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Abstract

Formative assessment is a teaching method that helps to determine the prior knowledge of students, schedule the course plan accordingly, give it the final shape based on the feedback received from students, and encourage conceptual learning. The aim of this study is to introduce the "annotated student drawings" as one of the common formative assessment strategies used in science courses in middle schools and to evaluate the practices. The study was conducted during the classes of two science teachers who are doing their master's degree. In total, 48 students participated in the study from 5th (20) and 6th (28) grades. For data collection tools, annotated student drawings on the concepts of "pollination" and "water cycle" before and after the intervention and the science teachers' feedback about the strategy were used. The pre and post-interventional annotated drawings of the middle school students were compared. On both concepts, it was several alternative conceptions from the students' pre-interventional annotated drawings that were recovered on the post-interventional drawings. The findings indicated that the annotated student drawings are fairly effective formative assessment strategies in uncovering the prior knowledge and alternative conceptions of students in class. After the intervention, the students' second drawings gave detailed information on how the students' level of understandings improved. Formative assessment techniques are suggested to be used by science teachers instead of traditional assessments in order to: 1) Getting info about their students' initial understanding; 2) Reshaping their classroom instruction according to the feedback they get from their students; and 3) Always revising their interventional methods until the students got the main idea during the teaching period.

Introduction

The Turkish Ministry of Education has updated the science and technology curriculum for primary schools twice in line with the international developments seen in the last decade. The vision for science and technology education was determined as making all students scientifically literate citizens (Ministry of Education (MEB), 2005). This vision prescribes that all students be cultivated as individuals who can think (research, question, and think critically) and behave (discuss, reason, solve problems, and take decisions) like scientists and who are environmentally conscious and have a scientific approach and scientific values. In the planning and implementation of the new science curriculum, the strategies and methods focusing on the active participation of students in learning environments that are based on problem-solving, devising projects, argumentation, and cooperation were taken as basis (MEB, 2013). However, it is seen that the current science and technology textbooks are aimed at demonstrating the accuracy of phenomena, concepts, principles, and rules in science through experiments rather than the teaching strategies and methods adopted. For this reason, it is necessary to generalize the teaching practices that are based on research, questioning, argumentation, and explanation in science classes.

Formative assessment method has come to forefront over the last 10 to 15 years in Europe and America especially with the book of Black and William (1998) titled *Working Inside the Black Box*. Additionally, the meta-analysis study by Black and White (1998) on 250 studies and practices concerning formative assessment demonstrated that formative assessment increases the classroom participation, conceptual understanding, and learning motivations of students. The result of that study led to the revision of the teaching methods and

techniques employed in science and mathematics education and made a significant contribution to the rapid increase in the number of modern practices, studies, books, and tests based on formative assessment. For example, various reference books aimed at teaching science (primary school level), physics, astronomy, and biology (high school level) through formative assessment strategies have been published (Keeley, 2005, 2007, 2008). In Turkey, there is no reference book on formative assessment that integrates teaching with assessment in science lessons. Also, the studies that have been conducted so far are limited (Bulunuz & Bulunuz, 2013: 2014; Bulunuz, Bulunuz, & Peker, 2014; Bulunuz & Bulunuz, 2016: Bulunuz, Bulunuz, Karagöz, & Tavsanlı, 2016; Bulunuz & Bulunuz, 2017; Bulunuz, Kıryak, Karagöz, Tomaç, & Recepoğlu, 2017; Metin & Özmen, 2010; Yalaki, 2010).

In general, the written and oral exams, the grades received from the exams and students' achievement ranking come to mind when it comes to assessment. Moreover, the concept of assessment is usually used in the same meaning with written and oral exams and assignments. According to Atkin, Coffey, Moorthy, Sato, and Thibeault, (2005), the use of the word of assessment in the same meaning with the exam types in question means simplifying the complex structure, phases and purpose of the assessment. Because, giving grade is the smallest part of the assessment. However, assessment is a quite comprehensive concept, and it is a skill which is situated at the highest level of Bloom's Taxonomy and requires advanced performance. The main point in assessment is to generate quantitative and qualitative solutions to determine what students know, in which subjects they have shortcomings or what kind of misconceptions they have. There are two types of commonly known assessment. These are diagnostic and summative assessments (Keeley, Eberle, & Farrin, 2005; Keeley, 2008).

