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AN EXAMINATION OF PRE-SERVICE TEACHERS' KNOWLEDGE ON THE CONCEPT CARTOON: A LONGITUDINAL STUDY

Abstract: This study was designed to examine the development of pre-service teachers' knowledge of concept cartoons for three years within the scope of the courses they took. For three years, pre-service teachers took courses in scientific research methods, instructional technologies and material development, special teaching methods and teaching practice. During these lessons, the learning levels of pre-service teachers towards concept cartoons were examined. In the analysis of the data, the concept cartoons evaluation rubric and the concept cartoons application observation chart were used. Although they were not able to prepare concept cartoons and make applications at the expert level, it was concluded that the education the pre-service teachers received was effective. It is thought that arrangements are necessary to ensure the continuation of communication between teachers and lecturers.

Key words: Concept cartoon, Teacher education, Misconception, Rational numbers, Exponents, Rubric.

Introduction

In the educational process, the concept of learning comes to the fore rather than teaching. Different teaching methods, techniques, and graphic materials should be used to ensure permanent learning. One of these graphic materials is "concept cartoon". Concept cartoon consists of designing a situation taken from daily life and a scientific event in the form of a cartoon. This material supports learning in education, especially as it allows for discussion. Discussion is necessary in the context for Vygotsky's social learning and Piaget's cognitive learning theories (Tudge & Winterhoff, 1993). Through discussion, peer learning can take place. In addition, thanks to the discussion, cognitive imbalance is created in students and knowledge is restructured. Concept cartoons, which support both these two important theories for mathematics education, are effective teaching materials that can enrich the learning environment.

Concept cartoons can be applied in class discussions or small groups. If there is a concept or misconception that the teacher emphasizes, a concept cartoon can be applied to a group of students with and without misconceptions. With the help of concept cartoons, the teacher can identify the pre-understandings of the students, create a cognitive imbalance thanks to the

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different ideas they defend, and design learning environments to investigate the correctness of the ideas they defend (Dabell, 2008; Keogh & Naylor, 1999).

To realize meaningful and effective learning in mathematics, the learning difficulties and possible misconceptions of students should be determined and the course should be designed accordingly. Misconceptions occur when students construct their knowledge differently from scientifically correct ones as a result of incomplete, incorrect learning or faulty reasoning. Misconception can be defined as abstract structures that lead to systematic and repetitive mistakes (Kaplan, Isleyen, & Ozturk, 2011; Umay & Kaf, 2005).

Another important aspect that makes concept cartoon valuable is that it allows both the detection and elimination of misconceptions (Kaplan, Altayli, & Ozturk, 2014). The most common use of concept cartoons is to hang the concept cartoons prepared in the form of posters in the classroom where they can be seen easily by all students. In addition, when students work in groups, a concept cartoon can be given to each group. The teacher introduces the characters in the concept cartoons and the ways of thinking they advocate for the students or asks a student to read these thoughts. She/He then asks the students to identify which character they agree with and to state their reasons for agreeing with this opinion. Thus, the thinking styles of students and the reasons underlying these thinking styles are revealed. At the same time, students have the opportunity to express their opinions and hear the opinions of their friends (Kabapinar, 2007). This allows students to express their opinions and discuss their misconceptions. In addition, the cognitive balance of a student who has different ideas begins to be questioned, that is, cognitive imbalance occurs. Then, the students discuss their ideas under the guidance of the teacher, defend their ideas and try to convince the other party. The teacher asks, "What happened? Why did it turn out like this? Which character's thoughts come true? Where did you go wrong in your thinking? These questions start from the general and go towards the specific, examining individual student thinking styles (Kabapinar, 2007). At the end of the process, they reach the scientific knowledge. The teacher's ability to direct the process is critical for the concept cartoon to achieve its goals.

When the related literature is examined, it is seen that concept cartoons are frequently used in other fields of mathematics education. Samkova (2020) examined the mathematical pedagogical content knowledge of classroom teachers using concept cartoons. Yilmaz (2020) stated that education supported by concept cartoons had positive effects on the success of fourth-grade students in the "earth crust" unit. Atasoy (2020) determined the epistemological beliefs of secondary school students with the help of concept cartoons. Serttas and Turkoglu (2020) identified the misconceptions of 7^{th}-grade students about "Astronomy" through concept cartoons. Aygun, Karadeniz, and Butuner (2020) stated that concept cartoon activities improve students' mathematical language skills in mathematics lessons and ensure their active participation in the lesson. Karaca, Kuzu, and Caliskan (2020) explained that mathematics lessons with concept cartoons increase the attention and interest of 7^{th}-grade students and contribute to their success. Balim, Inel-Ekici, and Ozcan (2016) stated that concept cartoon activities improved students' questioning skills.

