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Determination of science teaching students learning of several concepts of radyoactivity subject taught with emergency remote education and students' opinions on emergency remote education

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Abstract

With the negative impact of COVID-19 on educational activities, face-to-face education was suspended at universities and distance education was replaced with it. The aim of this study is to determine whether the students learned some concepts related to the subject of "radioactivity" taught by emergency remote education (ERE) and to reveal the students' opinions on both ERE and teaching of this subject by ERE. To this end, a qualitative study was conducted by asking five open-ended questions (29) to the students studying in the 1st year of Science Teaching Department in a public university in the spring semester of the 2020-2021 academic years. The data were collected through an online questionnaire and were analysed by content analysis. According to the results; it was determined that the students mostly learned the concepts taught by ERE and although they mostly had positive-negative views about ERE (52%), they reported more positive opinions (79%) about the subject "radioactivity" taught by ERE. The results obtained from this study is considered to contribute to the literature in terms of revealing both the learning of some concepts related to the subject and students' feedbacks from a broad perspective.

1. Introduction

Developments in the fields of science and technology require the change of our education system, taking into account the needs of the society. In our developing education system, besides the 2023 Education Vision, the teaching undergraduate programs applied in education faculties must also be qualified (Dağtekin & Zorluoğlu, 2018). For this reason, the council of higher education (YÖK) updated undergraduate teaching programs in our country in 2018. The reasons for updating the program involve structural changes in Turkish education system, societal needs and demands, and re-updating teacher training undergraduate programs by way of restructuring the departments of education faculties. In this context, with the General Assembly, resolution of the council of higher education (YÖK) dated 28.02.2017; the necessary transformations were made within the relevant faculties and institutes of our universities (YÖK, 2018). In addition, technology-based and applied courses were added to the curriculum in accordance with the Bologna process in higher education, course-teacher-technology association is being attempted to be created (Usta, 2018).

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Radyoactivity concept is included to the education program in consequence of re-updating teacher training undergradute programs. The subject of radioactivity was previously taught in the 3rd semester of the program in the General Physics III course in the universities, not in the chemistry courses of the 2007 science-teaching curriculum (YÖK, 2007). In the 2018 curriculum, this subject was removed from the General Physics III course and added to the Chemistry 2 course (YÖK, 2018). Therefore, the content of the Chemistry 2 course taught in the second semester of the 2018 Science Teaching Curriculum was re-arranged, and the subject of "nuclear chemistry" was included in the content as nuclear chemistry (radioactivity, nuclear energy). In the secondary school textbooks of 2019, this subject was covered in the second semester under the title of "Introduction to atomic physics and radioactivity", which is the fourth unit of the 12th grade physics course (MEB, 2019). That is, the students participating in this study learn this subject within the scope of the physics course, not within the scope of the chemistry course, while in high school. Therefore, this subject can be considered as a common subject of both physics and chemistry. Within the framework of the explanations above, the subject of "radioactivity" was chosen as the subject of this study. From now on, the term "radioactivity" will be preferred in the use of the subject.