Diagnostic Assessment

Diagnostic assessment is performed to determine the students' prior knowledge, incorrect, incomplete or misconceptions about a subject or in a field (Keeley, Eberle & Farrin, 2005; Keeley, 2008; Tan, 2010). In our country, these types of assessments are called a placement test and are commonly used to classify students only according to their levels of achievement in language courses and in preparation courses for high school and university entrance exams. The data obtained from these exams do not contribute to the conceptual learning of students unless they are used in the formation of content or teaching format in accordance with the students' needs. However, the purpose of the diagnostic assessment should be aimed at determining students' readiness levels by uncovering their incomplete and inaccurate information before teaching.

Summative Assessment

Achievement or summative assessment is a type of assessment that usually consists of exams performed at the end of the unit or term to determine whether students achieve the acquirements in any course, and measure the student's achievement in the course or courses by grading. In this type of assessment, the student achievement is measured and documented with a specified score, and students are ranked according to the point received (Keeley, Eberle, & Farrin, 2005; Keeley, 2008). The mid-term and final exams performed in universities, written and oral exams in primary and secondary education, SBS, YGS and the exams at the international level such as PISA and TIMMS can be given as examples for the summative assessment (Tan, 2010). These exams are also performed to reveal students' levels of achievement and ranking at national or regional level courses.

Formative Assessment

Formative assessment is less known than these two types of assessment; however its weight is increasing in educational applications and research every passing day. Formative assessment can be defined as an assessment which does not intend to give a grade and is performed for teaching and learning (Keeley, Eberle & Farrin, 2005). Here, what is meant by the assessment performed for learning is to reveal what students know about the subject to be taught; the assessment performed for teaching means the adaptation of the teaching of the course in the light of information collected from students (Black & William, 1998; Furtak, 2012; Izci, 2018; Yin, Shavelson, Ayala, Ruiz-Primo, Brandon, Furtak, Tomita, & Young 2008; Yin, Tomita & Shavelson, 2013). Students' prior knowledge and misconceptions shed light on the format of teaching lesson and in formative assessment; this is consistently performed to resolve students' incomplete and inadequate information at the beginning of the lesson and throughout the teaching process. It provides feedback about the learning and teaching of the course for both teachers and students when it is performed during the course.

According to Black and Wiliam (1998), Black, Harrison, Lee, Marshall and William (2004), the teaching performed in the classroom may result in conceptual learning in students if the teaching of the course is adapted again according to feedbacks received from the students. The main purpose of formative assessment is to support and increase students' conceptual understanding in the course. The information collected about what students know and what students do not know or what their incomplete information are in the placement test cannot be formative assessment unless they are used in the process of teaching of the course. Formative assessment is coherent to the process with feedback and teaching. In order to use formative assessment in classrooms in a more effective way, various strategies are suggested for teachers. One of these formative assessment strategies is annotated students drawings.

Annotated Students Drawings

The teachers can implement various strategies while they are using formative assessment in their classrooms. In her book, Page Keeley (2008) discusses on the benefits of using each 75 practical strategies as well as an annotated student drawings for teachers and researchers. In fact, she calls these strategies as "FACTs" (formative assessment classroom techniques) in her book. So, the term "strategy" can alternatively be used instead of the term "technique" in this paper. According to her, "Annotated student drawings are student-made, labeled illustrations that visually represent and describe students' thinking about a scientific concept" (Keeley, 2008, pp. 53). These drawings encourage students to uncover their initial ideas and give them a chance to represent their thinking. With this strategy, teachers let their students to think about how to express themselves by using minimal number of words. Annotated students drawings might be a helpful strategy especially for strong visual learners because of their graphic nature. Because Keeley (2008) thinks that these students are often at a disadvantage when asked to perform on written assessments that involve text only (pp 54). There are several advantages of using this particular strategy. The annotated student drawings are: 1) Student-made; 2) Labeled illustrations that visually describe students' thinking; 3) Requires minimal use of words; 4) Especially helpful for students who are strong visual learners; and 5) Encourage reflection. Keeley also states that initial drawings can be returned to students at the end of unit of instruction and these initial drawings are revisited to reflect on what students learned at the end of the class. The students can wonder why their second annotated drawings differ from their first drawing. And try to answer this question by them.