A teacher's competencies cannot be ignored in the effective implementation of a new graphic material, learning technology or teaching method. Likewise, in order to realize the contribution of concept cartoons to the success and attitude aimed especially in the student-centered system, teachers should have the competencies to determine the concept-misconception of concept cartoons, to develop the appropriate concept cartoon, to apply the caricature, and to identify and report what is obtained from the application.

It is thought that it is important for pre-service teachers to know concept cartoons that prove their effectiveness in teaching. For this reason, the aim of the study is to examine the development of

professional competencies of four pre-service teachers' regarding concept cartoons longitudinally. Thus, the mathematics teacher education system in Turkey will be examined and will be critical. In this sense, the question of the research is "What is the effectiveness of the teacher training system in terms of the use of concept cartoon?"

Method

Research Model and Participants

This research is a descriptive longitudinal study conducted to determine the knowledge of pre-service teachers in preparing and using concept cartoons. In longitudinal studies, changes in variables are obtained by examining the same people over a period of time. The number of people studied in longitudinal studies is small. Thus, in-depth and comprehensive information is obtained (Karasar, 2015). The participants of the study consist of four pre-service teachers who continue to the department of mathematics education. Since the research is a longitudinal study, pre-service teachers' knowledge of preparing and using concept cartoons was measured on the same individuals in the 2nd, 3rd, and 4th grades using the same scales. Explanations regarding the time of the study and the lessons are included in Table 1.

Table 1. *The time of the study and the lessons*

Academic year	Academic semester	Participants	Courses	Prepared assignment / task	Who
2014-2015	first	PT1*, PT2*	Scientific research methods	Reviewing the article and summarizing it as a presentation to classmates.	R1**
2014-2015	second	PT1, PT2, PT3, PT4	Instructional technologies and material development	Designing concept cartoons.	R1
2015-2016	second	PT1, PT2, PT3, PT4	Special teaching methods II	Application of the first concept cartoon to pre-service teachers and video recording	R1
2016-2017	second	PT1, PT2, PT3, PT4	Teaching practice	Application of the second concept cartoons to pre-service teachers and video recording	R1
2020-2021	---	---	---	Analysis of concept cartoons prepared by pre-service teachers and video recordings of applications	R2

* PT1 (pre-service teacher 1) and PT2 (pre-service teacher 2)
** R1 (first researcher) and R2 (second researcher)

Process of Research

The first researcher, the lecturer, who taught the course decided to do this study in the "Scientific Research Methods" course in the first semester of the 2014-2015 academic year. Within the scope of this course, participants PT1 (pre-service teacher 1) and PT2 (pre-teacher 2) examined an article about concept cartoons prepared by Ugurel and Morali (2006), and presented its summary to the whole class. At the end of their presentations, pre-service teachers stated that they were very happy to learn this graphic material and share it with their friends. Seeing the light in the eyes of pre-service teachers, the lecturer decided to design this research. In the second semester of the same academic year, the lecturer gave this group the task of designing a concept cartoon while conducting the material design course. The participant group also developed a concept cartoon about exponential numbers for 8th grade (Annex I).

In the second semester of the 2015-2016 academic year, the participant pre-service teachers taught by using concept cartoons, assuming their classmates were students. This lecture was recorded with a camera. The same pre-service teachers prepared a second concept cartoon suitable for adding rational numbers for the 6th grade within the scope of the "Teaching Practice Course" in the second semester of the 2016-2017 academic year (Annex II). They applied this concept cartoon, to identify and eliminate the misconceptions of 6th grade students, in the real classroom environment. The lectures of the pre-service teachers were recorded with a camera. The second researcher analysed the concept cartoons by using the evaluation rubric for the concept cartoons he developed. In addition, the second researcher analysed the video recordings of the pre-service teachers' practices using the observation form he developed.

Data Collection Tool and Data Collection Process

Data were collected over a 3-years period to examine the development of pre-service teachers. The data and the process of collecting these data are explained in detail in each year.

Data of the 1st year: In the first semester of the 2nd grade, the article presentation prepared by the pre-service teachers in the "Scientific Research Methods" course was observed. In the second semester, the concept cartoon (CC1) prepared by the pre-service teachers were examined in the "Instructional Technologies and Material Development" course.

Data of the 2nd year: In the second semester of the 3rd grade, in the "Special Teaching Methods II" course, pre-service teachers applied the concept cartoons (CC1) they prepared to their classmates. This application was recorded with the camera.

Data of the 3rd year: In the second semester of the 4th grade, in the "Teaching Practice" course, pre-service teachers developed a new concept cartoon (CC2). They applied this concept to the 6th-grade students of the cartoon. The application was recorded with the camera.

Explanations about CC1 used as data in the study and which character's opinion expresses which error are given in Annex-1. Explanations on CC2, which was used as a data collection tool in the study, and which hero's view represents which error are given in Annex-2.