Developments in science and technology require the use of new technologies in the field of education. Undoubtedly, computers are at the forefront of these technologies. Studies demonstrate that computers are effective in increasing students' success and attitudes, facilitating their learning, teaching concepts and eliminating misconceptions (Akçay et al., 2007; Feyzioğlu, 2002; Morgil at al., 2003; Morgil et al., 2005; Yiğit & Akdeniz, 2003; Yumuşak, 2013). Uşun (2004) states that computer-assisted education can be carried out by applying four methods, one of which is the distance education method via the internet. In the literature, distance education is defined as a form of education process which maintains teaching-learning activities in a planned, systematic manner, independent of place and time by giving students flexibility, responsibility and selections (Bozkurt & Sharma, 2020; Greenberg,1998; Moore & Kearsley, 2011). Bozkurt et al., (2020) describes distance education as “any educational process in which all or most of the teaching is conducted by someone removed in space and/or time from the learner, with the effect that all or most of the communication between teachers and learners is through an artificial medium, either electronic or print” (as cited in UNESCO, 2002, p. 22). In distance education, materials such as texts, videos, exercises are utilized more than personal interactions such as discussions, presentations and it is based on theoretical and practical knowledge related to the subject (Bozkurt et al., 2020; Rapanta, Botturi, Goodyear, Guàrdia, & Koole, 2020). On the other hand, emergency remote education (ERE) is encountered as a branch of distance education. Emergency remote education is also called as online learning, e-learning, m-learning or learning at home (Bozkurt et al., 2020). Emergency remote education is defined as a temporary solution by using all the sources online and/or offline during a crisis (Bozkurt et al., 2020; Bozkurt & Sharma, 2020a; 2020b; Hodges, Moore, Lockee, Trust, & Bond, 2020). The aim of distance education is to provide education to large masses, to reduce the cost of education, to bring long distances closer and to increase the permanence of information by providing as many repetitions as desired (Bayram et al., 2019; Karagöz, 2012). Distance education can be done asynchronously, synchronously or hybrid. Asynchronous distance education can be defined as the communication of participants without the need for simultaneous information sharing (Barker, 1999; Hellman, 2003; Wang, 2008). Information exchange in asynchronous distance education system; it takes place via e-mail or post and the educator delivers educational materials he /she produces to students via radio, television, mail, computer and/or internet (Hellman, 2003; İşman, 2005). Synchronous distance education is defined as simultaneous and interactive communication between participants (Barker, 1999; Hellman, 2003). In the synchronous distance education system, information exchange is provided by computer and internet, and is carried out via web conferencing over the internet (Karagöz, 2012). In web conferencing, both educators and students can see and hear each other at the same time, even if they are at different places. At the specified times, the educator starts a web conference/lesson from their computer via the internet and the students can attend this conference/lesson from their computers at the same time.

While listening to the conference/lecture, students can contact the educator and ask questions; Moreover, if they have webcams, speakers and microphones, they can also use them (Karagöz, 2012).

Especially in the current period that we are under the influence of COVID-19, a rapid transition has been made to computer-assisted emergency remote education, both synchronously, asynchronously and hybridly. As is known, in the spring semester of the 2019-2020 academic year, when COVID-19 first started, educational institutions were closed and quarantine practices were introduced gradually almost all over the world (Bozkurt & Sharma, 2020a; Bozkurt et al., 2020). For this reason, the process was launched so that students did not fall behind in their education and it turned out that the world would no longer be the same as before (Durak & Çankaya, 2020a; Durak, Çankaya & İzmirli, 2020). It is known that distance education can be performed as learner-centered, carried out anytime, anywhere, at any age, at any speed, and in any environment, has access to course materials and provides lifelong learning (Adıyaman, 2002; Durak & Ataizi, 2016; Kışla, 2016; Şenyuva, 2007; Usta, 2015; Usta, Uysal & Kur, 2016).

As in every technological development, distance education also has some advantages and limitations. Şenyuva (2007) lists the benefits of web-based distance education as follows: it allows students to come together in the web environment to communicate effectively, to review the topics, to reach the instructors in real time and the audience working in a job and studying at the same time, to receive instant feedback from the students and to create a rich educational environment with its access to audio-visual tools and other resources. In the same study, the author lists the limitations of web-based distance education as follows: creating some psychological and sociological elements in students, inability to perform skills and attitude-oriented behaviours adequately, failure to prevent incorrect learning in a timely manner, giving courses that are not suitable for distance education, such as laboratories and workshops, through distance education, inadequate computer network infrastructure, inadequate planning of the teaching-learning process and greater effort by students and educators. In the study of Oliveira, Penedo ve Pereira (2018), it is stated that the advantages of distant education are flexibility, content availability, low cost, studying at home at any time you want: while the disavantages are difficulty of asking questions and difficulty of disciplining

2. Literature

Studies on distance education/emergency remote education

Karatepe, Küçükgençay and Peker (2020) conducted a study with primary school mathematics, science and classroom teacher candidates receiving synchronous education and tried to determine the perceptions of pre-service teachers regarding synchronous education. At the end of the study, they determined that candidates have a negative attitude towards synchronous courses, are unwilling to use distance education method and do not to see themselves adequately and do not consider online courses as the future of education. In addition, they determined that the most useful method of synchronous courses is oral presentations. Türküresin, (2020) examined the opinions of teacher candidates related to distance education carried out during COVID-19 Pandemic Period by qualitative and quantitative data collection methods. According to the quantitative results of the study; considering the opinions of teacher candidates towards distance education, they were partially satisfied with it; on the other hand, significant differences were determined according to the variables of gender, accessing the Internet and the status of following the course and internet access quota. In qualitative results, the opinions of the teacher candidates were primarily divided into two themes as "the advantages of distance education" and "disadvantages of distance education". Afterwards, its advantages are divided into three categories as "being economic", "repetition" and "time and space flexibility". Its disadvantages are divided into six categories as "the Impermanence of learning", "measurement and evaluation issues", "disciplinary problems", "internet shortages", "system problems" and "lack of interaction". It was determined that its advantages are in the