There are three purposes of this paper: 1) To introduce "annotated student drawings" as one of the formative assessment techniques; 2) To determine fifth and sixth-grade middle school students' initial understandings about the "pollination" and "water cycle", extracted from their pre-instructional drawings; and 3) To compare the students' pre and post-instructional drawings on both concepts.

Specifically, this paper examines the following questions:

1) What were the fifth and sixth-grade students' pre-instructional understandings on the concepts of "pollination" and "water cycle" extracted from their drawings?
2) Did fifth and sixth grade students' nonscientific ideas and incomplete understandings of the "pollination" and "water cycle" change and improve after the intervention? and
3) What is the feedback received from the science teachers about the implementation of annotated student drawings strategy?

Methodology

Master Course Context and Course Assignment

In his book titled "*Science Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning*", Page Keeley (2008) comprehensively describes 75 teaching strategies with regards to formative assessment. In the present study, one of the formative assessment strategies called "annotated student drawings" that is introduced in her book was described and the practices carried out with middle school students were evaluated.

The author of this paper was the instructor of an master course called "Formative Assessment." This course was offered in an elementary science teaching department at a large university in Turkey during Fall Semester 2015. Two female (age around 25) science teachers who were teaching at different middle schools registered for this two-credit master course. At the beginning of the course, the author introduced Page Keeley (2008)'s book and

mentioned about the 75 formative assessment techniques discussed in the book. As an example, one of the formative assessment techniques written in the book, formative assessment probes, was explained in detail. She shared several papers on the effectiveness of the probes with the master students. As one of the course requirements, the author wanted the master students to choose one of the formative assessment techniques from Page Keeley (2008)'s book, translate into Turkish, actually implement it with their own students at the schools, and finally evaluate the results of their implementation. The term "science teachers" is reserved for these two master students and the term "students" will be used for the students of these two master students in the paper. This study employed a qualitative methodology (Yıldırım & Şimşek, 2005) to investigate the nature of students' ideas about the concepts of "pollination" and "water cycle" by looking at the pre and post-instructional drawings.

Participants

The study was carried out in the classrooms of two science teachers doing their master's degree in the department. In total, 48 students participated in the study from 5^{th} (20) and 6^{th} (28) grades. One science teacher implemented the annotated student drawings technique with 5th graders at one school and the other one implemented the same formative assessment technique with her 6th graders at another school. The science teachers implemented the same technique at their different schools at different times independently.

Implementing Annotated Student Drawing Strategy before Intervention

The science teacher applied the "annotated student drawings" strategy before the teaching of the "Reproduction in Plants" subject which is included in the 6^{th} Grade science curriculum. After the teacher told the students how to implement this strategy in class, , she posed questions over the flower model (Where are petals?, Which of them are sepals?, What was the function of petals?, Where does the photosynthesis occur?, Who can show the pistils and anthers? etc..) to remind students of their first knowledge because students learned the parts of the plant (petals, sepals, pistil, anthers, pedicle, crown board and so on.) in the 5^{th} grade students, a year ago. Then, teacher distributed A4 papers to all students and asked them to draw the pollination and fertilization activity using a minimum of words to understand what kind of picture they created about what he told in their minds. Although the students with drawing skills enjoyed this activity, those with drawing skills stated that they were anxious because they could not explain what they knew. Each student was given approximately 10 minutes for drawing. The science teacher who performed an application regarding the "water cycle" concept in the fifth grades applied this technique within the scope of the unit called "Mystery of the Earth's crust" which is included in the 5^{th} grade science curriculum. The teacher stated that she also applied the annotated student drawing strategy to students in a previous unit; he found the strategy very effective. Because the unit called "Mystery of the Earth's crust" is difficult to learn for students, he decided to apply the same technique for the "water cycle" concept under this unit. The science teachers gave the following directions for students: Draw, label, and briefly describe each part of the water cycle. Include the changes in form and location of the water.

Data Collection Tool / Data Analysis

Pre and post-instructional annotated student drawings, the 5th and 6th graders made on the worksheets, were used for data collection. These pre and post- instructional annotated student drawings were examined first by both science teachers and then the author independently. The alternative and nonscientific ideas, incomplete understandings of the students were extracted from the students' drawings. The groups of words that the students wrote on their drawings were also examined. So, both drawings and the groups of words they wrote on the drawings gave a general idea on the students' pre and post-instructional level of understandings to the research team. Also, the science teachers' feedback that was sent to the instructor about their school practices was used as data collection tool.

