.62 |
| Positive Ranks | 26 | 13.50 | 351 | | | |
| Ties | 0 | - | | | | |

*$p$ < .05

The data in Table 4 show that there were no students in the CC group whose success scores decreased after the teaching and that the success scores of all students increased. It was seen that the pre-test achievement mean score of the ABCC group increased from 7.42 to 16.11 after the treatment (Net increase=8.69 points). The mean rank value of the achievement points of the 26 students whose success points increased after the teaching was determined as 13.00. A statistically significant difference was found between the mean rank of knowledge scores of the participants in the research group before and after the treatment ($z$=4.47, $p$< .05). When the calculated effect size value ($r$=.62) was evaluated according to Cohen (1992) 's scale, it was understood that it had a large effect level.


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Based on these results, it can be stated that concept cartoons used in the teaching of RGDLT subjects significantly increased students' academic achievements.

The fourth question of the present research is about whether there was a statistically significant difference between the pre and post-test achievement scores of the Control group. Hence, the pre and post-test achievement scores of the Control group were compared.

**Table 5**
*Wilcoxon Signed-Tank Test Results Regarding the Pre and Post-Test Scores of the Control Group*

| Post-test - Pre-test | *n* | Mean Rank | Sum of Ranks | *z* | *p* | Cohen's r |
|---|---|---|---|---|---|---|
| Negative Ranks | 0 | .00 | .00 | -4.328 | .001* | 0.61 |
| Positive Ranks | 24 | 12.50 | 300 | | | |
| Ties | 0 | - | | | | |

*$p < .05$

When Table 5 was examined, it is seen that there are no students in the Control group whose achievement scores decreased after the teaching. After the teaching process in this group, the achievement scores of all students increased. It was seen that the pre-test achievement mean score of the ABCC group increased from 7.56 to 13.41 after the treatment (Net increase=5.85 points). The mean rank value of the increasing achievement scores of the 24 participants whose achievement score increased after the training was determined as 12.50. A statistically significant difference was found between the mean scores of achievement points before and after the training of the participants in the research group ($z$=4.32, $p$< .05). When the calculated effect size value ($r$=.61) was evaluated according to Cohen (1992)'s scale, it was understood that it had a large effect level. These analyses revealed that the difference between the pre and post-test scores of the *control group*, in which formal curriculum-based teaching activities were employed, were statistically significant. These results indicated that using the teaching activities based on the constructivist approach increase students' academic achievements in the teaching of the RGDLT subjects.

The fifth question of the present research was about whether there is a statistically significant difference between the post-test achievement scores of the three groups. The Kruskal Wallis test was used to reveal whether there was a statistically significant difference between the groups in terms of post-test mean scores.

**Table 6**
*The Kruskal Wallis Post-Test Analysis Results of the Three Groups*

| Group | *n* | $\bar{X}$ | Mean Rank | *df* | $\chi^2$ | *p* | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Control | 24 | 13.41 | 16.40 | | | | |
| CC | 26 | 16.11 | 42.58 | 2 | 38.903 | .001* | .52 |
| ABCC | 25 | 17.16 | 53.98 | | | | |

*$p$< .05

When Table 6 was examined, it is understood that there was a statistically significant difference between the post-test achievement scores of the three groups [$\chi^2(2) = 38.90$, $p$< .05]. The Kruskal Wallis test, which is based on comparing the mean rank of the groups, showed that there was a statistically significant difference between the post-test scores of the three groups. When the calculated effect size value ($\eta 2$= .52) was evaluated according to Cohen (1992)'s scale, it was understood that it had a large effect level.

In addition, The Mann Whitney U-test was performed to find out which groups had a statistically significant difference in their post-test achievement scores. The first of these analysis results is that there was a statistically significant difference between the Control and CC groups in favour of the CC group ($U$=78, $p$= .001). This hypothesis test shows us whether there is a statistically significant difference between the mean ranks of the two groups but does not provide information about the effect size of this difference. For this reason, the effect size value was calculated as it provides an objective measure of the importance of the effect. The calculated effect


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size value ($r$= 0.64) indicated that the difference had a large effect level ($r$ > 0.5) according to Cohen (1992). These findings showed that the students in the CC group, where concept cartoon activities were applied in addition to the methods suggested by the curriculum, were more successful than the students in the control group.