category of "lack of time and space" of the highest frequency and its disadvantages are in the category of “no interaction”.

In another study, the researchers examined the opinions of 32 students from four different universities on emergency distance education during the Covid-19 pandemic period by applying an online questionnaire consisting of open-ended questions. As a result, it was determined that two of the four universities used Microsoft Teams software as a distance education system, while the other two used Moodle and ALMS software, and students who used Microsoft Teams, where synchronous lessons were held, were more satisfied with this process. In addition, students’ opinions on some issues such as the positive and negative aspects of the distance education system, the communication of students with the instructor, getting feedback, socialization, motivation, academic performance, comparison with traditional teaching were also determined. While almost all of the students were anxious before distance education, it was concluded that their anxiety completely disappeared after receiving synchronous education (Durak & Çankaya, 2020b). Microsoft Teams software was also used in this study.

According to the results obtained by Bostan Sarıoğlan, Altaş and Şen (2020), in which they investigated the opinions of 34 science teachers about experimentation in the science course, during the distance education period, teachers determined that they had difficulties in experimenting due to material and technical deficiencies, students' motivation was low and active participation was insufficient. However, they stated that visuality attracted students' attention and that it was safer to conduct some experiments.

In another study, by the opinion survey the researchers prepared, they determined the opinions of 22 people consisting of science teacher candidates, graduate and doctorate students about distance education in the spring term of 2019-2020. In the study, they determined that participants found distance education advantageous in terms of time and opportunity, but disadvantageous in terms of laboratory applications and they asked distance education to continue for theoretical lessons (Benzer & Akkaya, 2021). Zorlu (2020) examined the opinions and suggestions of eight science teacher candidates by applying the cooperative learning model to distance education. Zorlu determined that most of the teacher candidates thought that it would be beneficial to apply this model in distance education environments and benefits group work, time management and socialization.

Different tools and materials are used in distance education. Durak et al. (2020) in their study asked those who were in charge of the emergency distance education period from 208 universities they determined as participants what tools and materials they could utilize in the system used at universities. They determined these as lecture videos, presentation files (power point, etc.), lecture notes (pdf, word, etc.), use of questionnaire, submission of assignment, exam, discussion/sharing forum and chat. These tools and materials were also used in this study. In some studies examining the benefits of distance education, it was stated that it provides students with the opportunity to participate in educational activities wherever and whenever teachers are located, allows them to re-watch the videos, reduces the cost of education and saves time (Benzer & Akkaya, 2021; Demiray, 1999; Fidan, 2016; Moore & Kearsley, 2011). In some studies examining the problems of distance education, they state that due to the lack of active interaction in distance education, it restricts the socialization of the individual students who do not know technology have difficulties in learning. Moreover, there are problems in teaching some practical courses through distance education, students are overburdened with responsibility and inequalities in access to education are revealed (Altıparmak et al., 2011; Altuntaş Yılmaz, 2020; Anderson, 2020; Bayram et al., 2019; Bostan Sarıoğlan et al., 2020; Can, 2020; Horzum, 2003; Usta et al., 2016).

