IJTASE

ISSN: 2146 - 9466
www.ijtase.net
International Journal of New Trends in Arts, Sports &Science Education – 2024, volume 14, issue 4

AN OVERVIEW OF FINE ARTS HIGH SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING LEVELS ON THE SUBJECT OF 'LIQUIDS' THROUGH THE ACTIVITIES OF CONCEPT CARTOONS

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Received: July 28, 2024 **Accepted:** October 24, 2024 **Published:** October 31, 2024

Suggested Citation:
Alpat, Ş., & Akkuzu Güven, N. (2024). An overview of fine arts high school students' conceptual understanding levels on the subject of 'liquids' through the activities of concept cartoons. *International Journal of New Trends in Arts, Sports &Science Education (IJTASE), 13*(4), 199-217.

Abstract

Students tend to consider "Chemistry" as a course difficult to perceive. In order to eliminate this perception, we thought that it would be important to use concept cartoons activities that include interesting and entertaining elements in line with the abilities of the students. From this point of view, the study aims to investigate the effect of the concept cartoons in teaching "Liquids" unit on the level of conceptual understanding of the ninth-grade students. The participants of the study included 29 students who were enrolled in a Fine Arts High School in the Aegean Region. The study was designed according to one group pre-test/post-test modeling. Concept Cartoons Conceptual Understanding Test (CCCUT), Scenario Drawings (SD) and semi-structured interview were used as data collection tools. The findings of the study revealed that activities based on concept cartoons made a significant difference in students' conceptual understanding levels. Besides, as a result of the interviews, we established that the concept cartoons are interesting, increase motivation, create a discussion environment and encourage students to think came to the fore. Consequently, positive views emerged that concept cartoons provide benefits in many respects and should be used in courses.

Keywords: Concept cartoons, conceptual understanding level, scenario drawings, liquids, fine arts, high school students.

INTRODUCTION

According to the philosophy of constructivism, knowledge is subjective. Information is interpreted and structured by the individual (Driver & Erickson,1983; Wittrock, 1974). The quality of this formation is determined by the individual's current thinking styles. Learning in constructivism is a process in which the individual actively constructs the new information in the light of his/her existing knowledge and even uses the creativity of the individual. It is necessary to use learning materials and activities that will allow the teacher to reveal the mentality of each student in the classroom, to discuss, inquiry and research for accuracy in the classroom environment during teaching (Driver, Guesne, & Tiberghien, 1985). Students learn most effectively when they are exposed to a variety of learning materials. One of the learning materials that are used in students' meaningful learning and encourage students to engage in active scientific thinking are concept cartoons (Keogh & Naylor, 2000).

Concept cartoons created to reveal students' ideas about a topic, to challenge their thoughts, and to support the development of their understanding are a new approach to teaching, learning and assessing in science (Keogh, Naylor, & Wilson, 1998; Naylor & Keogh, 2013). Concept cartoons, which are suggested as a way to acquire a constructivist understanding of learning in the classroom, have been applied by many researchers (Abrahams, 2019; Kusumaningrum, Ashadi & Indriyanti, 2018; Pekel, 2021; Say & Özmen, 2018; Strande & Madsen, 2018; Yurtyapan& Kandemir, 2021). These studies indicate that cartoons have high attention-grabbing and motivational features due to their visual nature, significantly increase motivation even in students with learning disabilities, and create in-class discussions with high active participation.

Concept cartoons are visual tools in which the ideas and discussions of cartoon characters regarding the cause or solution of an event from daily life are presented in written form through speech bubbles (Coll, France, & Taylor, 2005; Keogh & Naylor, 2000; Martinez, 2004; Sexton, 2010; Stephenson & Warwick, 2002). While one of the aforementioned ideas in the concept cartoons contains scientifically correct knowledge, the other ideas are included statements containing misconceptions or alternative conceptions (Chin & Teou, 2009; Kabapınar, 2005; Morris, Merritt, Fairclough, Birrell, & Howitt, 2007; Naylor, Downing & Keogh, 2001; Stephenson & Warwick, 2002). The ideas in the cartoon may be related to the misconceptions or alternative conceptions of the students, as well as different perspectives on an event or an experiment in daily life. The opinions in question are presented to the students at different stages of the course, and the students explain their reasons by determining the appropriate one among them or by writing their own opinions. In this context, various opinions that emerge in the classroom create an environment of cognitive conflict (cognitive imbalance) in the minds of the students. As Naylor, Downing and Keogh (2001) stated in their studies; concept cartoons are used as a stimulus to reveal different views as a result of students' discussions. Thus, it can be said that concept cartoons are designed to enhance scientific thinking and reasoning. Another important feature of concept cartoon is that it enables students to practice using their communication skills through group discussions and lead them to think, thus creating scientific argumentation environments among students (Dabell, 2004; Kabapınar, 2009; Kinchin, 2004; Naylor, Keogh, & Downing, 2007; Webb, Williams, & Meiring, 2008). Creating discussion environments is necessary to engage students in higher order thinking skills, to enable them to interpret scientific events and explore to construct knowledge by discussing it in social environments. In this regard, concept cartoons act as an effective stimulus for argumentation by inviting students to express their views and thoughts (Naylor & Keogh, 2013). Concept cartoons are one of the important evaluation tools in the science education literature in ensuring active participation of the students (Naylor & Keogh, 2009), revealing and increasing their conceptual understanding, identifying and eliminating misconceptions (Naylor & Keogh, 1999; Parkinson, 2004; Sexton, Gervesoni & Brandenburg, 2009; Şaşmaz Ören, 2009). There are many studies on the concept cartoons, especially in the field of science (Atasoy, Tekbıyık, Çalık, & Yılmaz-Tüzün, 2022; Pekel, 2021; Siong, Tyug, Phang, & Pusppanathan, 2023; Türkoğuz & Cin, 2013). For instance, Balım, İnel, and Evrekli (2008) investigated the effect of using concept cartoons in science teaching on students' academic achievement and inquiry learning skills. In their study, it was concluded that the students in the experimental group had higher perception scores on inquiry learning skills than the students in the control group. There was no significant difference between the academic achievements of the two groups. In the study conducted on fifth graders in the unit of living and life from biology subjects, Baysarı (2007) reported that concept cartoons did not cause a significant difference on achievement and attitude. Özyılmaz-Akamca, Ellez, and Hamurcu (2009) investigated the effectiveness of computer-assisted concept cartoon applications on learning achievement in their study on fourth grade students at primary school level. They found that the use of concept cartoons had a positive effect on students' academic achievement. In the study conducted by Webb et al. (2008), the effectiveness of using concept cartoons and written drafts was investigated in terms of using concept cartoons to improve discussion in science classes in Africa. The study was carried out with a total of 96 students in two 9th grades. Students in each class were divided into six groups of eight, and three groups were determined in the study, one of which was video recording, another one was audio recording, and the third was observation and field notes. Within the scope of the study, some of the students stated that the use of written drafts together with concept cartoons caused an increase in the students' in-class discussion levels (Webb et al., 2008). In their research, Chen, Ku, and Ho (2009) tried to determine the effects of discussion-based concept cartoons on the students' discussions. In the study, in which a single group pre-test and post-test design was used, the applications lasted for six weeks with 21 students studying in a primary school. According to the results of the research, they determined that the use of concept cartoons could increase the discussion skills of the students. In addition to all these studies, there are also various studies in the field of chemistry education. Especially when the aforementioned features of concept cartoons are considered studies indicate that concept cartoons might be used in chemistry teaching and learning for enabling students to assess their own level of understanding, elicit their own ideas and alternative conceptions and reinforce their meaningful learning (Gafoor & Shilna, 2013; Özmen, Demircioğlu, Burhan, Naseriazar, & Demircioğlu, 2012; Roesky & Kennepohl, 2008; Ültay, 2015). Studies examining the understanding, comprehension and conceptions show that students at all levels struggle with chemistry concepts and cannot be successful at the desired level. While students learn various fundamental chemistry concepts, they encounter several cognitive conflicts due to alternative concepts (Taber, 2020). In this context, concept cartoons help students to construct their knowledge, eliminate alternative concepts, if any, and improve their conceptual understanding. Since chemistry holds rich volume of abstract concepts that requires substantial time and effort commitments from the students, the use of concept cartoons is extremely important so that students do not have difficulty in learning new concepts (Gafoor & Shilna, 2013). In this regard, students' conceptual understanding levels on “Liquids”, one of the basic and abstract subjects of chemistry, were examined in this study. Within this framework, the research focused on whether the use of concept cartoons has a positive impact on increasing students' conceptual understanding. When studies on the effectiveness of concept cartoons in chemistry education are examined, it is seen that concept cartoons lead the students to clarify their thinking, consider alternative explanations and provide them learning meaningful and permanently (Kabapınar, 2005; Kusumaningrum et al., 2018; Say & Özmen, 2018; Özmen, Demircioğlu, Burhan, Naseriazar, & Demircioğlu, 2012). For instance, Özmen et al. (2012) examined the effectiveness of concept cartoons enhanced laboratory activities for teaching of concepts of acid-base chemistry in primary school and found that concept cartoons help students improve their understanding and reduce their alternative conceptions. Similarly, Kusumaningrum et al. (2018) have tried to identify the effectiveness of concept cartoon on detection student’s misconception in the topic of buffer solution. They suggested that concept cartoons can be used in science learning especially in chemistry because it makes student active in learning, increases motivate to discuss and inquire their knowledge. In fact, apart from the studies examining the effectiveness of concept cartoons alone, there are also studies claiming that concept cartoons have remained a part of various teaching approaches. One of the studies conducted with this perspective in mind was the effect of concept cartoons embedded within context-based learning approach on 8th grade students’ alternative conceptions of “chemical bonding” (Ültay, 2015). In another study, investigating the students' misconceptions about "gas pressure", concept cartoons, animation and diagnostic branched tree supported conceptual change texts were developed and point out that concept cartoon was an appropriate tool to enable students to express their prior knowledge clearly (Şahin & Çepni, 2011). All of these studies indicate that concept cartoons help students discuss their opinions in classrooms, reveal their misconceptions and improve their conceptual understandings.