Using Formative Assessment in Science Classroom as an Intervention

The drawings made by the student before the lessons were examined one by one by both teachers. The concepts on which they did not have any information about students' misconceptions and incomplete information were found in this examination. In the next lesson, teacher of the 6^{th} grade covered the subject in depth over the flower model without expressing what the incorrect and incomplete information he determined from drawings

were to students. The earning about this concept was: "Explains the growth and development processes in plants and animals by giving examples." It focuses on the example of a flowering plant. In science teaching program, all the earnings were supposed to be taught in 16 hours. But, this particular earning was taught only in 4 lesson hours. The lesson was also supported by videos. The teacher explained the concepts of pollination and fertilization again using animation. He solved multiple-choice questions with students at the end of the subject.

White papers were distributed to all students again before ringing the bell, and it was aimed to determine what was formed about the same concepts in their minds and whether their conceptual knowledge levels changed. Students were also given the same time to make the second drawing as in the first drawing. After all the applications had been over, both science teachers wrote a report in which they gave feedback to the author of the article, the course instructor about the school practices they conducted, and they sent it via e-mail. Research findings indicate that it is possible to develop a reliable, user-friendly instrument to generate a quantitative score for a qualitative work product, such as a drawing, and that a well-designed, research-based scoring rubric can be used to identify significant differences between drawings generated by individual students or different groups of students (Cronin-Jones, 2005, p. 231). However, in this study a specific rubric was not used to score the students' drawings. Two science teachers, who are the master students and their course instructor evaluated the drawings. The evaluation results were not transferred into the quantitative rubric scores.

Findings

The results obtained from the student drawings by science teachers who applied the "annotated student drawing" technique about the concepts of "Pollination and Fertilization" with sixth-grade students and "water cycle" with fifth-grade students before and after the course are respectively given below.

Implementing Annotated Student Drawing Strategy with 6th Graders

The science teacher applied this strategy to her twenty-eight students from 6th grade. A short while after she made an introduction to the lesson on pollination and fertilization in plants, she distributed blank papers to the students and asked them to depict the pollination and fertilization phenomena in drawing with as few words as possible. When she examined all drawings, she found out one of his students drew the pollens falling on the ground are germinating themselves in soil the most striking. This is because; it demonstrated that the student confused the concepts of seed and pollen. His drawing also indicates that he has a clearly evident misconception on fertilization. The following Picture 1. presents Arif's 1st drawing before the instruction with a clearly evident misconception on fertilization.

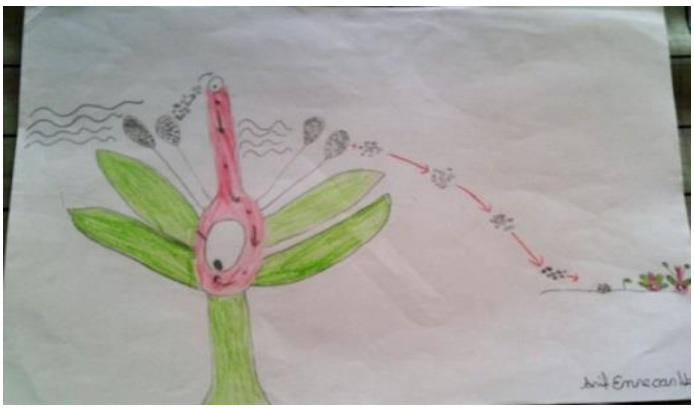

Figure 1. Arif's 1st annotated student drawing

In the next lesson, the science teachers taught the subject once again based the nonscientific ideas that she noticed in the first drawings by motivating the students by videos and animations. At the end of the lesson, the teacher distributed blank papers to the students and asked them to draw the same concepts once again. When she compared the second papers with the first ones, she saw that the concepts of pollination and fertilization became clear in the minds of most students, and the students who had confused pollen with seeds noticed their mistake and corrected his nonscientific ideas in their second drawings after the instruction. The following Picture 2. presents Arif's 2nd drawing after the instruction. In the second drawing, one can easily see that the initial misconception was overcomed.