Rapanta et al., (2020) states that it is necessary to make the courses simpler and to reduce the expectations from the students in order to decrease their anxiety level while heading emergency remote education during COVID-19 Pandemics. Because students have to deal with serious emotional stress and quarantine conditions brought by the pandemics, it will be more difficult to adapt to mew learning and teaching styles. Hence, it is highlighted to eliminate the unnecessary parts of the curriculum to decrease the

studying load of the students. Also, how students explain those process should be more important than how the educational content is presented successfully (Bozkurt, & Sharma, 2020a; Holme, 2020). In a study in which the subject of Chemistry of Food and Cooking was explained as non-STEM to undergraduate students during the transition period to emergency distance education, the researchers applied a questionnaire measuring students' motivation and expectations for taking the chemistry course and their scientific literacy before and after the instruction. According to the results of their studies, it is determined that the teaching met the expectations of the students in teaching the chemical concepts of Chemistry of Food and Cooking, the students had difficulty in sticking to the course in emergency distance education, some students were affected much more by the interruption of education, the participation of the students in asynchronous courses increased compared to the synchronous courses and it was effective in improving scientific literacy (Perets et al. al., 2020). Sunasee (2020) in his study comparing synchronous classroom participation with face-to-face classroom participation, it has been determined that problem solving exercises in synchronous and asynchronous teaching are effective on student learning and increasing student participation, on the other hand, approximately 64% of students prefer face-to-face teaching instead of online teaching in learning Organic Chemistry. In addition, the researchers found that students experience emotional difficulties during emergency distance education, they face obstacles such as the lack of starting university life, students with no/restricted internet access cannot attend synchronous courses to a large extent and this creates an inequality of opportunity, and it is also obtained that students missed in-person laboratory courses that help to learn chemistry (Giri & Dutta, 2020; Jeffery & Bauer, 2020; Sandi-Urena, 2020; Van Heuvelen, Daub & Ryswyk, 2020).

Studies on radioactivity

When looking at the literature, many studies on this subject have been found at the high school level (Henriksen & Jorde, 2001; Nakiboğlu & Bülbül Tekin, 2006; Yalçın, 2003). There are many studies conducted especially in the 2002-2003 academic year (Akçay et al., 2007) In the 2002-2003 academic year, by teaching the subject of radioactivity to the 2nd grade of high school using computer aided and traditional methods, they examined students' success in chemistry course and their attitudes towards chemistry course. As a result of the study, they determined that computerized education had a positive effect on students' attitudes and increased students 'success more. Morgil, Yılmaz and Uludağ (2004) examined the content, teaching and learning activities on the subject of "Radioactivity". In the 2002-2003 academic year, a 20-question Radioactivity Knowledge Test was applied to 184 students studying at second-year at high school to evaluate their knowledge on radioactivity. They determined that the students gave 90.8%-31%-correct answers to the questions in this test, that their knowledge of radioactivity was limited to the topics in the textbooks, and that they had no knowledge of health, environment and radiation technology.

In another study, researchers identified second-year high school students' misconceptions about radioactivity in the 2002-2003 school year by conducting a radioactivity concept test and interviewing specific students. They investigated the effectiveness of textbooks in the formation and reinforcement of these misconceptions. At the end of the study, it was determined that some of the misconceptions identified in the students were also in the textbooks and that some expressions, pictures and figures in the books were arranged in a way that would lead the students to misconceptions (Yalçın & Kılıç, 2005). Tezcan, Yılmaz and Babaoğlu (2005), in the 2002-2003 academic year, compared the effects of the traditional method and the collaborative method on success on 79 second year high school students regarding the subject Radioactivity. For this purpose, they applied the 15-question radioactivity concept test to the students before and after the instruction and concluded that the collaborative method was more successful than the traditional method.

In the 2008/2009 academic year, the subject of radioactivity was taught through the problem-based learning (PBL) approach to the students who took the Nuclear Physics I course. The effect of this approach on student achievement, radioactivity achievement test and the use of radioactivity in age

determination were measured with two open-ended questions. As a result, it was determined that this approach did not increase students' success in radioactivity adequately (Taşoğlu & Bakaç, 2011). In another study, researchers studied on 16 teacher candidates who took Nuclear Physics I and Nuclear Physics Laboratory I courses in the fall semester of 2015-2016 and researched the modelling with the traditional method in eliminating misconceptions about radioactivity and the effect of attitudes towards nuclear incidents and gender on misconceptions on this subject. As a result of the study, they determined that there was no significant difference between the methods and that attitude and gender had no effect on misconceptions (Bakaç & Taşoğlu, 2016). In another study, in the 2000-2001 academic year, researchers studied on 180 students studying in the second year of high school and taught the subject of "radioactivity" through the traditional method in the control group and through the constructivist method in the experimental group. In addition, they applied a 20-question concept test they prepared as a pre-test and post-test before and after instruction. According to the results; by selecting 13 students from both groups through interview, they determined the reason for the misconceptions that could not be eliminated from the exam results and that the experimental group was more successful (Tezcan & Erçoklu, 2010). Yumuşak (2013) used conceptual change texts in order to eliminate the existing misconceptions about radioactivity in science teacher candidates, examined the effects of computer-assisted and traditional teaching and concluded that computer assisted instruction was more effective.