Concept cartoons also facilitate conceptual understanding with their visual aspects. Dempsey and Betz (2001) claimed that "an excellent way to describe an object is to draw it". Through drawing, students learn to see natural phenomena and scientific concepts in their minds from an aesthetic point of view (Pugh & Girod, 2007). This shows that the content of scientific education is not far from art, and that art supports it in many ways.

As a result; the difference of this study is that the concept cartoon technique has been used in the teaching of the subject of liquids, and it has been tried to ensure that the knowledge is structured by the student, considering the special talents and interests of the students studying at the Fine Arts High School painting department. Hence, the aim of this study was to investigate the effect of concept cartoons on the conceptual understanding of the liquids of Fine Arts High School 9th grade students. For this purpose, answers were sought to the following sub-problems in this study:

- Is there a significant difference between the pre-test and post-test mean scores of the students for the concept cartoons test?
- Is there a significant difference between the pre-test and post-test mean scores of the students' scenario drawings on liquids test for determining the level of conceptual understanding?
- What are the students' views on concept cartoons activities?

METHOD

Pattern of the Research

This research was carried out using a single-group pretest-posttest experimental design, which is one of the quantitative research approaches. In experimental studies, researchers observe the effects of at least one independent variable on one or more dependent variables (Cohen, Manion, & Morrison, 2005; Gay & Airasian, 2000). In the study, a single group pre-test post-test experimental design, which is one of them was used and the measurements were evaluated by considering the pre-test and post-test scores on a single group (Table1). The measurements of the dependent variable of the experiments were applied to the students as a pre-test before the application and as a post-test afterwards, using the same measurement tools.

Table 1. Research design of the study

Pre-test	Process	Post-test
T1: Concept Cartoon Conceptual Understanding Test (CCCUT) T2: Scenario Drawings (SD)	Teaching process with concept cartoons activities	T1: Concept Cartoon Conceptual Understanding Test (CCCUT) T2: Scenario Drawings (SD) T3: Semi-structured Interview

Study group

In order to determine the participants of the research, the convenience sampling method, a kind of non-probability sampling procedure in which the sample is obtained from a group of individuals easily accessible or reachable, was used. This method is expressed as including the closest individuals in the sample on a voluntary basis in the selection of the participants to be included in the research (Dörnyei, 2007). The study group of the research consisted of 29 students studying in the ninth grade of a Fine Arts High School located in the Aegean Region of Turkey.

The reason for conducting this study on fine arts high school art department students is to see to what extent they can associate chemistry with their fields. Fine arts painting department students take chemistry as a common course in the 9th grade. For 4 years, they take courses in subjects such as basic art, sculpture, graphic design, art history, drawing studies and charcoal drawing. For example, within the scope of the basic art education course, they learn subjects such as point-line, stain, texture, shape and form, color information, and gouache paint, oil paint, watercolor techniques in the two-dimensional art workshop course. These subjects require students to comprehend the general properties of liquids. As a result, their conceptual understanding of "liquids" in chemistry classes is critical. Members of the target population were included in the sample because they met practical criteria such as easy accessibility, availability at a given time, and willingness to participate. The ages of the participants vary between 14-15, and 65.52% (n=19) of the participants are female and 34.48% (n=10) are male students.

Data Collection Tools

Concept Cartoon Conceptual Understanding Test (CCCUT), Scenario Drawings (SD) and semi-structured interview were used as data collection tools in the research.

Concept Cartoon Conceptual Understanding Test (CCCUT)

In order to determine the effectiveness of concept cartoon-supported activities on the conceptual understanding of the subject of "Liquids" of the "States of Matter" unit, a concept cartoon test consisting of open-ended questions was developed by the researchers. CCCUT were prepared in accordance with the learning outcomes within the scope of the curriculum and it consisted of 9 concept cartoons with open-ended questions on the subject of "Liquids" of the "States of Matter" unit. While preparing the concept cartoons, the related literature was reviewed and concept cartoons were designed according to the instruction prepared by Atasoy (2017). This instruction, which consists of six stages, is presented in Figure 1.

