Worksheets Enriched with Computer-Assisted Activities Based on the Constructivist Learning Theory: An Example of Half-Life and Radioactive Decay

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Abstract
This study is aimed to enrich the worksheets, which are based on the constructivist learning approach for the concepts of half-life and radioactive decay, with computer-assisted activities. For this purpose, the worksheet developed for the constructivist learning theory related to half-life is enriched with virtual experiment and animation, and the other worksheet developed for the concept of radioactive decay is enriched with animations containing cube activity. The pilot application of the worksheets enriched with computer-assisted activities was carried out with eighteen 11th grade students. The main application of these worksheets was carried out with a total of 35 11th grade students, 14 of which were from an Anatolian High School and 11 from an ordinary high school. Following the main applications, 2 chemistry teachers and 6 students were interviewed about the worksheets and the application process. The data obtained from the interviews are presented by direct quotes for the purpose of thoroughly reflecting the opinions. As a result of the study, the application process and the worksheets enriched with computer-assisted activities were found to be different, attentive-grabbing, and fun for teachers and students. We think that the worksheets created by computer-aided activities will help teachers, teacher candidates, and researchers who would like to work in this field.
Keywords: Half-life, radioactive decay, chemistry education, material development

1. Introduction

The constructivist learning theory, which allows learners to be active, to structure and interpret their own knowledge, is used quite often in learning environments. It is necessary to be in control in the class, systematically monitor the students, to identify the individual opinions of students and most importantly to keep the necessary communication with students when running activities that are suitable for the constructivist learning theory (Proctor, Enstwistle, Judge & McKenzie- Murdoch, 1997). Furthermore, various materials are needed in learning environments for teaching in line with this learning theory. For instance, conceptual transformation texts (Chambers and Andre, 1997; Dönmez Usta, 2011), conceptual caricatures (Ültay 2015), conceptual maps (Botton 1995; Dönmez Usta & Ültay 2016), and worksheets (Ültay, Ültay & Dönmez Usta, 2016; Coştu, Karataş & Ayas 2003; Dönmez Usta & Ayas 2013) can be used. It is claimed that worksheets prepared in line with the constructivist learning theory make students active, help students effectively construct concepts in their minds, and minimize misconceptions about concepts (Demircioğlu & Atasoy 2006). Worksheets are prepared for the purpose of minimizing the role of teachers in learning environments and thus ensuring students access information by themselves (Uslu, 2011). Worksheets that ensure students access information by themselves are documents, which guide students for their learning, in order to materialize effective conceptual teaching in the course of teaching process (Özmen & Yıldırım 2005). Worksheets prepared based on the constructivist learning theory are effective in ensuring the expected behavioral transformation of students and alleviating misconceptions about concepts (Özmen & Demircioğlu 2005). In addition, students engage with their teachers and peers in classes run with worksheets, and discussion environments can form. In turn, these discussion environments inform teachers about student opinions. In this process, the duty of a teacher is to lead and guide students through questions in order to help them reach the target concept (Kurt, 2002; Çalik 2006). It is argued that worksheets improve communication in group activities and contribute to students' interests and attention towards classes (Dönmez Usta, 2011). When applied individually, worksheets make students accountable for their own learning and help in improving their self-confidence. Some studies identify certain disadvantages of worksheets such as limiting students' freedom of thought, making the preparation and application stages cumbersome and being costly (Kurt 2002; Demircioğlu & Atasoy, 2006).

Worksheets need to have certain criteria for making students acquire the desired attitudes, allowing the use of multiple skills, and preventing situations that can arise from lack of discipline and boredom in classroom environments. These criteria recommended by Cohen, Manion and Morrison (1996) can be listed as follows:
What is the actual purpose of preparing worksheets?

- Is there a required need for a worksheet?
- How can worksheets be prepared and presented for different students for the purpose of using in a single class?

- Will worksheets make it harder for smart and quick students to come to a conclusion?
- Do students know how to answer questions on worksheets? If not, what would be the role of students? How would students find the answers for questions?
- What sort of equipment and resources are needed for assignments on worksheets?
- What topics should worksheets address more?
- Is it necessary for teachers to identify any textbook as a source?
- How many activities should exist on a worksheet?
- How can it be ensured that worksheets are readable?
- How would worksheets encourage and improve group or classroom discussions?
- Should the necessary duration be specified clearly for finalizing worksheets?
- How should worksheets be associated with equipment presented for accessing information?

Worksheets prepared in line with the criteria above are generally composed of three parts. They can be listed as drawing attention, active involvement, and assessment (Yigit, Alev, Altun, Özmen & Akyıldız, 2005). In the first part, the goal is to draw attention of the students by using situations such as drawing, caricatures, questions, and stories. Students are expected to be curious about what follows a specific worksheet and then automatically proceed to the second section. However, specific instructions can be placed in order to ease the transition to the second section (Sands & Özçelik 1997; Demircioğlu & Atasoy, 2006). Students should be guided through instructions in the second part; they should both physically and mentally operate and organize their data/observations. In other words, if necessary, they should conduct experiments and take measurements, draw graphs, take notes by questioning the relationship between variables, contemplate on questions, and record the necessary information (Çınkı, 2007). In the third section, students should organize and evaluate the information they have obtained, can make inferences and adapt what they have learned to the situations they face.

Preparers should make sure that worksheets are appropriate to the level of students in terms of language in particular; information should be short but to the point; important sections should be clearly highlighted; instructions should be numbered and written according to their order of use; appropriate blanks, on which answers and comments related to questions can be written, should be present; graphs and tables should be clear, and a pilot study must be carried out before the application (Kurt, 2002). Worksheets, which are prepared for minimizing the role of a teacher in a learning environment in science education and making sure that students individually access information, can also be used for acquiring a new behavior and consolidating a newly acquired behavior (Uslu, 2011).

Modern technologies increase the expectation of training qualified individuals by putting new tools to use and transforming the forms of communication (Dönmez Usta, 2016). Societies of information age being able to respond to these expectations depend upon improving variables such as educational programs, training instructors, and physical environment. Computer, which can be the most effective tool used in teaching is a technological instrument that supports the development of education-teaching process and quality. The fact that qualified teachers have become insufficient for the increasing number of students in the field of education, and an increase in behaviors needed to be acquired in line with technological developments have caused the emergence of many issues (Uşun, 2000). One of these issues is the lack of material for any discipline such as physics and chemistry in the Computer Assisted Instruction (CAI) applications in Turkey and the lack of their development by experts in their fields (Yiğit & Akdeniz 2003). One of the major factors that provide a productive learning environment and play a role in improving the efficacy of the CAI applications for alleviating these issues is to provide information by using various multimedia devices such as texts, sound, videos, graphs and animations. In this context, this study aims at enriching the worksheets for the constructivist learning theory, which is developed for the concepts of half-life and radioactive decay, by using various multimedia devices.