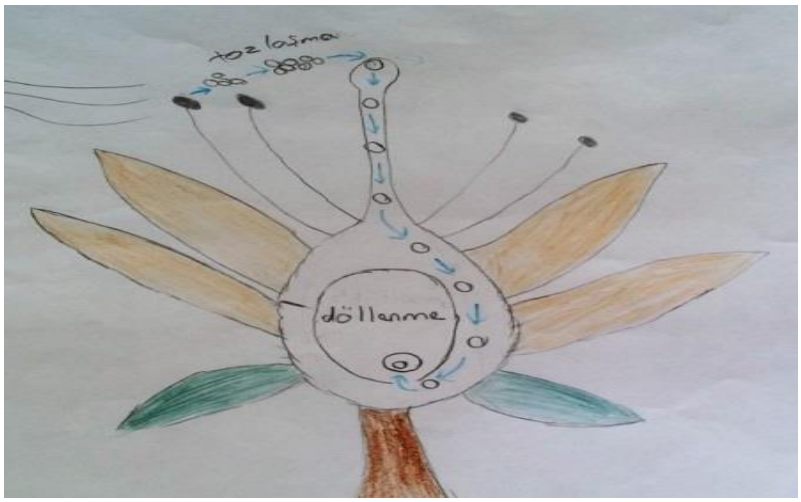

Figure 2. Arif's 2nd annotated student drawing

Ahmet, another student in the same class who participated in the research, drew a round object the inner side of which was painted black which was considered as "pollen" as placed/stuck on stigma, related to the concept of "pollination" in his first drawing he made course teaching. Regarding pollination, it can be said that he had the knowledge about the fact that the pollen should somehow come and settle on stigma. On the other hand, no information was found regarding "fertilization" in the first drawing of Ahmet. He used the word of fertilization but did not show how it occurs in his drawing. Ahmet did not write more descriptive information about both concepts in addition to his drawing. The following Picture 3 presents Ahmet's first drawing before the instruction:

Figure 3. Ahmet's 1st annotated student drawing

After the first drawings, Ahmet's science teacher analyzed the first drawings of students in accordance with the formative assessment, identified the students who had misconceptions and incomplete information or no information about that concept from their drawings, and shaped the course by the information obtained from the drawings. In Ahmet's second drawing after instruction, it is seen that he thought the concept of pollination as a germ cell which is brought by a bird from another flower to the stigma of the other flower. Regarding fertilization, it is seen that Ahmet drew that the male germ cell that came to stigma came down to ovarium through the stigma tube of the pollen. He drew a point waiting in the ovarium; and it is thought that probably this point is the "ovarium", female germ cell. Ahmet wrote only the words of "fertilization" and "pollination" over his drawings as in his first drawing, however, he did not write more detailed information about what these concepts were. You can find Ahmet's 2nd drawing after instruction below.

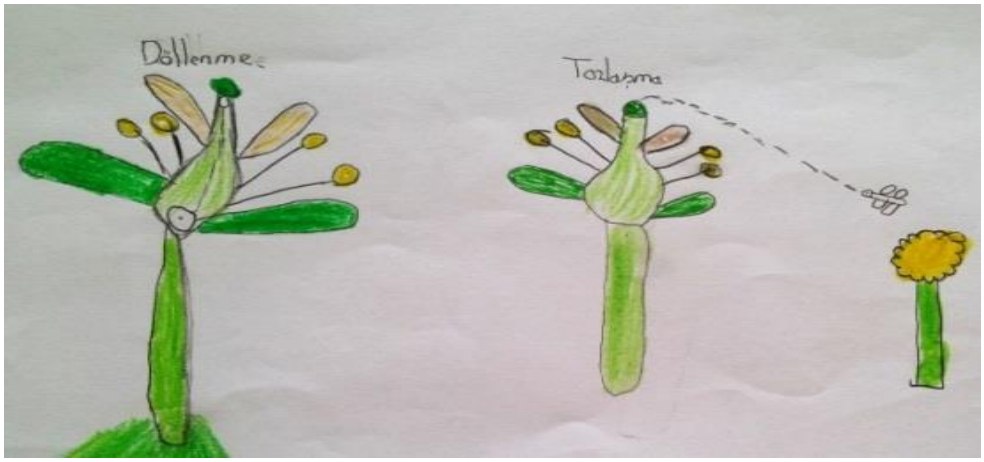

Figure 4. Ahmet's 2'nd annotated student drawing

Sixth Grade Science Teacher's Feedback about Formative Assessment Strategy

The feedback given by the science teacher about the annotated student drawings strategy she applied in the sixth grade as a formative assessment is as follows:

> I think this activity is quite effective in revealing students' misconceptions in science lessons. Because it is very difficult to recognize the right to speak to each student within the same duration in the classroom and get their opinions. In this activity, it is possible to see what they create in their minds without words by giving equal time to all students. This removes the advantages of students with high communication skills compared to other students, and equity is assured about duration and right to speak. It is a useful activity especially for students who are shy and have difficulty in expressing themselves. Regarding the limitation of the activity, it can be said that it causes stress in students with low drawing ability and may lead to a lack of motivation against the activity.

Implementing Annotated Student Drawing Strategy with 5th Graders

The students' pre-interventional annotated drawings revealed arrows labeled "evaporation" going from a body of water straight up to a cloud and to the sun. Arrows in their drawings that indicate that evaporated water goes immediately up to the clouds and sun may reveal that the student does not understand that the evaporated water first stays in the air around us in a form of water vapor we cannot see (Keeley, 2008). According to Keeley (2008), if this is the case, the science teacher needs to probe further to find out a student's notion of what happens to water after it evaporates. In Figure 5, the student has the similar understanding that water directly evaporates from sea /rives to clouds.

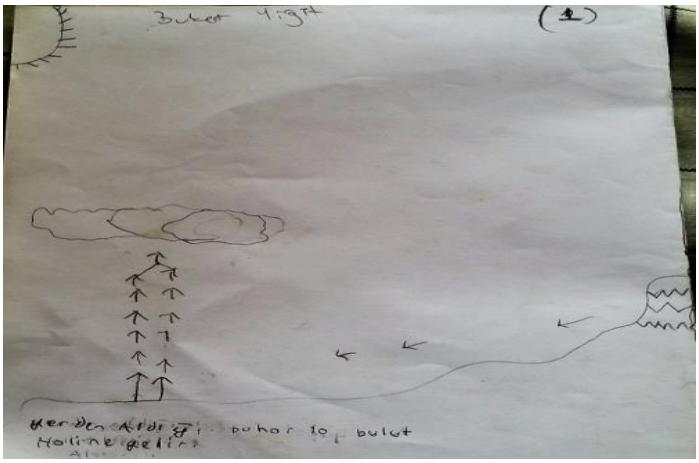

Figure 5. Buket's 1'st drawing

When the same student's drawing after the instruction is analyzed, the arrows rising from ocean up to the air indicate that water is firstly evaporated and then creates the clouds by the condensation of the water vapor. It

seems that the student has partially eliminated the mistake in the first drawing. But this time, it is seen that the student has incorrect information about groundwater in the second drawing of that student. This drawing shows a large, underground river labeled "groundwater." This student's second drawing indicates that he has a new misconception that groundwater exists in large, underground lakes or rivers, rather than in spaces between the particles of soil or rock (see Figure 6 and Figure 7 for the similar misconception in their drawings).