The second of these analysis results was that there was a statistically significant difference between the Control and ABCC groups in favour of the ABCC group ($U$=15.5, $p$= .001). The calculated effect size value ($r$= 0.81) indicated that this difference had a large effect level ($r$ > 0.5) according to Cohen (1992). These findings showed that the students in the ABCC group, in which argumentation-based concept cartoon activities were applied in addition to the methods suggested by the curriculum, were more successful than the students in the control group.

The third, and most notable of these analysis results was that there was a statistically significant difference between the CC and ABCC groups in favour of the ABCC group ($U$= 210, $p$= .027). The calculated effect size value ($r$= 0.31) indicated that the difference had a medium effect level ($r$ > 0.3) according to Cohen (1992). These results revealed that the students who were applied argumentation-based concept cartoon activities in addition to the methods suggested by the curriculum were more successful in the post-test than the students in the CC group who were applied concept cartoon activities in addition to the methods suggested in the curriculum.

The sixth question of the research was about determining whether there was a gender effect on the post-test points of the groups. For this purpose, whether there was a gender difference between the post-test scores of each group was examined using the Mann Whitney $U$-test, and the findings are presented in Table 7.

**Table 7**
*Gender Analysis Results of the Groups' Post-Test Achievement Mean Points*

| Groups | Gender | *n* | Mean Rank | Sum of Ranks | *U* | *z* | *p* |
|---|---|---|---|---|---|---|---|
| Control | Female | 12 | 12.25 | 147 | 69 | -.177 | .860 |
| | Male | 12 | 12.75 | 153 | | | |
| CC | Female | 12 | 13.04 | 156.5 | 78.5 | -.287 | .774 |
| | Male | 14 | 13.89 | 194.5 | | | |
| ABCC | Female | 12 | 14.92 | 179 | 55 | -1.293 | .196 |
| | Male | 13 | 11.23 | 146 | | | |

As seen in Table 7, as a result of this analysis, it was understood that there was no significant difference between the post-test scores of male and female students in the Control group in terms of gender ($U$= 69.000, $p$>.05). When the post-test mean scores of the male and female students in the CC group were compared, it was also seen that there was no significant difference in terms of gender ($U$= 78.500, $p$>.05). Similarly, when the post-test scores of the male and female students in the ABCC group were compared, it was seen that there was no significant difference in terms of gender ($U$= 55.000, $p$>.05). These results showed that the teaching activities used in the groups did not significantly affect the academic achievements of the students in terms of gender.

## Discussion

The present research aimed to explore the effects of argumentation-based concept cartoons and concept cartoons-based teaching activities on the academic achievements of sixth-grade students in science education. With these interventions, while trying to promote the success of the students on the RGDLT unit, on the other hand, it was aimed to reveal how the normal use of concept cartoons and their argumentation-based use affect the achievements of the students.

For this purpose, when the pre-test achievement mean points of the CC, ABCC, and Control groups were compared, it was found that there was no significant difference between them. This result showed that the students in the CC, ABCC, and Control groups were similar in terms of previous learning backgrounds before the treatment.

When the pre-and post-test results of the Control, CC, and ABCC groups were compared, it was determined that there were significant differences in favour of the post-tests in each group. In addition, when the pre and post-test mean scores of the Control group were compared, a statistically significant difference was found between them. Although this result showed that students can be successful if RGDLT topics are taught through


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the activities suitable for the constructivist approach, when other results of the research were considered, it is seen that this success in the Control group was lower than CC and ABCC groups. As hypothesised, the concept cartoons and argumentation-based activities significantly leveraged students' understanding of the given topics. This finding has a major implication that if teaching activities based on the constructivist teaching approach are supported with concept cartoons or argumentation-based activities in teaching appropriate subjects, they can increase the academic success of students. The comparison of the results in this paragraph with the results of previous studies in the literature is given in the next paragraph in order to preserve the integrity of the subject.