2. Methodology

This section discusses the development of the worksheets for the constructivist learning theory related to half-life and radioactive decay, and the enrichment of these worksheets via computer-assisted activities.

2.1. *The worksheet created based on the constructivist learning theory related to the concept half-life (The Worksheet 1)*

A detailed literature review was conducted before developing the related worksheet in this study. After the literature review, misconceptions about the concept of half-life were identified. The worksheet consists of three sections as also stated in the literature on the constructivist learning theory. In addition, the goal in the first section is to draw attention by using situations such as drawing, caricatures, questions, and stories. For this reason, the question “What comes to your mind when I say the half-life of a radioactive matter and measuring the half-life? Please explain” appears in the first section of this study. Therefore, students’ attention was drawn regarding the concept of half-life, and their background information on the concept was aimed to be determined.

The main screenshot of the respective worksheet is presented in Figure 1.

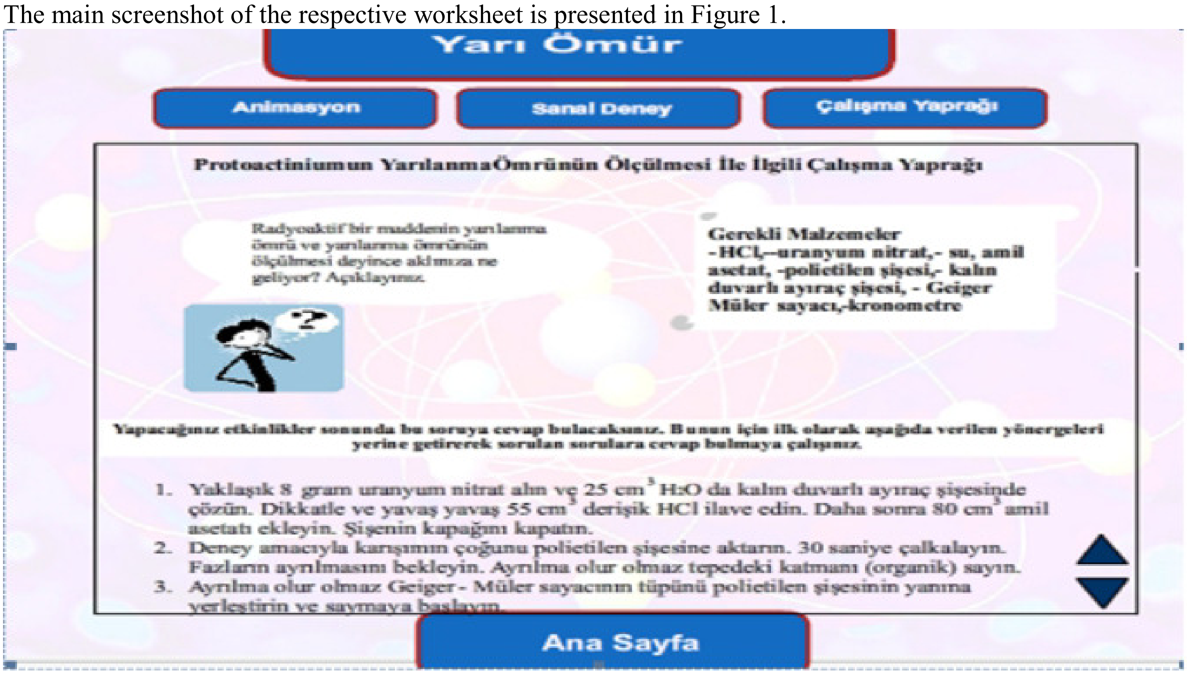

Figure 1.The sample main screenshot for the worksheet

The second section of the worksheet on half-life aims at students observing and mentally organizing the data through instructions. For this purpose, a virtual experiment was prepared for students to conduct experiments with instructions, question the relationship between variables, and record the required information. The half-life of protactinium was attempted to be calculated in this related experiment. The reason for preparing a virtual experiment on the half-life of protactinium is to make abstract concepts such as half-life concrete, and to provide an opportunity for experimenting with matters such as uranium that is difficult and dangerous to work with in laboratories. Besides, the fact that obtaining materials and tools such as the Geiger-Muller counter and uranium nitrate is difficult makes a virtual experiment for the related concept unavoidable. The related virtual experiment was first designed on paper. Then, feedback from experts in the field was received about the issue area and visual design, and necessary adjustments were made. After making the necessary adjustments, required steps are presented in the second section of the worksheet, which is then transferred to virtual environment, in order for students to carefully read the instructions and gain experience about how to carry out an experiment. The following stages were followed in the order described below for this virtual experiment:

1.Take an approximately 8 grams of uranium nitrate and dissolve it within 25 cm3 H20 in a thick-wall reagent bottle. Carefully and slowly add 55 cm3 concentrated HCl. Then, add 80 cm3 amyl acetate. Put on the bottle cap.

2.Transfer the majority of this mixture into a polyethylene bottle for the purpose of this experiment. Shake for 30 seconds. Wait for phases to separate. Count the (organic) layer on top once separation occurs.

3.Place the Geiger-Mueller tube beside the polyethylene bottle once separation occurs and begin counting.

4.Count every 20 second. Wait for 10 seconds in-between counting. In other words, record the total number of the average of 0-20, 30-50, 60-80, 80… and 20-second periods. Thus, count C1 in 10, C2 in 40, C3 in 70 and C is the total number of a 20-second period.

5.Once you are finished, put the mixture in thick-wall reagent bottle again.

The stages needed to be completed in the second section of this virtual experiment of the worksheet about half-life are presented above. The sample screenshots about these stages are presented in Figures 2, 3, 4, and 5:

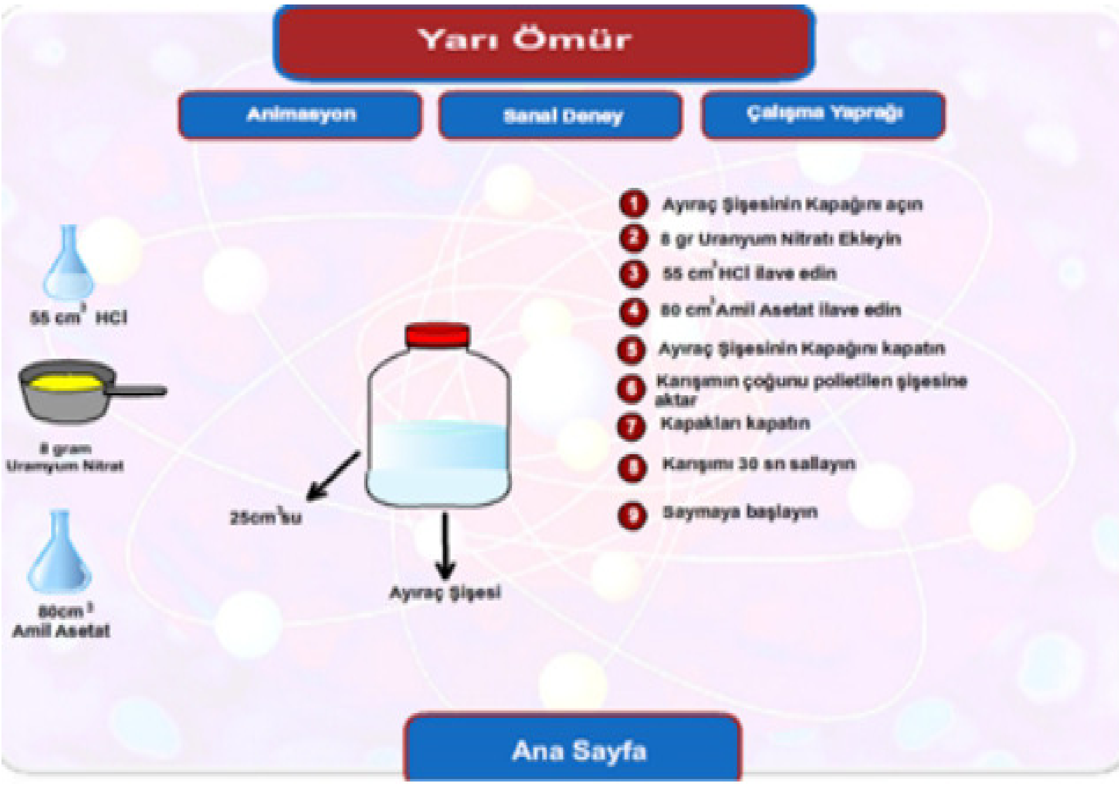

Figure 2. The sample screenshot 1 for the worksheet related to “the half-life of protactinium”

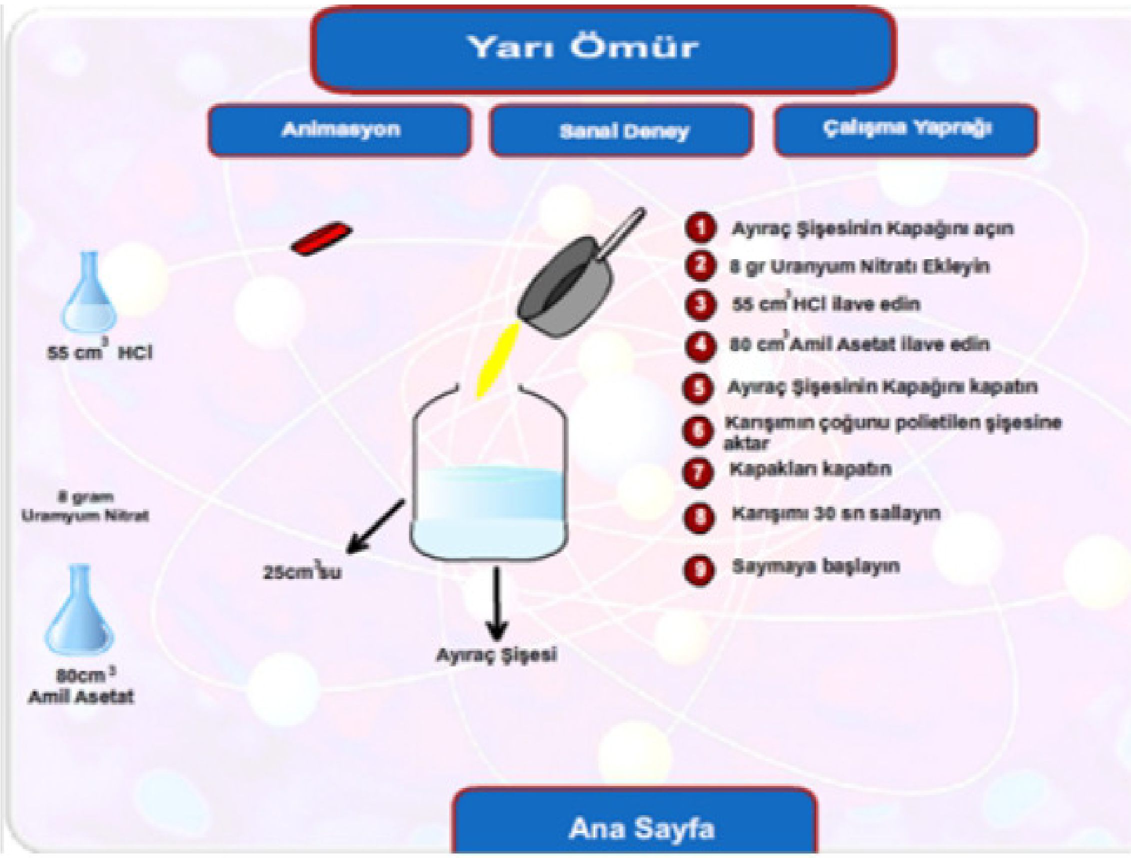

Figure 3. The sample screenshot 2 for the worksheet related to “the half-life of protactinium”

Figure 4. The sample screenshot 3 for the worksheet related to “the half-life of protactinium”

Figure 5. The sample screenshot 4 for the worksheet related to “the half-life of protactinium”

After completing these steps, questions “Why would the results be counted in every 20 seconds, and why does the counting occur by waiting for 10 seconds in-between these counts?”, “What would be the reason for putting the mixture in a thick-wall reagent bottle again?” and “What can you say about the concept of half-life after your experiences?” were asked to students and the necessary scientific information was provided. Students were asked to graph the results, which are counted in every 20 seconds, and to find the half-life of protactinium. The graph was then reflected to the screen in order for students to make comparisons with the results that they have found. The screenshot about the related graph is presented in Figure 6.