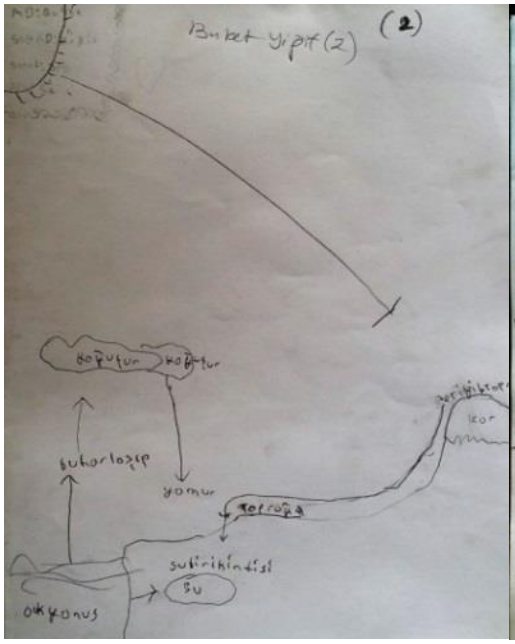

Figure 6. Buket's 2'nd drawing

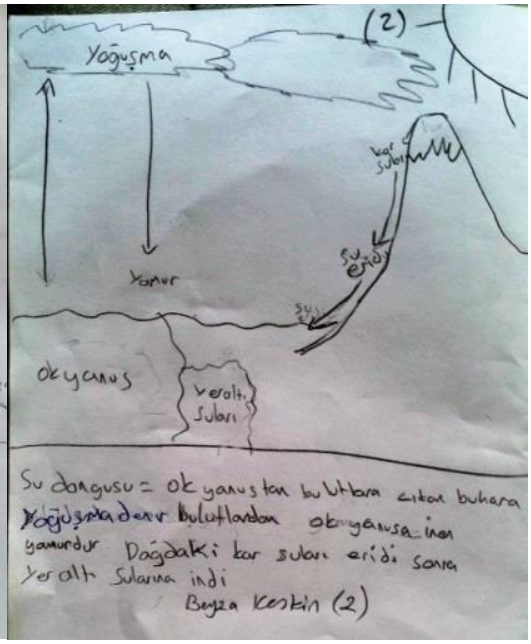

Figure 7. Beyza's 2'nd drawing

One student's pre-interventional drawing indicated that he had a misconception on raining. He wrote the word of "rain" in a cloud. He has confusion about what actually the clouds have. Do they have rain in them? Or, something else? He used the word of "precipitation" instead of "raining" in his 1st drawing. Please look at the following Picture 8. to see this misconception on rain and condensation.

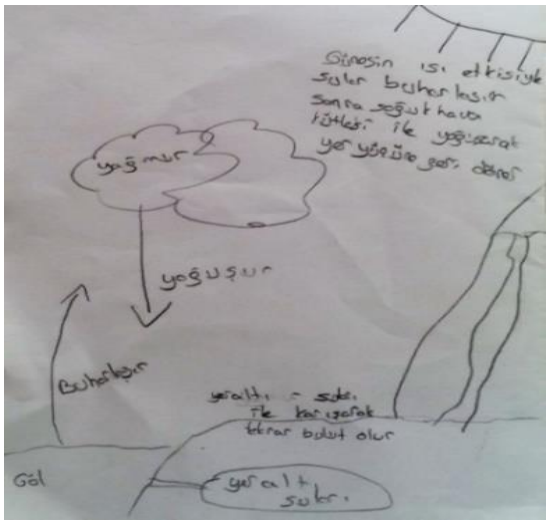

Figure 8. Ali's 1st drawing

When we look at Ali's second drawing after the intervention, it is seen that there is no misconception about the concept of "rain" in this drawing. Ahmet did not write the word of "rain" in the cloud in the second drawing, instead, he wrote the expression that the water vapor "falls down to earth as a rain" as a result of condensation. This finding indicates that the misconception in the first drawing has disappeared. Nevertheless, the misconception about underground water which was previously mentioned above appears in the 1st and 2nd drawings of Ali. What Ali understands from the concept of underground water is a small piece of enclosed sea or a little lake having a connection with sea under the ground.

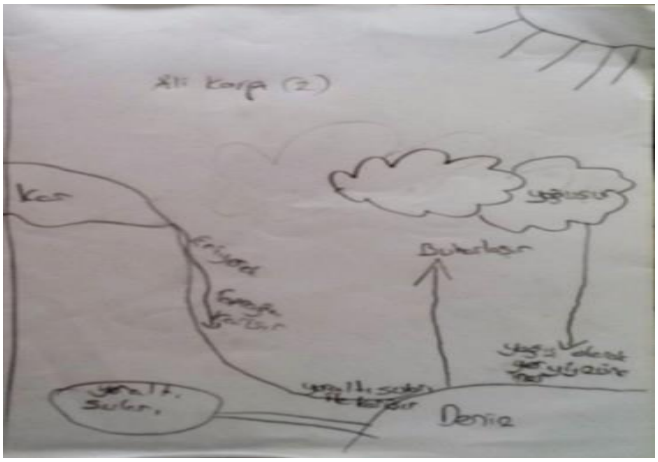

Figure 9. Ali's 2'nd drawing

Fifth Grade Science Teacher's Feedback about Formative Assessment Strategy

The feedback given by the science teacher about the annotated student drawings strategy she applied in the fifth grade as a formative assessment is as follows:

> Using annotated drawing strategy in my lessons was very helpful for me in determining my students' misconceptions. I had the opportunity to organize my lessons according to the information I get about my students. Our lessons were very enjoyable. I was a teacher who felt much more tired before using formative assessment methods and strategies, but now I do not get tired as before and I have realized that my students are more open to receiving information as they take more pleasure in lessons. It has become easier for them to learn information and make an interpretation. I think all these have led to the realization of a deep learning. Their achievements have increased. Therefore, my self-confidence has also increased as a teacher in this way. I think I'm more successful.