IJTASE
ISSN: 2146 - 9466
www.ijtase.net
International Journal of New Trends in Arts, Sports &Science Education – 2024, volume 14, issue 4

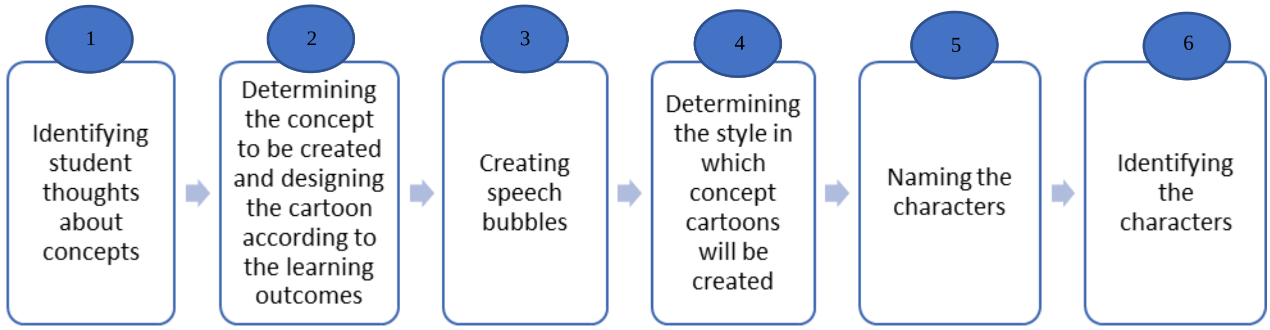


Figure 1. The process of designing concept cartoons

At the stage of determining student thoughts about concepts, studies on the misconceptions on the subject of liquids were examined and common misconceptions were identified. In the second stage, concept cartoons were prepared for each learning outcome in order to determine the concept to be created and design the cartoon. While preparing the concept cartoons, the expert opinion of the art teacher at the school was consulted in terms of suitability for the level of the student, character selection and attractiveness. The learning outcomes of concept cartoons on the subject of liquids are presented in the Table 2. Cartoons were prepared based on the learning outcomes in the 2017 fine arts secondary education curriculum.

Table 2. Learning Outcomes of CCCUT

Cartoons	Learning Outcomes
C1	Relates the surface tension, viscosity, vapour pressure of liquids with intermolecular interaction.
C2	Relates the viscosities of different liquids to temperature. a. Viscosities of different liquids such as water, glycerine, olive oil, honey, jam, molasses are compared. b. Examples from daily life are given for the variation of viscosity with temperature.
C3	Uses concepts related to fluids and their properties to explain natural phenomena.
C4	The presence of water vapour in the atmosphere is associated with the concept of humidity.
C5	The concepts of real and felt temperature given in meteorology news are associated with relative humidity.
C6	Explains the concept of equilibrium vapour pressure through the evaporation-condensation processes in closed vessels.
C7	It is emphasized that boiling is an event that depends on external pressure (pressure above the liquid)/geographical altitude; Examples of industrial applications of boiling/evaporation under low/high pressure are given.
C8	Explains that boiling and evaporation are different from each other.
C9	Explains the capillary effect of liquids and the tendency of liquids to form drops through the concept of surface tension. a. The transport of water to tree/plant stems is explained with examples of mercury's non-wetting.

In the third stage, which is "creation of speech bubbles" in preparing concept cartoons, three or four student thoughts were formed in each cartoon. While one of these thoughts consists of valid thought; the other thoughts include the misconception. Alternative ideas about the concept in the concept cartoons were created equally, and it was paid attention that there were no signs that would direct the students to the valid idea. In the fourth stage, since the written expressions of the students will be examined, concept cartoons in the style of the worksheet containing the student responses were used. At the stage of naming the characters, attention was paid to give names that the students might encounter in their lives. In the stage of determining the images of the characters in the concept cartoons, concept cartoons were prepared by paying attention to the fact that the visuals that the students could encounter in their lives, that would attract their attention and were convincing. After the cartoons were created, views from professionals in the field of chemistry education were sought to determine whether the cartoons were appropriate for the learning outcomes and whether they accurately reflect the content. In line with expert opinions, changes were made in three questions in the test, and these were in the sections of relating to daily life or in the speech bubbles of the characters. Four students who were not part of the study group were interviewed about the questions after the necessary modifications had been made in order to determine the concept cartoon test and the questions' clarity. The final version of the CCCUT on the subject of liquids, which consists of 9 questions, was developed after certain modifications were made in response to the students' comments. Sample concept cartoons are given in Figure 2.

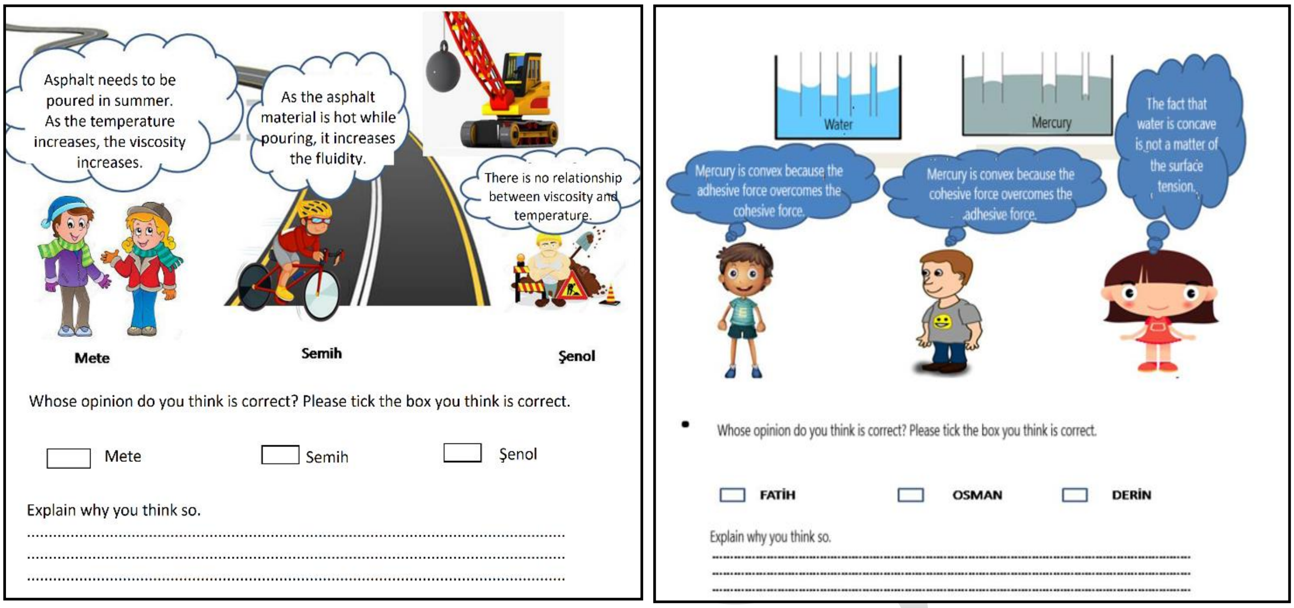


Figure 2. Sample cartoons from the CCCUT.