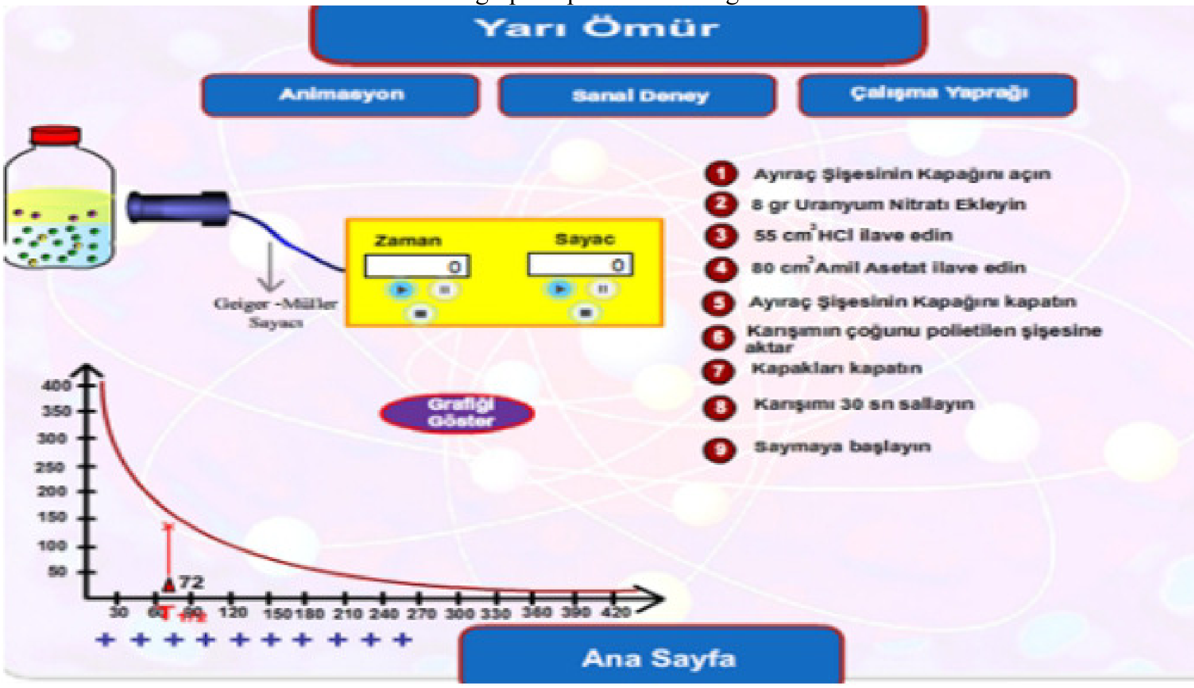

Figure 6. The sample screenshot 5 for the worksheet related to graph

Students watch an animation on half-life prepared by the researcher in order to consolidate the concept of half-life. The animation is about the half-life of the elements 226Ra, 14C, and 239Pu. The number of elements decayed in time was shown with a graph in this animation. Also, the number of decay is also present in the Geiger counter in terms of the becquerel unit. The screenshot of this animation is shown in Figure 7.

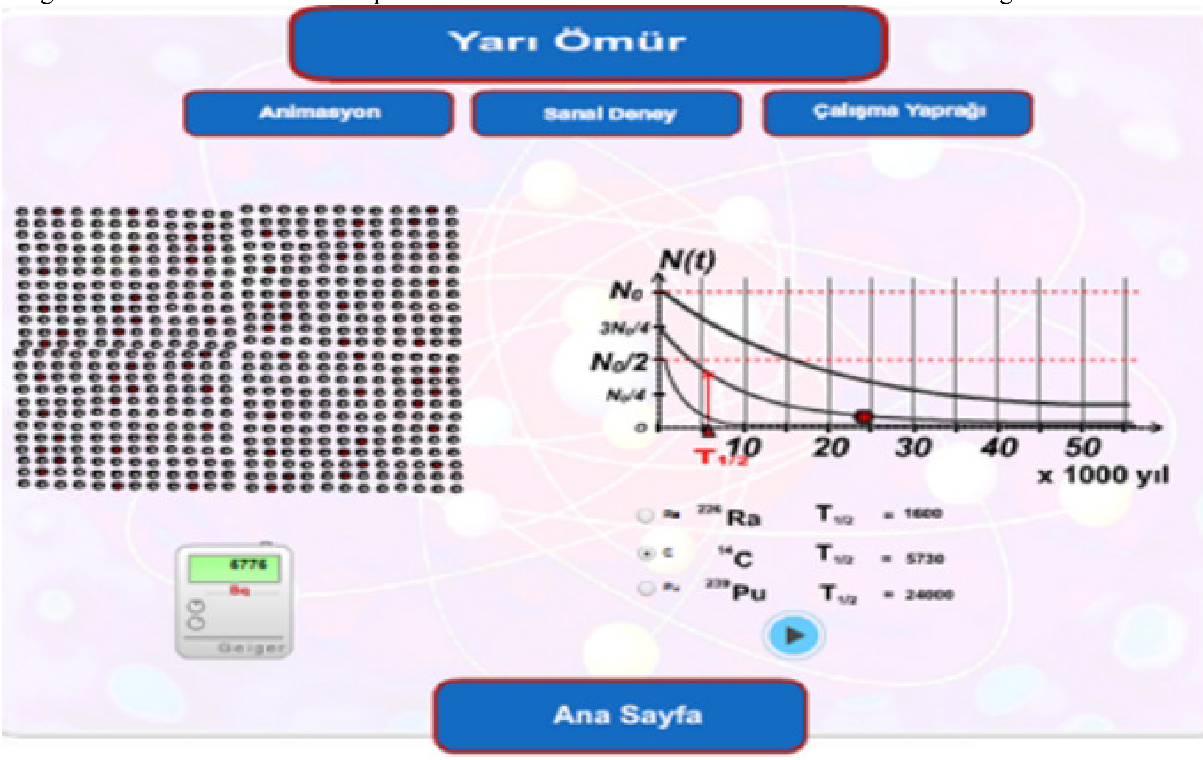

Figure 7. Sample screenshot from the half-life animation

In the third section, students should be able to organize and evaluate the information they have obtained, make inferences, and adapt what they have learned to the newly experienced situations. For this reason, students were asked operational questions about the concepts they have learned in the third, or the last, section of the

worksheet. Here, the goal was for students to apply the information they learn to new situations. These questions are as follows:
1.What is the half-life of a radioactive element if 6.25 percent of the said element is able to remain without decay in 16 hours?
2.One gram radioactive element is needed for a research lab. This element will be brought to the lab from a nuclear reactor that is 60 hours away. Given that the half-life of this element is 10 hours, how many grams of material should be brought from the reactor?

2.2. *The worksheet developed based on the constructivist learning theory related to the concept of radioactive decay (The worksheet-2)*
A detailed literature review was conducted in this study before creating the respective worksheet. After this literature review, misconceptions about the concept of radioactive decay were identified. The worksheet consists of three sections as also stated in the literature in line with the constructivist learning theory. Besides, the goal is to draw attention by using situations such as drawing, caricatures, questions, and stories in the first section. For this reason, the question "what comes to your mind when I say radioactive decay?" was asked to students in the first part of the worksheet. Thus, students' attention to the concept of radioactive decay was drawn, and the goal was to determine the level of prior knowledge they have on the concept. The main screenshot of the related worksheet is presented in Figure 8.