Analysis of Data

Concept cartoons prepared by pre-service teachers were analysed with the help of the "Concept Cartoons Evaluation Rubric" developed by Yildiz, Es and Turkdogan (2021). The reliability index of the rater surface of the scale was 0.87; the reliability index of the scored (concept cartoon) surface is 0.80; and the reliability index of the item surface was calculated as 0.89 (Yildiz et al., 2020). These values show that this rubric is a reliable measurement tool for the evaluation of concept cartoons. This rubric is included in Annex-3. Video recordings of pre-service teachers' concept cartoon applications were analysed using the "Concept Cartoon Application Observation Chart" developed by Yildiz (2020).

Validity and Reliability

The validity of scientific research is ensured by explaining in detail how the data were collected and how the results were obtained (Yildirim & Simsek, 2013). In this context, to increase the validity, data collection and analysis processes are explained in detail, and direct quotations are included in the findings section.

The analysis of the concept cartoons was made by two different researchers and the reliability of the research was calculated. Consensus and disagreements in the reliability calculation were calculated using the formula specified by Miles and Huberman (1994). The reliability coefficient was calculated as 0.91 and this result shows that the research is reliable.

Findings

Findings Obtained from the First Semester of the 2nd Grade: Scientific Research Methods Course

The scientific research methods course was given by the first researcher. Since the researcher was the only mathematics educator at the university in the year of the application, he teaches almost all of the field education courses himself. Within the scope of the course, the first researcher assigned each group the task of analysing and summarizing a scientific article, making its summary a presentation, and presenting it to their classmates in the remaining time of the course. The lecturer distributed the topics of the articles to be summarized within the scope of the lesson to each group. he did it by taking into account the content of the instructional technologies and material development course he will conduct in the second semester of the same year. Among the topics distributed to the groups, there are also concepts, misconceptions, concept maps, concept cartoons and meaning analysis tables.

In the first year of the study, the participating pre-service teachers examined Ugurel and Morali's (2006) concept cartoons within the scope of the scientific research methods course. Afterward, they presented the information they obtained to their classmates. In their presentations, the pre-service teachers gave the definitions of cartoons and concept cartoons and revealed the relationship and differences between them. They mentioned who used the concept cartoons for the first time and for what purpose and common areas of use. They listed the contributions of using concept cartoons to learning-teaching in items. They stated what should be considered while preparing and applying concept cartoons. It was stated that the teacher should do the application in small groups or classes, encourage discussion, and express his/her ideas comfortably. They completed their presentations by giving examples of the concept cartoons in the study they examined. While introducing examples, misconceptions, conceptual confusions, and incomprehensible points were frequently mentioned.

At the end of the presentation, the pre-service teachers stated that they had read a scientific article for the first time and they liked the work very much. They even presented examples of concept cartoons from different sources, stating that they researched the subject because they liked it very much. They talked among themselves that their friends should be aware of the studies they have examined. They stated that they introduced this graphic material to some of their friends before the lesson and that their friends also liked it.

In this process, it was observed that the pre-service teachers read the article, understood it, chose examples, explained the selected examples, expressed the statements in the article sometimes as they were and sometimes in their own sentences and transferred them to the presentation. It was observed that the pre-service teachers who completed the given task acquired information such as the definition of caricature, the definition of concept cartoon, the difference between caricature and concept cartoon, and graphic materials. In addition, it has been observed that they can effectively share the information they have learned with others.

Findings Obtained from the Second Semester of the 2nd Grade: Instructional Technologies and Material Development Course

Within the scope of the instructional technologies and material development course, each group designed a concept cartoon. It was stated that each material should be prepared considering the 8th grade topics. The groups interviewed a teacher about the common mistakes and misconceptions they encountered. In this course, two more pre-service teachers were added to the participant group and the group consisted of four people. The group interviewed a teacher as part of their work and identified the mistakes that the teacher often encountered. The misconceptions detected by the group are as follows.

When the students are asked about the result of the "2^{-3}" operation;

- Students can find (-6) by multiplying 2 by (-3).
- Students can answer 9 by considering it as the square of (-3).
- Students can answer (-8) by thinking that the result should be negative.

Apart from these misconceptions, the teachers also stated 12 situations that could be misconceptions. The first researcher wrote down the misconceptions that other pre-service teachers learned from the interviews on the board. The misconceptions were examined one by one and the pre-service teachers in the study group were asked which misconceptions attracted the most attention. The students stated that the first misconception that caught their attention the most among the above misconceptions. They also stated that from time to time they encounter people who make these mistakes. Thereupon, the study group was asked to develop a concept cartoon on exponential numbers within the scope of the instructional technologies and material development course. The concept cartoon prepared by the group is included in Annex-1.