The scoring of the concept cartoons was done by taking into account the scoring of Ormancı and Şaşmaz-Ören (2011). The categories and scores related to the concept cartoons test are given in Table 3.

Table 3. Category and scoring for the CCCUT

Categories	Points
Correct Answer - Correct Explanation (CA-CE)	3
Correct Answer -Partly Correct Explanation (CA-PCE)	2
Wrong Answer - Correct Explanation (WA-CE)	2
Correct Answer - Incorrect Explanation (CA-IE)	1
Wrong Answer - Partially Correct Explanation (WA-PCE)	1
Wrong Answer -Wrong Explanation (WA-WE)	0
Null	0

Scenario Drawings

Considering the interests and abilities of the students studying at the Fine Arts High School Painting Department, the scenario drawings in which the students could reflect their thoughts on the subject of liquids were evaluated. As a data collection tool, the scenarios created by the researchers on the subject of 'Liquids' were presented to the students before and after the application, and they were asked to reflect the events related to the subject of liquids in the scenarios as drawings. The researchers created scenarios, and at this point, scenario preparation procedures were followed. First of all, attention has been paid to the fact that there are three main sections in the structure of the scenario: introduction, development and conclusion. To ensure that the content of each scenario is appropriate for the achievements of the subject of liquids, that there is a constant development and progress in the scenarios, and that they are fluent and understandable, care was taken not to include long and complex sentences. Also taken into consideration were the choice of words, the way physical events related to liquids were handled in the script, the existence of a specific plot, characters, and setting. The story was intentionally kept brief. All of these factors are useful in assisting pupils in simply visualizing the scenarios. The appropriateness of the content of each scenario in light of the achievements in the subject of liquids was discussed and necessary corrections were made after consulting relevant experts. The students were instructed to draw a total of 9 scenarios that were provided to them. Example Scenario is given in Figure 3.

Melis and Filiz go home to cook because they are very hungry after school. They decide to make pasta on the way. When they come home, they see that the pot is dirty in the kitchen. While thinking about how to remove the dirt, Filiz remembers what she saw from her mother and says that the pot should be washed with detergent and then rinsed with water. They decide to wash in this way and see how easily the dirt is separated with detergent during washing. After washing, she sees that the water droplets are stuck on the pot. She asks Melis why this happened. Then, to boil the pasta, they fill the pot with water and wait for it to boil on the stove. Filiz says she wants to eat her pasta with ketchup and Melis with grated tomato sauce. Filiz poured ketchup on her pasta and ate it with pleasure, while Melis poured tomato sauce and ate her pasta with pleasure.

a) How do you think the detergent interacts with the water and removes the dirt from the pot? Please explain.

b) After rinsing the pot with water, what do you think might be the reason why the water droplets cling to the spherical pot? Please explain.

c) If we closed the lid of the pot while boiling the pasta water, do you think the boiling point would decrease? Please explain.

d) How would you explain the concepts of boiling and evaporation? Are they both the same concept? Please explain.

e) If we added salt to water, what do you think would change the boiling time? Please explain.

f) What kind of difference do you see between the grated tomato sauce and the fluidity of the ketchup? Explain why.

Describe the events mentioned above by drawing them and explaining their causes.

Figure 3. Example scenario.

Drawings of scenarios were scored based on the categories of conceptual understanding. Data analyzes related to scenario drawings are given in Table 4.

Table 4. Scoring of the scenario drawing

Categories	Explanation	Points
Sound Understanding (SU)	Drawing and explanation are scientifically correct	3
Understanding (U)	Drawing is incorrect and explanation is scientifically correct	2
Partial Understanding (PU)	Drawing and explanation are partially correct	1
Conceptual Misunderstanding (CM)	Although there are drawing and description; but they are not related to the concept and mixed with other concepts.	0
No Response (NR)	Drawing is incorrect-No explanation No drawing – No explanation	0

Semi-structured Interview

In the research, an interview was held after the application in order to get the opinions of the students about the concept cartoons activities. Interviews can take different forms depending on the availability of resources and the characteristics of the data to be collected in the research. These are structured interview, semi-structured interview, unstructured interview, ethnographic interview, and focus group interview. In our study, a semi-structured interview was used. Semi-structured interview is applied in order to obtain both fixed-choice answering and in-depth data in the relevant field. It has advantages such as ease of analysis, opportunity to express oneself to the interviewee, providing in-depth information when necessary, and disadvantages such as loss of control, spending too much time on unimportant matters, and decreased reliability because the interviewees are not approached with certain standards. In the preparation phase, an interview form consisting of 6 open-ended questions was prepared by the researchers for the purpose of semi-structured interview. Expert opinion was sought while forming the interview questions. During the implementation process, each interview lasted 15 minutes and the interviews were conducted with 12 volunteers. Data analysis of semi-structured interviews was done by content analysis (f and %) and the percentage of agreement was found.

Implementation Process

Since the school where we carried out the application were the students of the Fine Arts High School Painting Department; the concept cartoon technique was chosen in accordance with the interests and abilities of the students. The implementation process took 4 weeks and the process is explained in Table 5.

Table 5. Application process

Weeks	Applications
1.Week	First of all, the students were met. Permission was obtained from the teachers and students to carry out the application. In order to implement the process, information was given about the subject, concept cartoon, scenario drawing and the process. It was emphasized that the study would be implemented without any grade concerns. Our aim was to make the students feel comfortable during the application. When the pre-test papers were distributed to the students, the concept cartoons first caught the attention of the students. Extra blank papers were distributed so that students could make free drawings in the scenario drawing in order to benefit from their painting skills. The pre-test process was applied.
2.Week	According to the constructivist approach, the subject of Liquids was handled by using concept cartoons. In order for the students to be active during the process, worksheets containing concept cartoons were distributed. A discussion environment was created by reflecting the concept cartoons in the worksheet on the smart board and the misconceptions were tried to be eliminated.
3.Week	CCCUT and SD were applied as the post-test on the subject of Liquids.
4.Week	Considering the scores of the students in the post-tests, 12 students at lower, middle and upper levels were selected for the interview. Semi-structured interviews were conducted to collect students' thoughts on the concept cartoons activity.

Data Analysis

Normal distribution is checked with Shapiro-Wilk test in order to use parametric tests in the analysis of the data, and test distribution is found normal. After determining the conformity of the data to the normal distribution, independent groups t-test was used to compare the pre-test-post-test scores. Descriptive statistics such as frequency and percentage distribution were used in achievement tests. SPSS statistical package program was used in the analysis.