The aim of this research is to determine whether the concepts about the subject of radioactivity are learnt as a result of the conduction of emergency remote education by science teaching students. Also, it is intended to specify the opinions of the students on emergency remote education in a general manner. For this reason, emergency remote education, the subject of "radioactivity" was taught synchronously by using the existing learning management system of the university and the live course software Microsoft Teams. The course was given for two weeks, 90 minutes twice a week, for a total of 720 minutes. During the lecture, lecture videos, power point presentations, lecture notes were used and discussions with students were made to ensure understanding of the subject.

2.1. Research questions

Within the scope of this research, answers were sought to the following questions:

1. Although the beta particle (β^-) is not in the nucleus of the atom, how do radioactive atoms eject this particle?
2. Although gamma (ɣ) rays do not change an atom's atomic number and mass number, why do radioactive atoms emit gamma radiation?
3. On what does it depend whether a radioactive atom is stable or not?
4. What do you think about emergency remote education?
5. What do you think about learning the subject of "radioactivity" through emergency remote education?

3. Methodology

If necessary, subheadings should be used. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Fusce ac fringilla nisi. Vivamus nibh mi, pretium sed est sit amet, lacinia ultrices nunc. Aliquam laoreet ut massa vitae consequat. Nunc luctus nisi quam, vitae placerat justo vulputate ac. Donec iaculis eu nibh nec venenatis. Maecenas lobortis bibendum sem et interdum. Phasellus et egestas felis. Donec id sodales dui.

3.1. Research Model/Design

The research was conducted in the form of one group pretest-post-test design which is one of quasi-experimental designs (Cohen, Manion & Morrison, 2007, p.272). In this design, it is determined whether there is a significant difference in the behaviours of the participants depending on time (Bakaç & Taşoğlu, 2016). In this design, experimental application is made in a single group and dependent variables

determined before and after the application are measured and interpreted to see the effect of the application (Cohen, Manion & Morrison, 2007, s.282; Fraenkel, Wallen & Hyun, 2012).

The one group pretest-post-test design can be represented as: (Cohen, Manion & Morrison, 2007, s.282)

Experimental	Pre-test	Treatment	Post-test
	Q_1	X	Q_2

Q_1: Pre-test

X: Computer-assisted teaching of the subject of "radioactivity"

Q_2: Post-test

3.2. Data Collecting Tools

An online questionnaire consisting of open-ended questions was used in the research. The research consists of two stages. In the first stage, three open-ended questions were prepared by the researcher in order to determine whether some concepts were learned or not as a result of computer-assisted teaching of the subject of "radioactivity" through distance education. These questions were applied to the students as a pre-test before the research and as a post-test afterwards. In the second stage, two open-ended questions were prepared in order to determine the opinions of the students about distance education. These questions were applied to the students after the research. Thus, a questionnaire form consisting of five open-ended questions was created for the students. The purpose of the study was explained to the students with an instruction given at the beginning of the test. The data of the study were collected on the internet and the students were given 45 minutes to answer the test. In addition, after the pre-test was applied to the students, their opinions about what they learned about radioactivity while in high school were recorded by conducting a collective interview for 25 minutes.

3.2. Sample

The sample of this research consists of 29 students, 24 girls and 5 boys, who are studying in the first year of the science-teaching program at the faculty of education of a state university in the Marmara region. The sample of the research was determined by the easily accessible sampling method, which is one of the non-random sampling methods, which is one of the purposive sampling methods (Yıldırım, & Şimşek, 2008, s.107). This sampling method allows researchers to reach the sample in a short time and to make an easy application (Baltacı, 2018; Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2018, p.91; Yağar & Dökme, 2018). In addition, the researcher sample in convenient sampling determines by selecting a sufficient number of items from the already existing items (Singleton, B. Straits & M. Staraits, 2005).