The adequacy of the concept cartoon was determined by the rubric developed by Yildiz et al. (2021). Accordingly, the qualification status of the concept cartoon developed is as follows; The "Content" in CC1 is completely related to the field of mathematics. The content is consistent with each other and no unnecessary information is included. Therefore, the "Content" sub-dimension was given 4 points. Only one problem is contained simply and understandably. Therefore, the "problem situation" sub-dimension was given 4 points. Alternative ideas about the solution to the problem, one of which is correct and the other one containing possible errors, are given equal status. However, the "Alternative ideas" dimension was given 3 points because there was no place for the student to express a different opinion. Scientific terms are included clearly and consistently. However, there are some deficiencies in the language spelling rules. For this reason, 3 points were given to the "Text writing" dimension. The characters are named and the concept cartoon is interesting. However, the location of the speech bubbles disrupts the layout and reduces readability. Therefore, the "design" sub-dimension was given 3 points. The average of the sub-dimensions is 3.4, which corresponds to excellent performance.

The developed concept cartoons were also examined by the second researcher. The feedback given includes; the suitability of the characters used, the clarity of the expressions in the concept cartoon, the size and length of the text, and the need to clarify exactly which character the balloons belong to.

Although the feedback received (twice) is important and can be considered as the inadequacy of the pre-service teachers, it should be accepted naturally that the learner makes mistakes in the learning process and the teacher gives feedback. It is also possible for pre-service teachers to have received help, ideas, and suggestions from other people or sources. It is thought that these possibilities will not diminish the value of the study or the concept cartoons and learning ambitions of the pre-service teachers.

Findings Obtained from the Second Semester of the 3rd Grade: Special Teaching Methods II Course

In the second semester of the third grade, the pre-service teachers were given the task of preparing worksheets as much as the number of people in their groups related to the unit given to them in the "Special Teaching Methods II" course. Later, they were asked to teach their classmates as if they were teaching in a real classroom, assuming they are students. Their preparation for the course is based on the theoretical knowledge they received in the "Special Teaching Methods I" course in the first semester.

In the course, the subject of "exponential numbers" was given to the participant group as homework. In addition to the worksheets they prepared, the group also applied CC1 to their classmates. During the application, each pre-service teacher applied a worksheet. During the application of CC1, the second researcher was in the classroom as a viewer. CC1 was applied by PT2 as follows (S: Student);

001. PT2: "Good Morning." (A student distributes CC1 to his friends. There are four printouts and these printouts were distributed to groups of 3 people sitting side by side.)
002. PT2: "Can you read what the teacher said in the concept cartoon?" (S1: From the group1)
003. PT2: "Read the thoughts of the characters in the concept cartoon and take note of the most correct statement. What do you think?" (S2: From the 2nd group)
004. S2: "I think Melek is telling the truth and the answer is (-6). But my friend says another character's opinion is correct."
005. PT2: "What do you think? "(S3: From the group 3)
006. S3: "Celal is telling the truth. The result must be negative so the answer is (-8).".
007. PT2: "What do you think?" (S4: From the group 4)
008. S4: "I think Sarp is saying the truth."
009. PT2: "What do you think?" (S5: From the group 1)
010. S5: If 2 was to the power of 3, the answer would be 8. But since it's 2 to the power (-3) the answer must be 1/8.
011. PT2: Can you come to the board and explain to us why 2 power (-3) is 1/8??

After PT2 saying good morning (pretending to be a teacher who had just entered the class), he had a concept cartoon distributed on the tables (a sign of doing group work). Students were asked to read the concept cartoon. A student (a classmate previously determined by the pre-service teacher) read aloud the problem situation in the concept cartoon. Then everyone was asked to read the concept cartoon. Afterwards, PT2 asked a classmate for his thoughts. The character adopted by the classmate contains a misconception. In addition, the pre-service teacher also stated that his classmate defended the idea that expresses another misconception. This shows that pre-service teachers are taught to behave as if they are arguing. However, PT2 probably continued his lesson as he had planned in his own mind, without considering this statement of the student. PT2 asked the person who defended the right idea to come to the board and explain his reasoning. The student who came to the board did the following operations and drew the figure.
012. S5: How were we operating on exponential numbers? If the exponent is negative, we were making it positive, right? So $2^{-3} = \frac{1}{2^3} = \frac{1}{2.2.2} = \frac{1}{8}$. Also, our teacher used a pattern while teaching us the power of exponential numbers, let's remember that pattern.

$$2^4 = 2.2.2.2 = 16$$
$$2^3 = 2.2.2 = 8$$
$$2^2 = 2.2 = 4$$
$$2^1 = 2 = 2$$
$$2^0 = 1$$