Figure 8. The sample main screenshot for the worksheet

The cube activity (Ayas, Cepni, Johnson & Turgut 1997) related to the concept of radioactive decay in the second section of the worksheet was transferred to virtual environment by the researcher after some modifications. In this activity, the goal was for students to observe and mentally organize the data through instructions. The necessary steps for this cube activity are as follows:
1.Mark one side of the cubes. Then, this side should be clearly separated from the others.
2.Put these cubes into a box. Close the box and shake it.
3.Open the box. Remove the cubes that show the marked side. Count them.
4.Record this figure, the number of cubes left in the box, and the number of fires into the box seen on the lower

left end of the screen.
5.Continue this process until a few or no cube remain.
6.Graph the number of remaining cubes compared to the number of fires.
The sample screenshots about these stages are presented in Figures 9, 10 and 11.

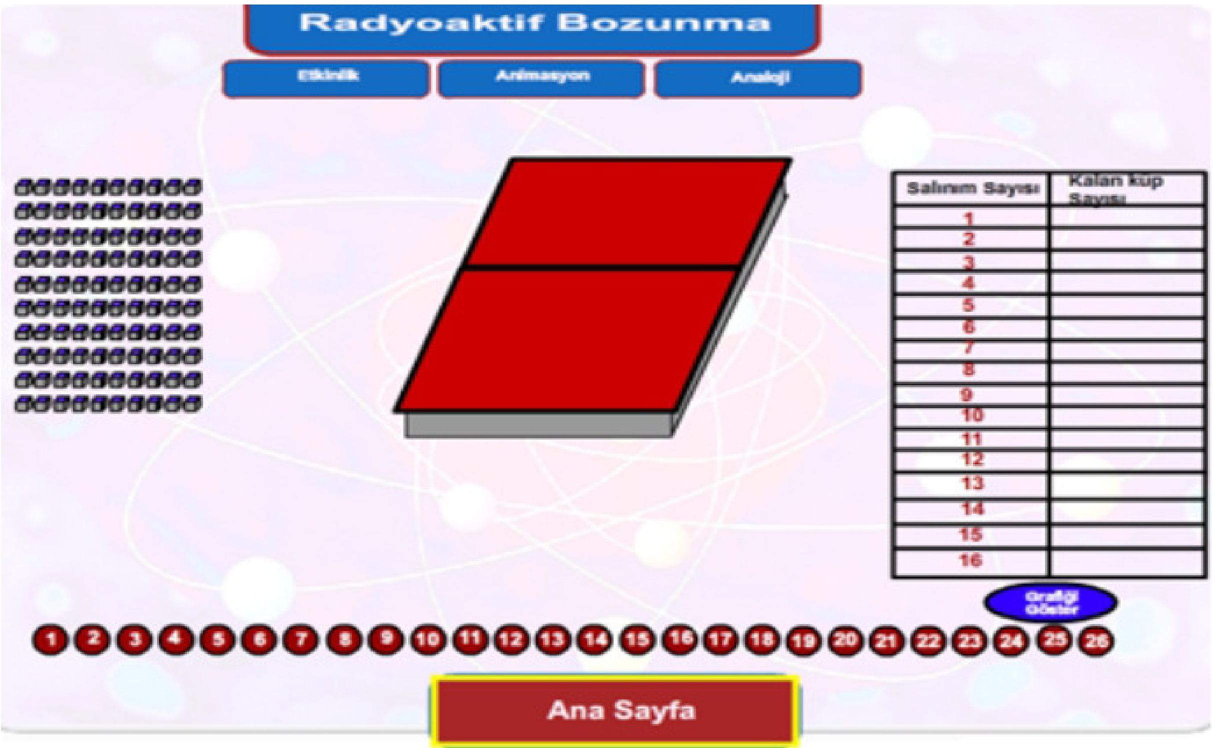

Figure 9. The sample screenshot 1 for the worksheet related to the cube activity

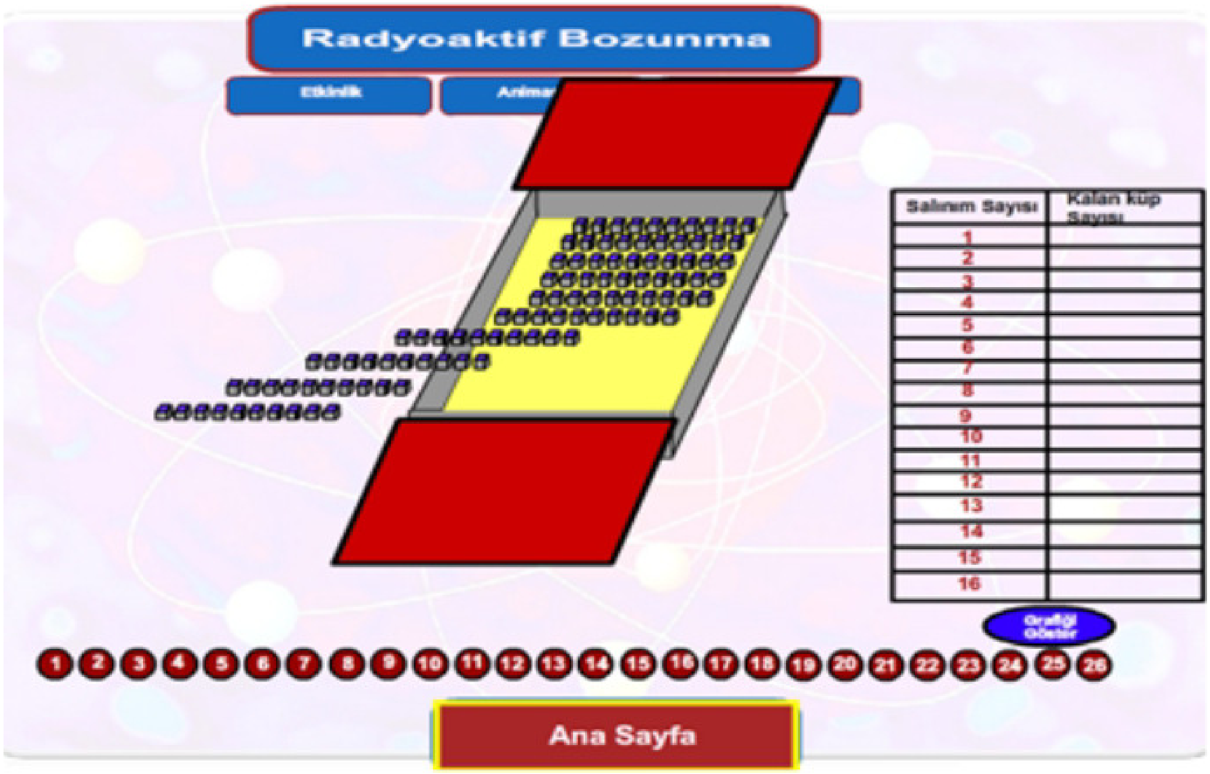

Figure 10. The sample screenshot 2 for the worksheet related to the cube activity