3.2. Data Analysis

The data obtained from the test were analysed by content analysis. In content analysis, first, concepts and themes that can explain the collected data are created. Afterwards, these concepts and themes are organized and interpreted in a way that the reader can understand (Selçuk, Palancı, Kandemir & Dündar, 2014; Yıldırım & Şimşek, 2008, p.227). In this context, for the analysis of the data, the researcher carefully read the answers given by the students to each question of the test one by one. Afterwards, each student's paper was coded with a letter and a number. For example, student number 13 was coded as "S13". Then, common categories were created for the answers to each question of the test.

In this study, a week later, the researcher examined the answer categories determined for each question in order to ensure reliability in terms of time. In addition, the finalized categories were rearranged with feedback from three researchers who were experts in their fields. Each expert independently read the

answers of seven randomly selected students (~20% of the sample) and evaluated them according to the created categories. When the evaluation results were compared, Inter-coder reliability was achieved by determining the percentage of agreement to be 85% (Miles & Huberman, 1994). The fact that the percentage of agreement is more than 70% indicates that the analysis is reliable (Yıldırım & Şimşek, 2008, p.259). In addition, the findings obtained from the analysis of the data are presented in tables by specifying frequency and percentage frequency values. If the student's answer includes more than one category, this answer is also included in the other categories. Therefore, the total frequency and percentage value of the relevant category in the tables may be higher than the number of participants. In addition, by giving example sentences from the answers of the participants, the categories were attempted to be made more understandable.

The categories determined for the analysis of the first, second and third questions of the research and which types of answers are included in these categories are explained below (Dolu & Ürek, 2015):

Correct: The answers in this category include all explanations accepted as scientifically correct.

Partially misconception: The answers in this category include answers that do not fully explain the required explanation for the question, but provide incomplete explanations.

Misconception: The answers in this category are those that do not match scientific facts and contain misconceptions.

Irrelevant: The answers in this category contain illogical explanations Irrelevant to the answer to the question and have no scientific value.

No response: In this category, the questions were either left blank or answered; as I do not remember/I do not, know.

The fourth and fifth questions of the study were only asked in the post-test as they were related to teaching. The analysis of these two questions was carried out in two parts. For the first part, three categories were determined as positive, negative and positive-negative answers. In the second part, separate sub-categories were created for these two questions and analysed.

3.3. Findings and Discussions

In this part of the research, the frequency values of the answers given by the students to the research questions after the teaching were determined and visualized in tables. In addition, Sample student statements for each category were given in order for the defined categories to be more understandable.

3.3.1. Findings Related to the First Question of the Study

The findings obtained from the students' answers to the question "Although the beta particle (β^-) is not in the nucleus of the atom, how do radioactive atoms eject this particle?" evaluated in five categories. Analysis results are presented in Table 1 as frequency (f) and percentage frequency (f %).

Table 1.

Findings related to the first question of the study

	Pre-test		**Post-test**	
Categories	**f**	**% f**	**f**	**% f**
correct	1	4	19	65
partially misconception	0	0	6	21
misconception	6	20	0	0
irrelevant	2	7	2	7
no response	20	69	2	7
total	**29**	**100**	**29**	**100**

When Table 1. is examined, it is seen that the highest frequency in the pre-test answers of the students is in the "no response" category (69%) and this is followed by the categories of “misconception” (20%), “correct” (4%) and “irrelevant” (7%). In addition, it was determined that there was no response in the "partially misconception" category. On the other hand, in the post-test answers, it is seen that the percentage frequency value is in the highest “correct” category (65%). This is followed by the “partially misconception” category with a frequency of 21%. Student answers concentrate a pleasing result on these two categories. In addition to these results, it was determined that the post-test answers of the students were equal to each other (7%), in the " Irrelevant " and "no response" categories. It is also pleasing that there were no students who had misconceptions. Below is an example of student answers for each category:

Correct: “*Nuclear with neutron/proton > 1 emit beta radiation. The neutron particles in the nucleus are broken down into electrons and protons. Since electrons cannot be found in the nucleus, these electrons are ejected” (S14).*

Partially misconception: “*Nuclear with neutron/proton >1 emit beta radiation and become stable” (S22).*

Misconception: “*Beta particles are around the nucleus. If the atom is energized, these particles will fly out” (S21).*

Irrelevant: “*The location of the neutron in the nucleus is not the nucleusa and it removes it from the atom by radiation” (S28).*

3.3.2. Findings Related to the Second Question of the Research

The findings obtained from the student answers related to the research question, “Although gamma (ɣ) rays do not change an atom's atomic number and mass number, why do radioactive atoms emit gamma radiation?” were evaluated in five categories. The results are shown in Table 2.