What is written to the right of the equation when we continue this pattern? Actually, if you look at it from the beginning, what comes after 16, 8, 4, 2, 1? Half of the previous number will be written here. In other words, 1/2 will be written to the right of the next equation. So, let's continue our pattern;

$$2^4 = 2.2.2.2 = 16$$
$$2^3 = 2.2.2 = 8$$
$$2^2 = 2.2 = 4$$
$$2^1 = 2 = 2$$
$$2^0 = 1$$
$$= \frac{1}{2}$$
$$= \frac{1}{4}$$
$$= \frac{1}{8}$$

Now let's fill in the left side of the equation.

$$2^{-1} = \frac{1}{2}$$
$$2^{-2} = \frac{1}{4}$$
$$2^{-3} = \frac{1}{8}.$$

So, as Celal said, the power of two is minus three over eight, right?
013. PT2: Are you convinced?
014. S6 (A student from Group 3): It was very understandable, my teacher, he explained like a teacher (laughter).

The concept cartoon prepared by the group is sufficient., It is also seen that this group teaches their classmates how to defend the right idea to eliminate the misconception. For this reason, it is seen that this group, who understands the logic of the group's concept cartoon, can create concept cartoons containing misconceptions. When Yildiz's (2020) observation chart regarding the adequacy of the PT2 application of concept cartoons was filled, the situation in the table 2 was obtained.

Table 2. *Observation for the use of concept cartoon*

Concept Cartoon Usage Steps	Observation 1
After making a short introduction to the subject, concept cartoons were distributed to the class.	No
He informed the students about the concept cartoon.	No
Students were given time to review and reflect on the concept cartoons.	Yes
It enabled the students to exchange ideas in small groups.	No
He received brief feedback from students on alternative ideas.	Yes
An in-class discussion was held in order to determine the scientific opinion accepted as scientific and its reason.	Yes
A class discussion was held in order to determine which ideas containing misconceptions.	No
If there was a change in the students' ideas, he asked why.	No

He made a clear and concise summary of all the results achieved.	Yes

The table was discussed and filled by two researchers. When Table 2 is examined, PT2 directly distributed the concept cartoons without making a short introduction to the subject. The lesson started without informing the students about concept cartoons. Time was given to examine and reflect on the concept cartoon. Students received feedback on alternative ideas without exchanging ideas among themselves. While conducting the class discussion about the scientifically correct idea, he did not do anything about the misconceptions. He completed the activity by making summarizing the results obtained without asking whether there was a change in students' ideas.

PT2 did not perform 5 of the 9 behaviours that should be followed in the implementation of the concept cartoon. In particular, it is an important deficiency that he receives different ideas from each group and does not discuss the differences of opinion within the same group. The fact that the ideas were not opened to the view of the whole class also caused the discussion not to be spread to the class. In this sense, we cannot say the application was successful.

In addition, the second researcher made some suggestions to the group based on the lack of implementation. These suggestions;

1) Different ideas should be taken from the same group, groups should be encouraged to discuss based on different ideas.
2) Internal discussions for each group should be encouraged.
3) After these first two stages, the in-class discussion should be started.
4) Using models and materials, the reasons for right and wrong should be explained.

The second researcher explained the successful aspects of the application to the students. After receiving feedback, the study group could not find the opportunity to be observed during the preparation and application of the concept cartoon. The artificiality of the classroom environment, the fact that the student body consists of classmates and a group that does not have any real deficiencies in the subject is an obstacle to observing how competent the students are.

Findings Obtained from the Second Semester of the 4th Grade: Teaching Practice Course

Pre-service teachers go to schools in the first semester within the scope of the school experience course and observe how mathematics teachers teach. In the second semester, they teach in classes within the scope of the teaching practice course. In this process, pre-service teachers prepare and use lesson plans and worksheets. Both the lecturer and the application teacher evaluate these plans and worksheets. After the feedbacks, the pre-service teacher lectures and discusses their experiences with the teacher, lecturer and other pre-service teachers. The study group prepared and implemented CC2 within the scope of this course. Researchers gave no feedback on CC2. The analysis regarding the adequacy of CC2 (Annex-2) is as follows.

The content in CC2 is entirely related to the field of mathematics. The content is consistent, but contains unnecessary information. The "Content" sub-dimension was given 3 points. There is only one problem, but it is not written simply and understandably. The "problem situation" sub-dimension was given 3 points. Various alternative ideas regarding the solution to the problem, one being correct and the other possible errors, are of equal status. The correct solution is not detailed. There is no place for the student to express a different opinion of his/her own. The "Alternative ideas" dimension was given 3 points. Scientific terms were included in the understandable, consistent and proper language. The "Text writing" dimension was given 4 points. Concept cartoon is interesting, organized and legible. However, the characters are not

named. The "Design" dimension was given 3 points. The average score of the sub-dimensions is 3.2 which corresponds to "successful performance".