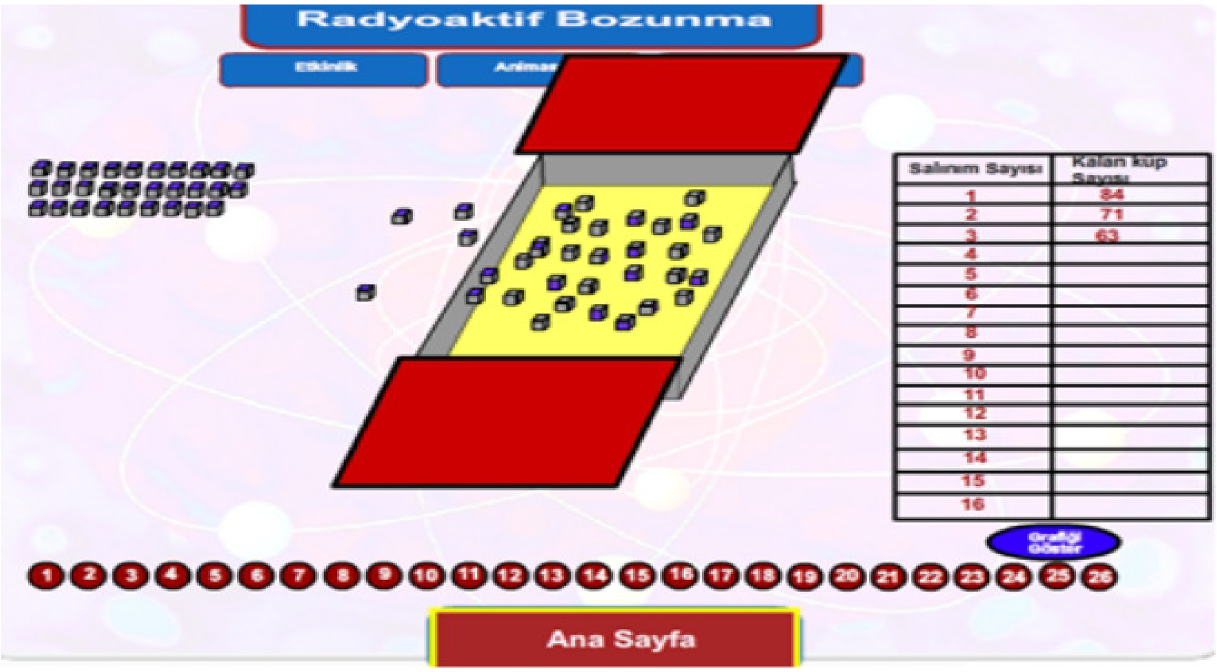

Figure 11. The sample screenshot 3for the worksheet related to the cube activity

After completing these steps, questions "What would be the reason for continuing this process until a few or no cube remain? Please explain", "What does the graph that shows the number of remaining cubes compared to the number of fires refer to?" and "What can you say about the concept of radioactive decay after your experiences? Please explain" were asked to students and the necessary scientific information was provided. Students were asked to graph the number of remaining cubes compared to the number of fires. The graph was then reflected to the screen in order for students to make comparisons with the results that they have found. The screenshot about the related graph is presented in Figure 12.

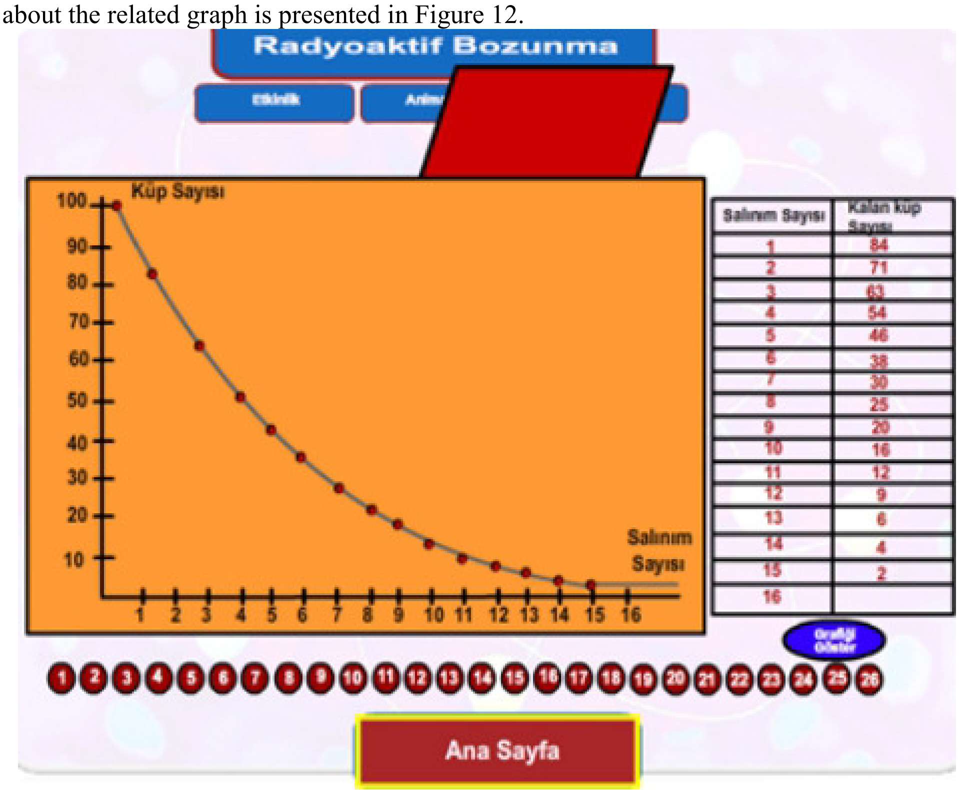

Figure 12. The sample screenshot for the worksheet related to graph

In the third section, students should be able to organize and evaluate the information they have obtained, make inferences, and adapt what they have learned to new situations they experience. For this purpose, the goal in the third (or last) section of the worksheet was for students to apply the information they learn to new

situations. In this respect, the following questions were asked to students:
1.What other simple tool can you use to show a different probability of decay?
2.State your own opinions as a result of this activity and discuss it in class.

2.3. Pilot Application

The pilot study was conducted with 18 11th grade students at the school lab of the Anatolian High School in the provincial downtown of Görele in Giresun. The researcher noted any situation needed to be carried out in order to alleviate potential problems during the pilot application process, and the necessary changes were made to the worksheets created following the application. Materials were re-organized and finalized after the pilot application. Post-pilot study changes are as follows:

Any shifting at writing and tables used on the worksheets was corrected. Mistakes in words and sentences were corrected.