The data obtained from the interview data were subjected to content analysis. This method is based on the creation of concepts and themes related to data. With this method, the semantic contents of the participants' expressions are systematically defined (Altunışık, Coşkun, Bayraktaroğlu, & Yıldırım, 2010: 322; Yıldırım & Şimşek, 2008: 89). In the data analyzed question by question, repetition statements with the same meaning were combined and considered as a single statement. In the next stage, the data were coded according to the key concepts created by considering the relevant literature, and these key concepts were gathered under the themes determined by the researchers. Attention was paid to the fact that the data collected under the determined themes for the internal consistency of the research constitute a meaningful whole, and for the external consistency, the themes provide integrity within each other (Denzin & Lincoln, 1998; Silverman, 2000). The reliability of the coding process of the data was calculated using the percent agreement percentage formula of Miles and Huberman

(1994) between the three raters. The reliability calculation of the study was determined using the Percent Agreement Formula [P = (Na / Na + Nd) x 100] (P: Percent Agreement, Na: Amount of Agreement, Nd: Amount of Discord). When the percentage of agreement in the reliability calculation is 70%, the percentage of reliability is considered to have been reached (Yıldırım & Şimşek, 2008). According to the data we obtained, the percentage of agreement in the reliability calculation was determined as 88% and it was accepted that the percentage of reliability was reached. The themes determined as a result of the content analysis were presented as frequency and percentage analysis. Sample student sentences were also quoted in order to directly reflect the thoughts on the determined themes. In the light of the analyzed data and themes identified, the findings are presented in tables for each question separately for each question in the results section.

RESULTS

In this part, the findings and interpretations obtained from the research are given in line with the problems addressed in order to determine the effectiveness of the use of concept cartoons together.

Findings Related to First Sub-Problem

The first sub-problem of the study, "Is there a significant difference between the pre-test and post-test average scores of the students in the CCCUT?" was sought to be answered. Findings related to the first sub-problem are presented in the Table 6 and in the Table 7. The scores that the students got from the concept cartoons pre-test and post-test are given. While the students had an average of 1.92% and 8.04% in the pre-test, CA-CE and CA-PCE, respectively, these rates increased from 33.34% and 20.69% in the post-test. Similarly, a decrease was observed in the WA-WE category in terms of percentage (33.72% to 12.64%) in the post-test. Additionally, the number of students who left the questions blank decreased considerably and students answered the questions in the post-test.

Table 6. Results from the pretest of the CCCUT

CATEGORY	**CA-CE**		**CA-PCE**		**WA-CE**		**CA-IE**		**WA-PCE**		**WA-WE**		**Null**	
CARTOON	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
1	1	3.45	4	13.79	0	0.00	15	51.72	0	0.00	2	6.90	7	24.14
2	1	3.45	5	17.24	0	0.00	1	3.45	0	0.00	9	31.03	13	44.83
3	0	0.00	3	10.34	0	0.00	17	58.62	0	0.00	8	27.59	1	3.45
4	1	3.45	0	0.00	0	0.00	3	10.34	3	10.34	22	75.87	0	0.00
5	0	0.00	2	6.90	0	0.00	24	82.76	0	0.00	2	6.90	1	3.45
6	0	0.00	0	0.00	0	0.00	15	51.72	0	0.00	13	44.83	1	3.45
7	2	6.90	6	20.69	0	0.00	17	58.62	0	0.00	4	13.79	0	0.00
8	0	0.00	1	3.45	0	0.00	17	58.62	0	0.00	10	34.48	1	3.45
9	0	0.00	0	0.00	0	0.00	10	34.48	0	0.00	18	62.07	1	3.45
TOTAL	**5**	**1.92**	**21**	**8.04**	**0**	**0**	**119**	**45.59**	**3**	**1.15**	**88**	**33.72**	**25**	**9.58**

Table 7. Results from the posttest of the CCCUT

CATEGORY	**CA-CE**		**CA-PCE**		**WA-CE**		**CA-IE**		**WA-PCE**		**WA-WE**		**Null**	
CARTOON	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
1	4	13.79	9	31.03	0	0.00	14	48.28	0	0.00	2	6.90	0	0.00
2	16	55.17	8	27.59	0	0.00	3	10.34	1	3.45	1	3.45	0	0.00
3	9	31.03	2	6.90	2	6.90	9	31.03	5	17.24	2	6.90	0	0.00
4	12	41.38	1	3.45	0	0.00	2	6.90	4	13.79	10	34.48	0	0.00
5	7	24.14	7	24.14	0	0.00	12	41.38	0	0.00	2	6.90	1	3.45
6	7	24.14	6	20.69	0	0.00	4	13.79	2	6.90	10	34.48	0	0.00
7	15	51.72	4	13.79	0	0.00	10	34.48	0	0.00	0	0.00	0	0.00
8	9	31.03	11	37.93	0	0.00	7	24.14	0	0.00	2	6.90	0	0.00
9	8	27.59	6	20.69	0	0.00	7	24.14	4	13.79	4	13.79	0	0.00
TOTAL	**87**	**33.34**	**54**	**20.69**	**2**	**0.77**	**68**	**26.05**	**16**	**6.13**	**33**	**12.64**	**1**	**0.38**

Sample scoring for the analysis of the concept cartoon test given in Figure 2 is presented in Table 8. It shows some examples of the students' responses to the CCCUT.

IJTASE
ISSN: 2146 - 9466
www.ijtase.net
International Journal of New Trends in Arts, Sports &Science Education – 2024, volume 14, issue 4

Table 8. Example scoring for the CCCUT

Category	Explanation	Point
CA - CE	*Osman – Cohesion force is the force of attraction between molecules within the substance itself. Mercury is a non-wetting substance and is convex because its cohesive force overcomes the adhesion force. (S9).*	3
CA - PCE	*Osman – It is convex because it has cohesive force (S7).*	2
WA - CE	*Fatih and Derin – The cohesive force is between molecules of the same kind, the adhesion force is between molecules of different kinds. (S4).*	2
CA - IE	*Osman – It is convex because it is a mercury-wetting substance. (S25)*	1
WA - PCE	*Fatih and Derin – It is concave because it is a water-wetting substance, and convex because it does not wet mercury. (S16)*	1
WA -WE	*Fatih and Derin – Surface tension is not related to mercury (S18).*	0
Null	-	0

In order to answer the question "Is there a significant difference between the pre-test and post-test average scores of the students' concept cartoon test on liquids?", an independent t-test analysis of the pretest-posttest scores of the students related to the CCCUT was conducted and the results are given in Table 9.

Table 9. Independent t-test results of students' pre-test and post-test scores of CCCUT

Test	N	Mean	S	sd	t	p*
Pre-test	29	3.069	2.250	56	-6.309	.00
Post- test	29	9.172	4.698			

p<.05

According to the results of the Table 9, a significant difference was found according to the pretest-posttest scores of the students on the CCCUT. However, the findings also show that the scores did not increase significantly. This may be due to the low chemistry background of the fine arts high school students who enter high schools with the talent exam.

Findings Related to Second Sub-Problem

The second sub-problem of the study is as follows: "Is there a significant difference between the pre-test and post-test mean scores of the students' scenario drawings test on liquids?". Findings related to the second sub-problem are given in Table 10 and Table 11. The scores of the students in the scenario drawing test pre-test and post-test are presented. While the students had an average of 1.53% and 5.36% in the SU and U categories, respectively, in the pre-test, these rates increased to 13.79% and 12.64% in the post-test.