When the formal success of CC2 is examined, it is seen that it is less successful than the first one. However, considering that they did not receive feedback about CC2, it is thought that pre-service teachers' performances were successful.

In this sense, if the process is evaluated as a whole; Pre-service teachers can identify students' misconceptions about the subject; they can choose the appropriate characters; they can prepare designs; they can set up the event; they can prepare a concept caricature, although not better than the previous one. In addition, they were able to apply concept cartoons in the classroom. In this sense, it can be said that they have reached a good level in preparing concept cartoons in the second semester of the 3rd grade.

Then, pre-service teachers were asked to apply CC2 in a real classroom environment within the scope of the "teaching practice" course in the 4th grade 2nd semester. The pre-service teachers stated that they wanted to ask a test question to the students before the application. The question asked to the students is as follows:

$\frac{4}{7}+\frac{4}{13}=?$ Which of the following is the answer to this question?

a) $\frac{8}{20}=?$ **b)** $\frac{80}{91}=?$ c) $\frac{8}{91}$ d) $\frac{4}{20}$ e) 1

The question is similar to the one in CC2 and aims to measure the same misconceptions. PT2 implemented CC2 in the classroom. The analysis of the video recording of the application is as follows:

001. PT2: "Today we have a concept cartoon. We will try to do this concept cartoon together. Rumeysa, can you read us the question?"
002. Rumeysa read grandma's bubble.
003. PT2: "We're going to help grandma, right? What is our process? We'll add 2/5 to 2/11 and find out how many slices of cake grandma ate. I'm giving you some time now. Let's take a look and find the right answer." (After a little waiting)
"Did you find it?? Rumeysa, how did you do it? Which one of your actions fits? Read and tell us, please."
004. Rumeysa chose Sylvester's bubble and read it.
005. PT2: "Come and do this process. Show us your argument on the board."
006: $\frac{2}{5}+\frac{2}{11}=\frac{2}{5x11}+\frac{2}{11x5}=\frac{4}{55}$ Rumeysa did the operation.

As far as it was learned from the pre-service teachers, Rumeysa repeated her mistake in the pre-test because the same mistake was repeated in the concept cartoons (option c). It has been determined that the student has a misconception.
007. PT2: "Okay, thank you. Let's get you in your place. Sukeyna what do you think? Do you read your answer?"
008. Sukeyna read Tweety's balloon.
009. PT2: Come and do these operations. Show us your argument on the board.
010. $\frac{2}{5}+\frac{2}{11}=\frac{4}{16}$ Sukeyna did the process.

It was seen that the student repeated the same mistake he made in the pre-test in the concept cartoon (option a). Repeating the mistake is proof that the student has a misconception.
011. PT2: "Thank you. Let's get you in your place. Yes Mehmet? You say it too".
012. Mehmet read Bugs Bunny's balloon.
013. PT2: "Okay, let's see your opinion."
014: $\frac{2}{5}+\frac{2}{11}=\frac{2}{5+11}=\frac{2}{16}$ Mehmet did the operation.

It is seen that the same mistake made by the student in the pre-test is repeated in the concept cartoons (option d), so he has a misconception.
015. PT2: "Yunus Emre, what do you think? Read it, let's see."
015. Mehmet read Duffy Duck's balloon.
016. PT2: "Okay, come and write your thoughts on the board."
017. $\frac{2}{5}+\frac{2}{11}=\frac{2x11}{5x11}+\frac{2x5}{11x5}=\frac{32}{55}$ Yunus Emre did the operation.
018. PT2: "We thank you. Let's get you in your place. As you can see, the question is here and everyone has their own answers, right?"
019. Rumeysa: "Yes teacher."
021. PT2: "Who owns this answer?" (Showing Rumeysa's answer on the board)
022. Rumeysa: "Me".
023. PT2: "Why did you think like that? What led you to this?"
024. Rumeysa: "This is how I saw it while studying yesterday."
025. PT2: "Did you see it this way?"
026. Rumeysa: "Yes. I believe this is true."
027. PT2: "Was it written like this in your notebook or did you do that in the questions you solved?"
028. Rumeysa: "This is how I did in the questions I solved."
029. PT2: "Sukeyna! What do you think?"
030. Sukeyna: "I do not agree with Rumeysa. That's what we do with my father when I study with my father."

In line 24, it is seen that Rumeysa defended her answer. Already in the test, it was seen that she had a misconception by marking the relevant option. Her insistence on her answer here also supports that the mistake is the result of misconception. In the 27th line, the pre-service teacher tries to get to the cause of the mistake, but it is not possible to say that she is very successful.