- Estimated duration for each activity was determined.
- Some mistakes occurred in steps for the virtual experiment conducted in the context of the "half-life" worksheet. We recognized and corrected for these mistakes during the pilot application.
- Since the Bq values on the animation for half-life did not fully reflect the actual values, they were corrected and made closer to the values in practice.
- The molecule names were written in order for students to better understand which molecules have transitioned to the next phase in the detailed investigation section after the eight step of the virtual experiment.
- Problems in the cube activity were solved, and colors of the cubes were changed.
- Auxiliary, complimentary materials were identified for teachers, and these materials were prepared before the actual application.

Lesson plans based on the constructivist learning theory, which contain the instructions for teachers on how to use these worksheets, were prepared before the pilot application. Problems in these lesson plans were noted and necessary adjustments were made during the lesson of this pilot application. The lesson plan recommended for half-life is presented in Table 1 below:

Table 1.The Lesson Plan for Half-Life

Unit name/number	Nucleus Chemistry / Nucleus Physics
Recommended Duration	1 class hour
What Students Gain	• It explains the concept of half-life
Teaching-Learning Methods and Techniques	Four-stage model of the constructivist learning theory, discussion, Q&A, group study, virtual experiment
Instructional Technologies Used -Equipment, Materials, and References • Teacher-Student	The worksheet on Half-Life (Worksheet-1)
Learning-Teaching Activities	
• (1st Stage) • (2nd Stage) • (3rd Stage)	The question "What comes to your mind when I talk about the half-life of a radioactive matter and measuring half-life" on the worksheet is directed to the class and prior knowledge of students on the concept is determined before distributing the Worksheet-1. Also, what the rate of radioactive decay means is asked. The Worksheet-1 is distributed to students in order to make sure that they acquire sufficient experience. The instructor emphasizes that uranium salt decays; and protactinium, which is a by-product of this decay, can be separated and counted; it forms a transition metal complex with HCl; this complex dissolves in organic solvents and thus can be isolated. Virtual Experiment The virtual experiment is counted as stated on the Worksheet-1. After the experiment, the questions such as "Why would the results on the Worksheet-1 be counted as stated above?" "What is the reason that we put the mixture in a thick-wall reagent bottle again?" "What can you say about the concept of half-life after these experiences you have acquired?" are directed to the students, a classroom discussion is stimulated, and these questions are examined. The fact that the duration passed for decaying half of radioactive element atoms is called half-life is pointed out. Students watch an animation on half-life.
Measurement-Assessment	
(4th Stage)	The last 2 questions on the Worksheet-1 are used as assessment questions.

A lesson plan recommended for radioactive decay is presented in Table 2.

Table 2.The Lesson Plan for Radioactive Decay

Unit name/number	Nucleus Chemistry / Nucleus Physics
Recommended Duration	1 class hour
What Students Gain	It explains radioactivity, radioactive beam, radioactive element and decay.
Teaching-Learning Methods and Techniques	Four-stage model of the constructivist learning theory, discussion, Q&A, group study, virtual experiment
Instructional Technologies Used -Equipment, Materials, and References Teacher-Student	Worksheet-2
Learning-Teaching Activities	
(1st Stage)	The first question on the worksheet and the following questions of "What is Radioactivity?" "What is Radioactive Beam?" "What is Radioactive Element? Explain." is directed to the class, and prior knowledge of students on the concept is determined before distributing the worksheet.
(2nd Stage)	The Worksheet-2 is distributed to students in order to make sure that they acquire sufficient experience. The instructor walks inside the classroom, monitors studies of the students, and ask questions (but avoids providing hints to students).
(3rd Stage)	Then, the radioactive decay activity is carried out as stated in the Worksheet-2. The questions "What would be the reason that we continue this process until a few or no cube remains? Explain. What does the graph of the number of remaining cubes compared to the number of fires indicate for us? Explain. What can you say about the concept of radioactive decay after your experiences? Explain" were asked to the class after this activity, and a classroom discussion forms. Students are asked to graph the number of remaining cubes compared to the number of fires, and students are given the opportunity to compare their own graphs with the activity graph in CAI material. Then, necessary scientific explanations are made. The French physicist Henri Becquerel observed in 1896 that uranium salts dissipate rays that cannot be seen with naked eye, and these rays reflect on photographic films by going through paper, glass as well as some other materials. Then, the thorium element was also identified to spread similar rays. In 1898, Marie and Pierre Curie found two elements called polonium and radium. They identified that polonium and radium have more severe characteristics than uranium salt. They also demonstrated that uranium beams are related to nucleus but not tied to the physical and chemical properties of uranium. Rutherford explained the characteristics of beams emitted by certain matters, and named these beams as alpha, beta, and gamma. These beams are called radioactive beams, and elements that can automatically emit these beams are called radioactive elements. The conversion of isotopes with non-stable nuclei to more stable elements through emission is called radioactive decay.
Measurement-Assessment	
(4th Stage)	The last 2 questions on the Worksheet-2 are used as assessment questions.

2.3. Actual Application

The main applications of the worksheets were carried out with a total of 35 11th grade students in an Anatolian High School (A-14) and an ordinary high school (G-21) in the Gorele district downtown of Giresun. The main application was conducted by the researcher. The researcher went to the class beforehand, made observations and met with students. No problems were observed in terms of the students accepting the researcher as their teacher in class and their communication. Besides, their actual teacher was also present as an observer in class during the researcher's applications. The reason for keeping the teacher in class is to get the teacher's opinion on both the worksheets and application process, and to make students' perception of seeing the researcher as a teacher easier.

2.4.Data Collection Tool

Opinions of teachers and 6 students from the schools A and G were obtained about the worksheets and application process. In this line, interviews were conducted with teachers from the schools A and G after the application. These interviews were conducted in school libraries or empty classes. Two main questions were asked to teachers. These questions are:

1.Do you use worksheets in your classes? Would you like to use computer-assisted worksheets in your classes?

2.What do you think of the worksheets and application process? Can you explain?

Students were asked to evaluate the application process in interviews.

2.5.Data Analysis

The data obtained from interviews conducted with students and teachers from the schools A and G were presented by direct quotations for the purpose of fully reflecting their opinions.

2.6.Coding Process

Teachers from the schools A and G were coded as AT and GT; students were coded as S1, S2, S3, … S6, and these codes were used in this study. The students S1, S2, and S3 from the school A, and the students S4, S5, and S6 from the school G were selected randomly and voluntarily.

3.Finding

Findings obtained from the interviews conducted with students and teachers are presented in two sections.

3.1.Findings obtained from the interviews conducted with teachers

Answers by the teachers AT and GT to the first question, which states "Do you use worksheets in your classes? Would you like to use computer-assisted worksheets in your classes?", are as follows:

AT: I sometimes try to use worksheets in experiments. However, I have never used a computer-assisted worksheet before. If someone makes it and we can readily access it, I would of lesson like to use it. Because, I am not able to create it myself. I have limited knowledge on computers.