Discussion

In this research both science teachers implemented the annotated student drawings as a formative assessment strategy in their classrooms with 5th and 6th graders. The main purpose of the science teachers was not only to uncover students' initial knowledge, but also to format, organize and revise their teaching intervention by using this strategy. In terms of cognitive level of the students, first drawings were full of lack of understanding, incomplete understanding, alternative conceptions or misconceptions in the 1st drawings. Both science teachers were quite enthusiastic about using different strategies in their classrooms with the students. So, they gained info about their students' cognitive levels on the concepts as much as they could from the 1st drawings. They did not prefer to use traditional teaching techniques in the classroom. They used models, animations, videos, solved related multiple choice problems while they were teaching. They tried their best. However, some students were somewhat able to recover their misconceptions. But, like in the most research some students still have incomplete understandings and even misconceptions.

In the feedback made in the aftermath of the practice, both teachers highlighted that this strategy was very effective in uncovering the nonscientific conceptions that students had in science lessons. They expressed that it was difficult to allocate the same amount of time to each student and ask their opinion, but through this activity the same amount of time was allocated to each student, thereby making it possible to see what was formed in their minds regarding the subject. They stressed that this strategy both eliminated the advantage that the students with advanced communication skills have over the others and became a helpful activity for the ones who have difficulty in expressing themselves. As regards to the limitations of the strategy, they also underlined that the students who are not very good at drawing experienced stress which led to a decline in their motivation.

When we compared the drawings of fifth and sixth graders in terms of the number of words they included in their drawings, there seems to have an unexpected result. The fifth graders focused on "water cycle" and they wrote much more words that explain what they actually drew than sixth graders who focused on "pollination and fertilization." Although the water cycle group is one year younger than pollination and fertilization group, they were able to express themselves by using enough number of words, and elaborated their annotated

drawings. This helped the science teacher to understand what the students actually know about the concept in detail. On the other hand, the sixth graders wrote only one or two words per concept. While the sixth graders colored their annotated student drawings, the fifth graders preferred to use only pencils rather than pencils with multiple colors. The reason having this difference can be is that both teachers might have given different instructions to their students before they started to implement the strategy. Probably, the science teacher who taught for fifth graders specifically highlighted them to write little explanations on their drawings, but the other science teacher might not have given the similar instruction. The reason of using or not using the colored pencils on drawings by students might be the same.

Similar to the findings of Black and William (1998) and Black, Harrison, Lee, Marshall and William (2004), both science teachers believe that formative assessment strategies are fairly effective in uncovering the prior knowledge of students and increasing their active participation in classroom. These practices generally: 1) Arouse the interest of students; 2) Encourage them to learn, and 3) Contribute to the improvement of their questioning skills (Keeley, 2007; 2008; 2009). Therefore, teachers can use different methods in their lessons as did these science teachers. In this research instead of uncovering students' first knowledge by conventional methods, formative assessment is not simply to uncover students' first knowledge. This means using first knowledge to shape the course and make students have acquisitions by constantly revising it. Formative assessment is performed for learning, not for giving a grade. The teacher constantly receives feedback from the student during the course and continuously improves the course within the scope of these feedbacks, so that the meaningful, permanent learning and conceptual change are ensured in students ….

Suggestions

The following are suggested based on the findings of this study:

1. The teachers need to avoid assigning this strategy as an "out-of-class" assignment. Otherwise, students can let their parents to make the annotated drawings instead of themselves.
2. The teachers also need to avoid or be careful when praising students who exhibit "artistic talent."
3. Students with strong verbal activities & less developed drawing skills may find this strategy frustrating. Therefore, the teachers ought to be careful on that.

Acknowledgements

Especially, I would like to thank to the master students, they are actually successful science teachers, for their enthusiasm and effort in this research. Also, many thanks to the students who participated in the annotated drawing activity during the intervention process.

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