Sukeyna's answer on line 30 also helps us to understand the reason for the misconception. This will also help us to understand a way to eliminate misconceptions and increase student's success in mathematics. By interviewing the father of the student, it should be stated that he does not have sufficient knowledge of mathematics and it can be said that the student should not interfere with his lessons.

031. PT2: "You always solve it like this, don't you?"
032. Sukeyna: "Yes."
033. PT2: "Mehmet! Let us give you a say. Why do you think so?"
034. Mehmet: "I disagree with both. Because that's how I did it in the exam and I got grades. I believe this is the answer."
035. PT2: "So this is how you did it in the exam and you study like this?"
036. Mehmet: "Yes".
037. PT2: "Yunus Emre! You?"

038. Yunus Emre: "I don't agree with any of them. Because that's how I saw it in my previous studies."
039. PT2: "Is this how you do it in class? Is that how your teacher showed you? Or did you study that way?"
040. Yunus Emre: "This is what my teacher showed me."
041. PT2: "Okay. What do you think we should do? We all study differently. We see the difference, don't we? In the lesson, we listen to our teacher carefully, but we get additional help. As Sukeyna said, she studied with her father, learned that way or repeated. This is how we saw it. But there are certain rules when adding fractional numbers. One of these rules is as Yunus Emre said. We thank Yunus Emre. Now I'm giving the correct answer. Let's show it one more time. Friends! When adding fractional numbers, if the denominators are not equal, we equalize the denominators." (PT2 repeats operations on the board.)

We multiply the number we have written under the denominators by both the numerator and the denominator, and we do the addition. (Pre-service teacher does). Agreed, right guys? Will we be careful not to make the same mistake from now on? I believe it is better this way and thank you.

When Yildiz's (2020) observation chart regarding the adequacy of the pre-service teacher's application of concept cartoons was filled, the situation in the table 3 was obtained.

***Table 3**. Observation for the use of concept cartoon*

Concept cartoon usage steps	Observation 2
After making a short introduction to the subject, concept cartoons were distributed to the class.	Yes
He informed the students about the concept cartoon.	Yes
Students were given time to review and reflect on the concept cartoons.	Yes
It enabled the students to exchange ideas in small groups.	No
He received brief feedback from students on alternative ideas.	Yes
An in-class discussion was held in order to determine the scientific opinion accepted as scientific and its reason.	Yes
A class discussion was held in order to determine which ideas containing misconceptions.	Yes
If there was a change in the students' ideas, he asked why.	No
He made a clear and concise summary of all the results achieved.	Yes

When Table 3 and the video recording are evaluated together, it is seen that the pre-service teacher did not perform only 2 of the steps to be taken in using concept cartoons.

When the video is examined, it is seen that the pre-service teacher gave a brief introduction to the subject, then distributed the concept cartoons and gave a brief briefing. She gave time to examine and reflect on the concept cartoon. However, it did not enable students to exchange ideas with each other. She received feedback from the students regarding alternative ideas, and had classroom discussions with all of their correct or misconceptions, along with their reasons. She completed the activity by clearly summarizing the results she obtained without asking whether there was a change in the ideas of the students. However, in the video recording, it is seen that the pre-service teacher focused too much on the students in this dialogue (because by applying the test, she determined that these students had misconceptions). In this sense, it is seen that they carry out the discussions by identifying a person with each misconception. It is seen that they do not want to spread the discussion throughout the class.

Results and discussion

The research assignment given within the scope of the scientific research methods course created an interest and awareness toward concept cartoons in pre-service teachers. Although the pre-service teachers were assigned to review only one article, they obtained more information about concept cartoons by examining different articles. They shared the information they obtained with their friends and tried to inform them about the concept cartoons. In order for teachers to implement an innovation in their classrooms, they must first believe that this innovation will be effective. For this reason, it is important for pre-service teachers to develop such a positive perception-attitude towards this graphic material in the second grade. This can be considered as a success of the education applied to pre-service teachers.

Kogce, Yildiz and Aydin (2019) and Yetim (2019), using teaching materials such as concept maps and concept cartoons to identify and eliminate mathematical misconceptions. While preparing the concept cartoons, the pre-service teachers received opinions from the teachers about the misconceptions of the students. This shows that the pre-service teachers understand that they can use concept cartoons to identify the misconceptions. And finally, they were able to detect misconceptions by using concept cartoons.

The first concept cartoon created by the pre-service teachers is in the category of "excellent performance". As a result of the feedback given to the pre-service teachers, the first concept cartoon was so successful. The second concept cartoon created by the pre-service teachers is in the category of "successful performance". The fact that the researchers did not give any feedback while creating the second concept cartoon may have been effective in this decline. In various studies, it was determined that chemistry (Tekin, 2004), science (Cakir, 2004), classroom (Akcadag, 2010; Sahin, 2013) and mathematics (Karalok, 2014) teachers were not successful enough in creating concept cartoons and other graphic materials. However, researchers think that these pre-service teachers were successful. The consciousness (affective components) revealed by the pre-service teachers may have been effective in this success.