The Kruskal Wallis *H*-test, which was used to determine whether there was a statistically significant difference between the post-test scores of the groups, showed that there was a statistically significant difference between the post-test scores of the groups. The fact that the effect size calculated for this result has a large effect level can be said to be another indicator that reflects the level of difference that emerged as a result of the teaching activities in the three groups. The results of Mann Whitney U-test analyses performed to determine which groups had a significant difference in their post-tests showed that there were statistically significant differences between the post-tests of all three groups. In order to interpret significant differences between the Control and CC, Control and ABCC, CC and ABCC groups, the effect-size values were calculated based on the results of Mann-Whitney *U*-test results. The calculated effect size values showed the large effect level for the relationship between the post-test scores of the Control-ABCC and Control-CC groups. However, the effect size value calculated for the relationship between the post-test scores of the Control-ABCC groups was higher than the effect size value of the Control-CC groups. In addition, when the net increases in the mean achievement scores of the CC and ABCC groups were compared, it was seen that the average success score increase of the ABCC group was higher than that of the CC group. This outcome is quite remarkable in that it reveals that the students in the ABCC group who use argumentation-based concept cartoon activities promote their success more than the students in the CC group who use only concept cartoon activities. Based on this result, it can be said that the use of argumentation-based concept cartoon activities in the teaching of the RGDLT unit increased the academic achievement of the students more than the CC group. In the light of the above data, it can be said that the possible reasons for achieving higher success in the ABCC group are that the inquiry and scientific discussion processes initiated by the argumentation process (Naylor & Keogh, 2013) lead the students to think and reason in more detail about the subjects. Because students are not passive listeners in an argumentation-based lesson (Naylor et al., 2007), they participate more actively and for a longer period thanks to concept cartoons and argumentation-based concept cartoons (Pekel, 2019; Türkoğuz & Cin, 2013). During the argumentation-based concept cartoon activities, students asserted claims about the learned subject, defended his/her claims, and attempted to confute the claims did not agree on. These processes may be the main reason for the synergetic increase created by the benefits of argumentation and concept cartoons. On the other hand, it can be stated that the social interactions of the students in the qualified scientific discussions in the small group activities during the argumentation process also facilitated the emergence of this result. These outcomes are in line with the results of previous studies reporting that concept cartoons and argumentation-based activities enable students to participate more in classroom activities (Naylor et al., 2007), increase their attitudes and motivation towards the lesson (Er & Kirindi, 2020), facilitate their learning of scientific concepts (Dawson & Venville, 2013; Jimenez-Aleixandre & Erduran, 2008), improve critical thinking, reasoning, decision making (Evrekli & Balım, 2015; Taşlıdere, 2013) and scientific literacy skills (Kabapınar, 2009; Köseoğlu et al., 2008), increase students' academic success (Ceylan & Atabek Yiğit, 2018; Yılmaz Korkut & Şaşmaz Ören, 2018) and self-confidence (Kıngır et al., 2011), and eliminate misconceptions (Akamca et al., 2009). However, there are also experimental studies using argumentation-based teaching activities reporting no significant difference between the control and experimental groups in terms of students' academic achievement (Çiçek & Öztürk, 2011; Karaman & Pekel, 2020), scientific process skills (Er & Kirindi, 2020), and knowledge retention (Çiçek & Öztürk, 2011).

The Mann Whitney *U*-Test, which was used to reveal whether the teaching activities carried out in the groups affected the post-test achievements of the students in terms of their gender, showed that there was no significant difference. Based on this result, it can be said that the teaching activities used in the control and experimental groups did not significantly affect student achievements in terms of gender. There is a limited number of studies examining whether student achievements vary according to gender in studies using concept cartoons or argumentation-based activities in science education. The above result is in line with the results of some experimental studies (Aslan, 2019; Pekel, 2019) in which argumentation-based teaching activities were used, which reported that there was no significant difference between the control and experimental groups in terms of student gender.