Table 10. The results of pre-test of scenario drawing test

CATEGORIES	SU		U		PU		CM		IR	
QUESTIONS	f	%	f	%	f	%	f	%	f	%
1A	0	0.00	0	0.00	4	13.79	2	6.90	23	79.32
1B	0	0.00	1	3.45	6	20.69	1	3.45	21	72.42
1C	0	0.00	2	6.90	4	13.79	13	44.83	10	34.48
1D	2	6.90	3	10.34	5	17.24	9	31.03	10	34.48
1E	1	3.45	3	10.34	12	41.38	5	17.24	8	27.59
1F	0	0.00	4	13.79	10	34.48	6	20.69	9	31.04
2A	0	0.00	0	0.00	3	10.34	3	10.34	23	79.31
2B	0	0.00	1	3.45	5	17.24	5	17.24	18	62.07
2C	1	3.45	0	0.00	4	13.79	7	24.14	17	58.62
Total	**4**	**1.53**	**14**	**5.36**	**53**	**20.31**	**51**	**19.54**	**139**	**53.26**

Table 11. The Result of post-test of scenario drawing test

CATEGORIES	SU		U		PU		CM		NR	
QUESTIONS	f	%	f	%	f	%	f	%	f	%
1A	0	0.00	2	6.90	6	20.69	1	3.45	20	68.97
1B	2	6.90	5	17.24	9	31.03	5	17.24	8	27.59
1C	3	10.34	7	24.14	5	17.24	9	31.03	5	17.24
1D	11	37.93	7	24.14	4	13.79	3	10.34	4	13.79
1E	4	13.79	3	10.34	9	31.03	4	13.79	9	27.59
1F	4	13.79	5	17.24	8	27.59	2	6.90	10	37.93
2A	7	24.14	3	10.34	7	24.14	1	3.45	11	34.48
2B	2	6.90	0	0.00	10	34.48	1	3.45	16	55.17
2C	3	10.34	1	3.45	7	24.14	0	0.00	18	62.07
Total	**36**	**13.79**	**33**	**12.64**	**65**	**24.90**	**26**	**9.96**	**101**	**38.7**

Sample scoring for the scenario drawing test is given in Table 12. Here, students' drawings were evaluated according to their conceptual understanding levels and a sample evaluation table was presented, which included student statements along with the drawings.

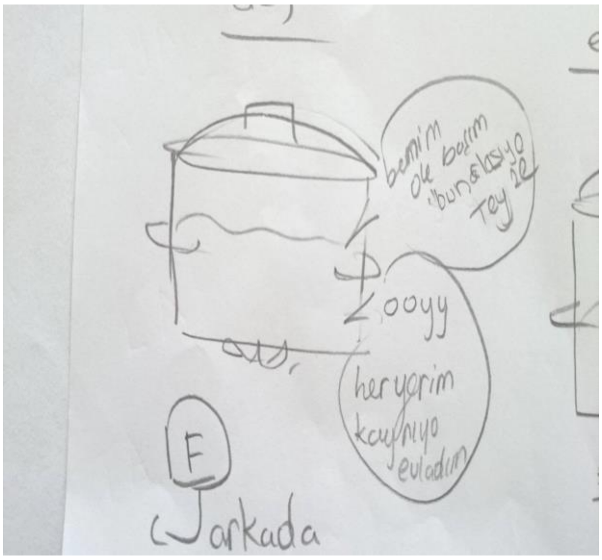
Table 12. Sample scoring for the scenario drawing

Category	Explanation	Point
SU	*1b) Drawing Correct – After the pot is rinsed, the reason why the droplets stick in the pot in the form of a sphere is the cohesion force arising from the attraction force between the molecules… The tendency of water to form drops is related to surface tension (S11).*	**3**
U	*1f) Drawing Wrong – Tomato sauce is thicker because of its higher viscosity.. Ketchup is more fluid (S2).* *1f) Drawing Correct - Grated tomato sauce has pulp. Not fluid. Since it is made by hand, there is no additive (S15).*	**2**
PU	*1c) Drawing Partially Correct – If we close the lid of the pot while boiling the pasta water, the boiling point will not decrease. (S29)*	**1**
CM	*1e) Drawing Wrong - When we add salt to the water, the water boils slower. Because if the amount of salt increases, the density of the water increases.(S13)*	**0**
Null	*1a) Drawing Incorrect – No explanation.*	**0**

How would you explain the concepts of 1d) Boiling and evaporation in the scenario drawings of the students in the Figure 3a below? Are they both the same concept? Please explain. The cartoons they made in the pre-test and post-test and their answers were given to the question.

Pre-test

Post-test



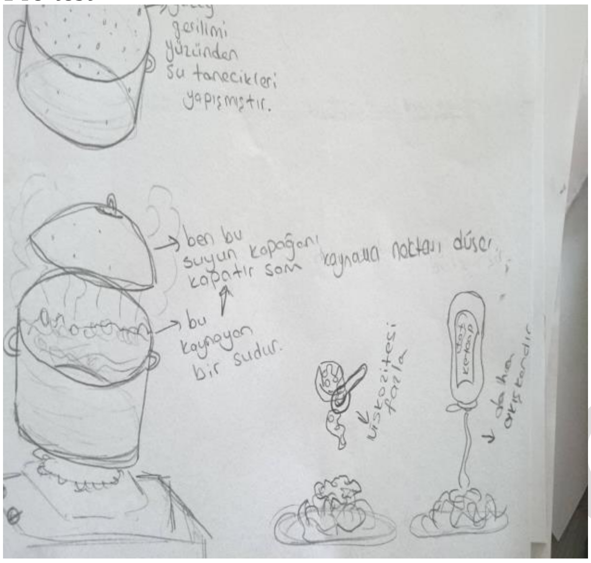
S.4 "Not the same concept but similar."

S.4 "Boiling happens all over the liquid, evaporation happens on the surface.."

Figure 3a. Some examples of students' test and posttest answers from the scenario drawing

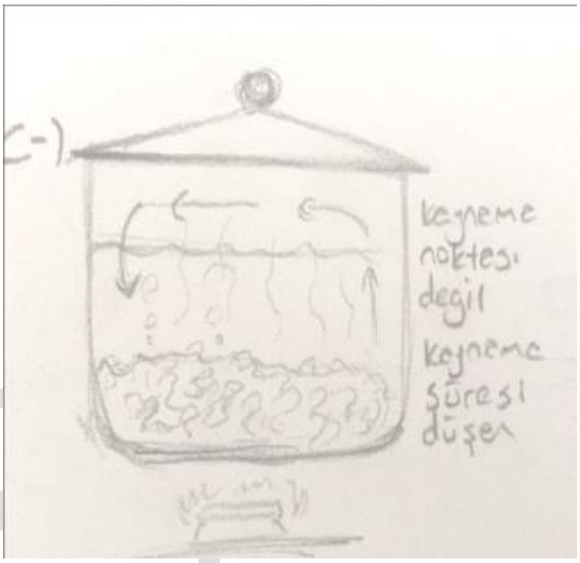
Students 1c) If we closed the lid of the pot while boiling the pasta water, do you think the boiling point would decrease? The caricature they drew in response to the question and the answer they gave to the question are given in Figure 3b.

Pre-test



S.2 "I think it decreases. Because the vapors cannot be separated and condensation increases. This lowers the boiling point."

Post-test



S.2 "The boiling time decreases, not the boiling point. Because there is a dense steam."