The pre-service teacher did not perform 5 of the 9 behaviours that should be fulfilled in the first application of the concept cartoon. In particular, it is an important shortcoming that she receives ideas from a different group each time and does not discuss the differences of opinion within the same group. In addition, the fact that the opinions taken from these different groups were not discussed by the class caused the concept cartoon to fall behind its cognitive purposes. Putting theoretical knowledge into practice takes time (Posnanski, 2002). It is also known that changing behaviour in any subject with short-term practices is a very difficult, long and laborious process (Sengul & Ekinozu, 2006). Teachers' reluctance to make discussions can be explained by the fact that they prefer to use teaching techniques that they are used to and that they can dominate the class instead of trying new methods (Tatto, 2002; Thair & Treagust, 2003).

In the second application of the concept cartoon, the pre-service teacher did not perform 2 of the 9 behaviours that should be performed. As in the first application, it did not allow students to exchange ideas in small groups. Also, if there was a change in students' ideas, she did not ask why. However, the pre-service teacher was more successful in the second application than in the first application. The fact that the researchers pointed out the deficiencies they saw after the first application to the pre-service teacher may have been effective in this. However, implementation is far from what is desired. It is also stated in the literature that pre-service teachers could not adequately reflect the knowledge they acquired in the classroom environment at first (Senel, 2008; Tekin, 2004). It is seen that there are deficiencies in the education given at universities in terms of qualifications aimed to be gained by teacher candidates in practice. For this reason, some changes should be made in the education given.

Recommendations

In this study, a group with a special interest in concept cartoons was determined and some special instructions were given to this group in many lessons they took. Although the point reached is good, it is insufficient. Other students may have much lower proficiency in concept cartoons. In this sense, pre-service teachers may be trained in preparation and using various graphic materials, including concept cartoons, as part of an elective course.

Pre-service teachers should be provided with an environment where they can communicate more with the instructors while doing their internships at schools. In this way, they will be able to reach the guidance of the instructors whenever they need it. For this reason, arrangements should be made so that instructors can spend more time in practice schools. The establishment of education faculties, including practice schools, is the most desirable thing in terms of transforming this learned knowledge into practice.

Teachers can be allowed to cooperate with experienced teachers or lecturers by taking a few courses in the first years of their employment. Teachers should be given the opportunity to work with lecturers so that they can implement a concept cartoon or another innovation in their classrooms. Such an opportunity will not be given only to teachers. Undoubtedly, lecturers, researchers, and society can gain a lot from these practices.

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Annex 1: *Concept Cartoon 1*

Annex 2: *Concept Cartoon 2*

Annex 3: *The concept cartoons evaluation rubric*

Entry level performance (1)	Performance to be improved (2)	successful performance (3)	excellent performance (4)	
The content is completely outside the realm of mathematics. The content is not consistent with each other. Unnecessary information is	The content is all about the field of mathematics. The content is not consistent with each other. Unnecessary information included	The content is all about the field of mathematics. Content is consistent with each other. Unnecessary information included	The content is all about the field of mathematics. Content is consistent with each other. No unnecessary information	
There is more than one problem. The problem is not stated in a complex way. The problem is not relevant.	There is only one problem. The problem is not stated in a complex way. The problem is not relevant.	There is only one problem. The problem is stated simply and clearly. The problem is not relevant.	There is only one problem. The problem is stated simply and clearly. The problem is relevant.	
There are no alternative ideas for solving the problem.	There are alternative ideas for solving the problem. Alternative ideas are not given equal status. At least one of the alternative ideas is not true.	There are alternative ideas for solving the problem. Alternative ideas are given equal status to each other. At least one of the alternative ideas is not true.	There are alternative ideas for solving the problem. Alternative ideas are given equal status to each other. At least one of the alternative ideas is correct.	
Scientific terms are not included. Terms are not clear, unambiguous, intelligible and consistent. Spelling rules were not followed.	Scientific terms are included. Terms are not clear, unambiguous, intelligible and consistent. Spelling rules were not followed.	Scientific terms are included. Terms are clear, concise, understandable and consistent. Language spelling rules are not followed	Scientific terms are included. Terms are clear, concise, understandable and consistent. Language spelling rules were followed.	
The characters are not named. The concept cartoon is not interesting. There is no order and it is illegible.	The characters are named. Concept cartoon is not interesting. There is no order and it is illegible.	The characters are named. Concept cartoon is interesting. There is no order and it is illegible.	The characters are named. Concept cartoon is interesting. It is neat and legible.	

Criterias	Content	Problem	Alternative Ideas	Text writing	Design	

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