Table 2.

Findings related to the Second question of the Research

	Pre-test		Post-test	
Categories	**f**	**% f**	**f**	**% f**
correct	7	24	29	100
partially misconception	3	10	0	0
misconception	7	24	0	0
irrelevant	1	4	0	0
no response	11	38	0	0
total	**29**	**100**	**29**	**100**

According to Table 2, when looking at the pre-test, it is seen that the highest value is in the "no response" category (38%). This is followed by the "correct" and "misconception" categories with equal value (24%). When the post-test answers are examined, it is seen that all the answers are only in the "correct" category. It is a pleasing result that there are no student answers in other categories. Below is a student answer belonging to the “correct” category:

Correct: *“Because being stable doesn't just mean n/p=1, it also has to have a minimum of energy. Therefore, the atom emits gamma radiation to minimize the energy” (S12).*

Partially misconception: *“This may be to control the intense energy contained in the Core” (S13).*

Misconception: *“gamma radiation is made to go from the excited state to the ground state (S28).*

Irrelevant: *“Every atom emits alpha, beta, gamma radiation” (S4).*

3.3. Findings Related to the Third Question of the Research

The findings obtained from the student answers related to the research question, "On what does it depend whether a radioactive atom is stable or not?" were evaluated in five categories. The results are shown in Table 3.

Table 3.

Findings related to the Third Question of the Research

	Pre-test		Post-test	
Categories	**f**	**% f**	**f**	**% f**
correct	0	0	21	70
partially misconception	13	45	8	30
misconception	4	14	0	0
irrelevant	3	10	0	0
no response	9	31	0	0
total	**29**	**100**	**29**	**100**

When Table 3.is examined; the highest value of the answers given by the students in the pre-test is in the category of "partly correct" (45%). It is followed by the categories "no response" (31%), "misconception" (14%) and "Irrelevant" (10%). On the other hand, when the post-test answers of the students are examined, it is noteworthy that the answers of the students are gathered in two categories as "correct" (70%) and "partly correct" (30%), and there are no response belonging to the other categories. Below is a student answer belonging to these two categories:

Correct: *"Stable atoms do not radiate. The neutron/proton ratio should be one. Its energy must be minimal" (S20).*

Partially misconception: *"it depends on the neutron/proton ratio being one" (S29).*

Misconception: *"It depends on its resemblance to noble gas. This is its attempt to make its last layer look like a noble gas" (S15).*

Irrelevant: *"it depends on the electrical repulsion force between the protons in the nucleus, and the weak nuclear force" (S17).*

3.3.4. Findings Related to the Fourth Question of the Research

The findings obtained from the student answers related to the research question "What do you think about emergency remote education?" were evaluated in two parts. In the first part, student answers were evaluated in general terms and presented in three categories (Table 4a). In the second part, in order to exemplify positive and negative student ideas; due to the wide variety of expressions used by students in their explanations, instead of giving sample student answers one by one, the opinions were tabulated in sub-categories. Expressions given to positive answers were divided into eight sub-categories and expressions given to negative answers were divided into eleven sub-categories, in total, were shown in nineteen subcategories (Table 4b). In addition, since a student's response includes more than one sub-category, the total frequency values differ.

Table 4a.

Findings of the first part of the fourth question of the research

Categories	**f**	**% f**
positive answers	3	10
negative answers	11	38
positive-negative answers	15	52
total	**29**	**100**

When Table 4a is examined; while half of the students (52%) express their thoughts about emergency remote education, it is seen that they make both positive and negative sentences in their answers. In addition, while the percentage frequency value of students who made only negative statements about emergency remote education was 38%, the percentage frequency value of students who made only positive statements was determined as 10%. Student answers for each category are given below:

Positive answer: *"I think it contributed. Although not face-to-face, it feels like we are at the university. We continue our lessons with the same stability. Even if we cannot attend the classes for some reason, we have the opportunity to listen later. With facilities such as videos, blackboards, and exchange of questions, the focus on the lessons increases. We can learn the subjects in detail and in a fun way" (S7).*