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However, there is also another experimental research that used argumentation-based teaching activities reporting significant differences between the students' academic achievements in terms of their genders (Karaman & Pekel, 2020). Kubiatko et al. (2021) also determined that females have more knowledge about Monocotyledonous plants than males in their studies but reported that the evidence in the literature on the effect of attitudes and knowledge about plants on gender is mixed and varies according to studies. Considering the number of studies on the subject, it can be said that more research results are needed to be able to say whether the use of activities based on argumentation and concept cartoons affects student achievement in terms of gender.

**Conclusions and Implications**

Although there are experimental studies in the science education literature where concept cartoons or argumentation activities are used separately, no research has been found in which concept cartoons and argumentation-based concept cartoons are used experimentally on the same sample. For this reason, the interventions in this research were aimed both to increase the success of the students in the RGDLT unit and to reveal how the normal use of concept cartoons and argumentation-based usage affect student achievement. Therefore, the present research is the first research in science education literature reporting that the argumentation-based use of concept cartoons in teaching the RGDLT unit increases student achievement more than the normal use of concept cartoons. Thus, it guides teachers about which of the two combinations may be more beneficial in increasing student achievement in teaching RGDLT subjects.

In the research, a significant difference in favour of the CC group was found between the post-test scores of the students in the CC group who used concept cartoon activities and the Control group students who only used the methods suggested in the curriculum. Another significant difference was found between the post-test results of ABCC students who used argumentation-based concept cartoon activities besides the methods proposed by the syllabus, and the Control group students. More importantly, when the post-test results of the CC and ABCC groups were compared, a significant difference was determined in favour of the ABCC group.

Research results show that concept cartoons and argumentation-based concept cartoons increase students' academic achievement when used in the teaching of the RGDLT unit. The results also revealed that the teaching activities applied in each group did not cause a significant difference in the post-test achievement scores of the students in terms of gender. Based on the current results, it is possible to say that the use of argumentation-based concept cartoon activities in the teaching of RGDLT subjects can increase the academic achievement of students more than the normal use of concept cartoons. Moreover, through concept cartoons or argumentation activities, teachers can turn difficult-to-learn concepts (e.g., misconceptions) into useful starting points for the correct teaching of related concepts. Thus, it will be ensured that science education is one step closer to its goals.

The recommendations based on the research results are as follows:

1. The results of the research indicated that the success of the students in the RGDLT unit can be promoted if the lesson activities are supported through the use of concept cartoons and argumentation-based concept cartoons while organizing the teaching environments. Considering these results, the use of concept cartoons and argumentation activities in teaching RGDLT subjects may be more beneficial in increasing student achievement.
2. Integrating concept cartoons and argumentation-based activities in other appropriate topics of the sixth-grade science lessons can transform students from passive listeners into active individuals who question and successfully construct what they have learned.
3. Argumentation-based concept cartoons can be used for formative purposes after the teaching process to determine students' understanding levels, knowledge deficiencies and misconceptions about the taught subject, to summarize and reinforce the learned subjects.

*Limitations*

Obviously, the present research also has its limitations. The first limitation of this research was that the research data were obtained only from the students of an urban secondary school, which may not be representative of general secondary school students. It is possible to think that this situation limits the generalisation of the research results. However, most of the misconceptions are not specific to the students of that country, even if they are detected in a particular country. Similarly, empirical research on learning and teaching conducted in local


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samples produce results that have also the potential for useful application in other countries. Because the results of educational research show that when an experimental method applied in one country is applied under similar conditions in other countries, similar results are often obtained. Even if the current research was conducted in a specific country, it is thought that similar results will be obtained if the same activities are applied to students in other countries under similar conditions. In addition, the degree of generalisability of the results obtained in this study will be revealed by the analysis of the results obtained from the application of similar activities on different samples. The second limitation of this study was that the research data were tested only in the teaching of the RGDLT unit of the sixth-grade students. In order to obtain more generalisable and more precise data, it is recommended to conduct research on the use of argumentation-based concept cartoon activities in other countries, in other classrooms, in the teaching of other subjects, in larger samples, in rural schools.

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