Figure 3b. Some examples of students' test and posttest answers from the scenario drawing

The independent t-test results of the students' pretest-posttest scores related to the Scenario Drawing Conceptual Understanding Level Determination Test are given in Table 13.

Table 13. Independent t-test results of students' pre-test and post-test scores for the scenario drawing test on liquids

Test	N	Mean	S	sd	t	p*
Pre- test	29	7.035	1.592	56	-9.090	.00
Post- test	29	15.965	5.046			

*p<.05

According to the results of the analysis, a significant difference was found between the scenario drawings and concept comprehension levels of the students from the pre-test to the post-test. While the mean score was 7.035 in the pre-test, this value increased to 15.965 in the post-test.

Findings of the Third Sub-problem

In the third sub-problem, semi-structured interviews with six open-ended questions were applied to get the opinions of the students on the applied activity, and the student answers were analyzed by content analysis and categories were determined. The data obtained from the open-ended questions are given in the tables 14, 15, 16,17,18 and 19. Six open-ended questions are presented consecutively.

1st open-ended question: Have you ever encountered concept cartoons before? How

Table 14. Frequency (f) and percentage (%) distribution of the answers given to the 1st open-ended question

Category	f	%	Sample student opinions
Yes	8	66.6	*Yes. An outside teacher taught a lesson like this in primary and secondary school. (S.1)*
No	4	33.3	*I did not meet (S.2)*

While 66% of the students said "yes" to the question of whether they had encountered concept cartoons before, 33.3% of the students stated that they had not encountered them before.

2nd open-ended question: What caught your attention most in concept cartoons? Why?

Table 15. Frequency (f) and percentage (%) distribution of the answers given to the 2nd open-ended question

Category	f	%	Sample student opinions
Visuality	12	100.0	*There were coloring and shapes, and it caught my attention that it was made so that those who could not perceive it audibly could understand it better with visual memory. (S.3).*

All of the students stated that concept cartoons attracted their attention in terms of visuality and this would contribute to visual memory.

3rd open-ended question: What are your views on the use of concept cartoons in chemistry class?

When the opinions of the students about the concept cartoons were analyzed, some of the students thought that concept cartoons help to increase motivation (f: 5; 41.6%); they were interesting (f: 6; 50.0%) and funny (f: 7; 58.3%). Besides that, all of the students' responses indicated that concept cartoons were memorable and facilitated learning (See Table 16).

Table 16. Frequency (f) and percentage (%) distribution of the answers given to the 3rd open-ended question

Category	f	%	Sample student opinions
Facilitating learning and ensure memorable	12	100.0	*I think it was very good, I am a person who does not understand chemistry lessons, formulas or something required memorization. Because what they presented to us was more visual and easier to understand (S.7).* *It should be used in every lesson, not just chemistry. Colorful things draw attention and make it easier for me to learn. (S.9).* *It's fun and more memorable for a student. (S.4)*
Funny	7	58.3	*A fun and enjoyable narration awaits us. (S.2)* *It was very nice, it was a fun and different experience, seeing things that would interest me made me adapt to that subject easily (S.11)*
Interesting	6	50.0	*Yes. Because I'm studying in the painting department, I liked learning about chemistry by cartooning the liquids topic of the chemistry course. (S.6).*
Increasing motivation	5	41.6	*It increased my motivation. Otherwise, there was not much visual in the chemistry class, it was more beautiful like that. (S.10)*

4th open-ended question: Were the events or cases in the concept cartoons the ones you encountered in your daily life? If your answer is yes, how do you establish the relationship between these cases or events in your cartoon and your daily life?"

Table 17. The frequency (f) and percentage (%) distribution of the answers given to the 4th open-ended question

Category	f	%	Sample student opinions
Reflecting daily life	10	83.3	*Most of the characters you give us are events we encounter in everyday life. That's why it allowed me to relate. (S.5)* *For example, it makes us think more about a weather event such as rain or hail.(S. 12)*
Facilitating understanding of facts	6	50.0	*It allows us to better analyze the events that take place in daily life and thus understand them more easily. (S.8)*

The students thought that they could encounter the cases in the cartoons in daily life, that they could reflect them to situations in daily life (f: 10; 83.3%), and that cartoons provided convenience in understanding and phenomena (f: 6; 50,0%).

5th open-ended question: Did the teaching of the lesson with concept cartoons affect your drawings about the events in the scenarios given to you? If so, how?

Table 18. The frequency (f) and percentage (%) distribution of the answers given to the 5th open-ended question

Category	f	%	Sample student opinions
Attracting attention	8	66.6	*Yes, it had an effect because it caught my attention, you just changed to good places. It made my drawing easier, more memorable. (S.12).*
Facilitation	4	33.3	*Yes, since my visual memory is slightly better than auditory memory, drawing something came to me rather than writing or reading it, it made it easier for me to learn (S.10).*
Improving modelling skills	3	25.0	*The elements I formed in my mind in the explanation of boiling and evaporation events have changed.(S.11)* *At first, I thought that mercury's non-wetting property was similar to water; I thought that both substances showed similar behaviours, so I showed it incorrectly in my drawing. However, after discussing it in the cartoons, I think I drew correctly about adhesion and cohesion forces.(S. 2)* *Yes, my drawing contained creative elements just like an art activity (S.4)*

In Table 18, it has been tried to determine whether explaining the subject of liquids using concept cartoons is effective in their learning. While some of the students stated that it attracted their attention (f:8, 66.6%), another part emphasized that it facilitated their understanding (f:4, 33.3%). Additionally, a few students (f:3, 25.0%) also expressed that the application improved their modelling skills.

6th open-ended question: ''Did the concept cartoons in chemistry lesson have any shortcomings for you? If yes, what are they? In another open-ended question, students were asked to indicate their deficiencies in the applied concept cartoons.

Table 19. The frequency (f) and percentage (%) distribution of the answers given to the 6th open-ended question.

Category	f	%	Sample student opinions
No	10	83.3	*It had no shortcomings, it was a successful study(S.7).*
Yes	2	16.6	*They don't explain the subject in detail, they just took it superficially, maybe you did it on purpose, I don't know (S.2).* *Sample cartoons that relate the topic of liquids to the field of painting could have been used (S.10)*

In Table 19, it was tried to determine whether there were any deficiencies in the applied study. Most of the students thought that there was no deficiency (f:10, %:83.3). Few students stated that the cartoons were superficial and not related to the field of painting (f:2, %:16.6).