GT: When you say worksheets, I think about study papers. In other words, these are papers that we prepare for students to study the respective topics and concepts. I thought of that when you have said worksheets. When we conduct experiments, we begin by directly installing experimental mechanisms. In fact, it would be very good if worksheets are created in this way and we use them in our classes. More importantly, computer-assisted worksheets would be very good for dangerous and financially costly experiments and activities; I would of lesson like to use them in my classes.

As obvious from these teachers' statements, they find computer-assisted worksheets interesting. However, GT confused worksheets with study papers.

Answers by the teachers AT and GT to the second question of the interview, which states "What do you think of these worksheets and this application process? Can you explain?", are as follows:

AT: It was really good to use computer along with worksheets and to find an opportunity to conduct an experiment with radioactive materials. In fact, I found the cube activity different. Ultimately, I appreciate the fact that this is a study with a great effort. I have heard statements like "Is there such a thing like a virtual experiment? Experiments are made for labs" from my students during the application process. I saw the same student moving with his chair to the front at the end of the class. I think that this experience has been different, interesting, and fun for them. Of course, it was a different experience for me as well.

GT: I observed that my students carefully completed activities without getting bored. Also, seldom-participating students participated in activities as well. Using computer-assisted worksheets was a different experience. The application process was interesting and fun. I wish we further have the opportunity to use such materials. Developing these materials is difficult, time-consuming and laboring. I enjoyed watching the application of worksheets, and even followed the class as if I was a student.

Teachers find the worksheets and application process intriguing and fun. In addition, they think that both their students and themselves have had a different experience in that process.

3.2.Findings obtained from the interviews conducted with students, and comments

Students' answers to the main interview question, which states that "What do you think of the application process and activities? Would you like to have your classes in this way?", are as follows:

S1: I think it was very fun. Because, we generally make operations in quantitative classes. I enjoyed the virtual experiment and cube activity very much in this process. I was a bit biased at first, because we do not cover our classes like this. However, of course, I would like to have our classes in this way from now on.

S2: I first thought of study papers when you said worksheets. We do not use such materials in our classes. We are given study papers, and we study exams based on those papers. The virtual experiment and the cube activity

were very good. Normally, we cannot calculate the half-life of a matter in our daily life but, we were able to calculate it thanks to that virtual experiment and understand how to calculate.
S3: I love computers very much, my teacher. Having our classes with a computer attracted my interest. I even said to you "Is there such a thing like a virtual experiment? Experiments are made for labs." And you told me that radioactive matters are harmful, so conducting such experiments virtually minimize the risk of accidents and increase security. Also, I saw what could be done with computers thanks to this experiment. This is why I liked the virtual experiment very much.
S4: We were able to conduct the virtual experiment and execute the cube activity without hassle. When I say hassle, I mean that we did not waste a lot of time; say we did not prepare cubes and materials by ourselves. We even did not wait for the matter's half-life. Quite frankly, our lives would not even be enough for that. It was quite interesting. I carefully followed the class.
S5: Actually, I thought in the beginning of our class why you did not directly provide or explain the topics you would like to teach. I thought that I wish the teacher would explain these topics and we listen. Then, I saw that we were having quite interesting animations and activities. I started doing these activities and did not even understand how time passed. It was different and beautiful.
S6: These applications were very fun, my teacher. I do not even know if you just taught us the topic without noticing or we just learned it. As if everything from what I should do to how I should do it is in my mind. I enjoyed it very much. Thank you.

As obvious from the student statements, they find the application process interesting, fun, and enjoyable. Students stated that they had a different experience, did not waste any time since they did not prepare any materials or matters during the lesson of a class, found an opportunity to work with radioactive matters even though they are harmful, and these applications piqued their interests. However, they also told that mentioning worksheets evoke study papers that they use for their exams.

4. Discussion and Conclusion

In our age, factors such as constantly increasing levels of information, improvement of educational programmes and an increased role of technology in education cause certain changes in duties expected from students and teachers, and in desired qualities to be had. In this context, the goal in this age, in which information has exponentially increased as stated by Tatar and Kuru (2006), is not to suffocate students with information but to make students grasp and understand information so that they are able to make connections by themselves and generate knowledge. The objective is that students become individuals, who investigate, question, interpret, think logically, and solves problems, by using different approaches, methods, techniques and strategies in science and technology-based classes, which play key roles in realizing this goal. Similarly, using the worksheets in activities in this study is intended to improve student skills such as conducting research and problem-solving. In this respect, computer-assisted worksheets based on the constructivist learning theory were developed in this study for the concepts of half-life and radioactive decay for physics/chemistry classes. Upon examining the respective studies in the literature, it is observed that there are worksheets prepared by using different teaching methods, techniques or strategies in different levels of learning, classes, and topics. In addition, worksheets are argued to be effective in increasing students' interests towards classes, ensuring students to be responsible for their self-learning and increasing success (Harms and Krombaß, 2008). Uslu (2011) examines the impact of worksheets on academic success for science and technology learning for the second grade of the elementary school in his study. According to results of the study by Ültay, Ültay and Dönmez Usta (2016), it was revealed that prospective teachers could not have reached a sufficient level in the development of the worksheets about acids and bases because of the worksheets' not including some necessary parts. Also, Kurt and Akdeniz (2002) created sample activities consisting of worksheets about the issue of energy in their study aimed at training investigative and problem-solving individuals.

Upon examining studies in the literature conducted on material development such as creating worksheets, it is observed that methods, techniques and strategies used are commonly introduced and also, topics become concrete by use of sample activities. In this context, material development studies are considered to be helpful for teachers, teaching candidates, and researchers. In this study, the worksheets based on the constructivist learning theory are enriched with computer-assisted activities. It can be argued that there are studies on worksheets based on the constructivist learning theory in the literature but, materials that contain different issue areas of chemistry/physics classes for the purpose of enriching worksheets based on this learning approach with computer-assisted activities are limited. At this point, this material, which is developed by enrichment of worksheets for different subject areas of physics/chemistry classes with computer-assisted activities, is considered to be a crucial resource in terms of both teachers and researchers.

Teachers in schools, to which the study was applied, have stated that they would like to use computer-assisted worksheets for dangerous and costly activities and experiments. But they do not have the ability of developing such instruments, which indicate important responsibilities for material development experts and domain experts. In this context, such applications should be increased in number and research should be conducted for the effectiveness of such applications. Student answers show that they find application process and activities intriguing, fun, and interesting. Opinions of teachers and students support each other. Even the fact that both students and teachers associate worksheets with study papers can be related to the lack of using worksheets in learning environments albeit they are known. In this context, we think that such activities and applications should be used in learning environments. Besides, it can be recommended that the impact of applying this material on cognitive gains of students such as success and permanence or their sensual gains such as attitudes and motivation should be investigated.

Note

This study is a part of the first researcher's PhD thesis which is entitled "Developing, implementing and evaluating CAI materials related to radioactivity topic based on constructivist learning theory".

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