DISCUSSION and CONCLUSIONS

In this study, considering the abilities and interests of 9th grade students of Fine Arts High School Painting Department, the effects of concept cartoons on the conceptual levels of the unit of states of matter "liquids" and their views on the method were examined. At the end of the research, when the findings obtained from the concept cartoons and scenario drawings of the students were examined, it was seen that the activities of concept cartoons significantly affected their conceptual understanding of liquids. The research was carried out with a single group of 29 students based on the pre-test-post-test model. Although there was a significant difference between the scores of the students in the concept cartoons test, the scores are quite low. There are many studies in the literature that the concept cartoons based on the constructivist approach increase the success of students due to their features such as ensuring active participation of students in the lesson and increasing conceptual understanding (Balım et al., 2008; De Lange, 2009; Kabapınar, 2009; Naylor & Keogh, 2009; Roesky & Kennepohl, 2008; Yılmaz, 2020). The results obtained in this study on concept cartoons can be compared with the results obtained in some studies in the literature in various aspects. For example, the results of this study are consistent with the studies indicating that they play a constructive role in detecting and eliminating misconceptions in students (Chin & Teou, 2009; Kabapınar, 2005; Minárechová, 2016; Ültay, 2015). For example, Minárechová (2016) determined that it is possible to develop/change children's naive ideas by applying the concept cartoon method to science teaching. In our study, for example, in relation to the items comparing intermolecular forces in concept cartoons, some student answers in the pre-test included statements such as "fat molecules hold on tighter than honey", but these were replaced by statements such as "honey is less fluid than milk due to the intermolecular attractive force" in the post-test. Similarly, Chin and Teou (2009) used concept cartoons, learners' own drawings and students' discussions with each other while explaining the inheritance unit in their research. When the students' drawings were examined, it was revealed that they had many misconceptions. They argued that concept cartoons can be used as a vital assessment tool to reveal learners' ideas about the subject.

When the students' interview findings about concept cartoons were examined, in summary; it could be grouped under the categories of facilitating learning, reflective daily life, entertaining, facilitating understanding of facts, visual, increasing motivation and improving modelling skills. These findings are related to another important aspect of concept cartoons, functional role of student enthusiasm/motivation of further learning (Keogh & Naylor, 1999). Studies in the literature show parallelism with our results of the study (Balım et al., 2008; Martinez, 2004; Naylor & Keogh, 2009; Ültay, 2015; Stephenson & Warwick, 2002; Yılmaz, 2020). These studies show that cartoons have high attention-grabbing and motivational features due to their visual nature, significantly increase motivation even in students with learning disabilities, and create in-class discussions with high active participation. Finbråten, Grønlien, Pettersen, Foss, and Guttersrud (2022) in a study investigating undergraduate nursing students' experiences with concept cartoons as an active learning strategy and formative assessment to improve conceptual understanding in anatomy and physiology, they found that the use of concept cartoons led to thinking and deeper understanding, which may be associated with deep learning. Cartoons can be used effectively in teaching because they do not only provide information, they also capture the students' attention; stimulate the active involvement of the students in the learning process (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvos, & Spyrellis, 2009). Beside this, it was seen that concept cartoons contributed to the development of students' mental modeling. By modeling, individuals reflect their thoughts, personal ideas, or internal representations about concepts or facts. Therefore, models can describe abstract concepts, and the entities that emerge as a result of modeling can be treated as if they have object properties. Norman (1983) defined models as schematic representations of a fact. In our study, the scenarios presented after the subject of "liquids" processed with concept cartoons were schematized by the students, and how they described the concepts emerged through the models in their minds.

Another remarkable result was that the average scores of the students in the test of scenario drawings are higher than the average scores they got from the concept cartoons test. This indicates that students can express themselves better with drawings. Scenario drawings that allowed the students to express themselves due to their inclination towards drawing better revealed their understanding of the subject of liquids. For example, as in other questions, they made drawings on the following questions "Are boiling and evaporation both the same concept?", "If we closed the lid of the pot while boiling the pasta water, do you think the boiling point would decrease?" and wrote texts related to the subject on their drawings. At this point, some students made various metaphors by stating that boiling and evaporation are "sister events", and some students made comments about the relationship between boiling point and boiling time by showing boiling and evaporation events with their drawings. In this context, we encounter the integration of chemistry and art in the study. Bautista, Tan, Ponnusamy, & Yau (2016) emphasize the integration of art with other disciplines as an emotional way to create a pleasant learning atmosphere in the classroom and state that it serves as a secondary method to increase the quality of social interactions between teachers and students and for teachers to see students' understanding of the subject matter. Therefore, art could be used as a tool to stimulate students' interest in learning and exploring, as well as a tool for understanding subject knowledge. Additionally, art is also a way for students to express and exchange their ideas as they make artistic creations and appreciate artworks. Through this research, students were able to express scenarios with physical expressions and artistic forms and easily reveal information and feelings that they could not convey in words. The results of the research obtained at this point also evoke the STEAM integrated learning model approach, which aims to systematically establish meaningful and holistic connections between disciplines based on science, technology, art and storytelling. Firmansyah (2019) states that the STEAM integrated learning model, which is a student-centered model, increases students' concept learning and offers them new learning environments. Our suggestion is to design STEAM integrated learning model activities to fill the gaps in this study and to conduct future research examining the effectiveness of fine arts high school students' comprehension of the subject of liquids.

On the other hand, although concept cartoons have been found to be powerful tools for teaching or remediating abstract concepts, they did not show a remarkable effect in our study. There are also findings in the relevant literature that studies conducted solely with concept cartoons are not effective. For example, Baysarı (2007) revealed in his study in a fifth-grade science and technology course that the use of concept cartoons did not create a significant difference in students' achievement. Balım et al. (2008) also determined in their study that the use of concept cartoons alone did not create a significant difference in achievement. This also suggests that more than one intervention method should be used to effectively teach concepts related to liquids. For example, Özyılmaz-Akamca et al. (2009) determined that computer-assisted concept cartoon applications in science and technology lessons caused a significant difference in the achievements of fourth grade students. In their study, they revealed that the use of concept cartoons together with analogy and prediction-observation-explanation (POE) techniques caused a significant difference in the achievement and permanence of fifth grade students. There are also studies on the use of concept cartoons with parallel findings with different methods and techniques. The use of concept cartoons on the subject of liquids, supported by various teaching methods or techniques, can further reduce misconceptions and increase the level of sound understanding. Additionally, understanding the subject of liquids can be facilitated through experiment-based activities. For example, simple experimental activities to compare the viscosities, surface tensions and vapor pressures of liquids can be conducted in the classroom and then concept cartoons can be presented to provide a better understanding of the subject of intermolecular interaction. Similarly, conceptual understanding of other acquisitions in the subject of liquids can be ensured by having students conduct experiments and think and discuss within the context of cartoons. This, in turn, affects conceptual change and results in the conceptual change being stored in the long-term memory of students (Ültay, 2015). Additionally, one of the limitations of this study is that the lack of a control group may prevent us from observing the effects of the teaching method alone on conceptual understanding.

Implications

Based on the results of the research, a large number of concept cartoon activities should be provided in the classroom environment so that students can improve their conceptual understanding. In such environments, students can first understand the concepts in the subjects correctly, visualize the concepts in their minds, give correct and explanatory answers to the questions, make connections between the subjects, reconcile the subjects with current case studies and increase their visual skills. This study also provides a clue about how students studying visual arts perceive chemistry. Especially, understanding chemistry topics such as liquids and solutions related to chemical substances such as paints etc. that they use in daily life correctly is also important in applying their own painting techniques correctly. Therefore, knowing the properties of intermolecular interactions such as evaporation, adhesion, cohesion, surface tension, viscosity and capillarity can be reflected in their technical applications. It can be ensured that the motivation of the fine arts high school painting department students to the chemistry lesson increases. Students who realize their own learning deficiencies and misconceptions can correct themselves.

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