Negative answer: *"I think that distance education made us very tired both psychologically and physically. Being at the computer all the time, not leaving the house, not seeing our friends and our university, quashed the desire to study in us. In addition, although I studied some courses, not receiving the compensation for my studies also affected me negatively. Therefore, I do not find distance education beneficial at all" (P27).*

Positive-negative answer: *"I think it is easy in terms of accessibility, as we have the opportunity to watch the course recording again in distance education but not everyone has the same conditions. I think there are students who do not have a computer and have internet problems. Also, we listen to the lecture when we are in the classroom but while at the computer or because the environment is not available, sometimes we cannot focus" (P26).*

Table 4b.

Findings of the second part of the fourth question of the research

Categories	Sub-categorys	f	%f
positive answers	being able to watch the course recording again	10	50
	comfort	2	10
	being with a family	2	10
	productivity	2	10
	saving time	1	5
	more possibilities	1	5
	practicality	1	5
	creating a classroom environment	1	5
	total	**20**	**100**
negative answers	difficulty of focusing/understanding	15	36
	connection/internet problems	7	17
	less catchy	5	12
	communication difficulties	4	9
	boring	4	9
	not being able to feel like a university student	2	5
	studying harder	2	5
	short exam time	2	5
	fatigue	1	2
	total	**42**	**100**

When Table 4b is examined, it is seen that the expressions given to negative answers (eleven sub-categories) are much more diverse than the expressions given to positive answers (eight sub-categories). Half of the positive answers (50%) are in the sub-category of "being able to watch the course recording again" (S1, S7, S13, S14, S20, S21, S23, S25, S26, S29). It was determined that the closest and equal frequencies (10%) were in the sub-categories of "comfort" (S5, S18), "being with a family" (S11, S21) and "productivity" (S6, S9). In addition, it is seen that the subcategories of "saving time" (S14), "more

possibilities" (S7), "practicality" (S5) and "creating a classroom environment" (S28) have a frequency value of 5%.

It is seen that negative answers are mostly collected in the "difficulty of focusing/understanding" sub-category (36%) (S1, S2, S3, S5, S7, S9, S10, S12, S15, S16, S19, S23, S24, S25, S26). It was determined that this is followed by “connection/internet problems” (17%) (S11, S14, S16, S19, S21, S23, S26) and “less catchy” (12%) sub-categories (S2, S3, S19, S21, S27). In addition, the percentage frequency of the "communication difficulties" (S1, S8, S18, S25) and "boring" (S17, S20, S23, S27) subcategories is the same and is 9%. Again, with the same percentage frequency (5%), there are student answers in the sub-categories of "not being able to feel like a university student" (S7, S24), "studying harder" (S4, S22) and "short exam time" (S13, S24). In addition, there is only one student (S27) answer in the "fatigue" subcategory.

3.3.5. Findings Related to the Fifth Question of the Research

The findings obtained from the student answers related to the research question; “What do you think about learning the subject of "radioactivity" through emergency remote education? “are shown in Table 5a in three categories as “positive”, “negative” and “positive-negative”. In addition, sub-categories were created to exemplify positive and negative student opinions. Expressions given to both positive and negative answers consist of three sub-categories. In addition, since a student's response includes more than one sub-category, the total frequency values differ.

Table 5a.

Findings of the first part of the fifth question of the research

Categories	**f**	**% f**
positive answers	23	79
negative answers	2	7
positive-negative answers	4	14
total	**29**	**100**

When Table 5a is examined; while the students express their opinions about learning the subject of radioactivity through emergency remote education, they make positive statements largely (79%). In addition, it was determined that the percentage frequency value of the students who made both positive and negative statements was 14% (S9, S18, S24, S27) and the percentage frequency value of the students who made only negative statements was 7% (S15, S22). Student answers for each category are given below:

Positive answer: *“I did not experience any difficulties. Distance education did not have a negative effect” (S6).*

Negative answer: *“It was a little late and difficult for me to learn this subject through distance education. I think that this subject can be understood more easily in face-to-face education” (S22).*

Positive-negative answer: *“It was a well-understood subject. The subject of radioactivity was slower but quite persistent. I would prefer it to be face to face” (S9).*

Table 5b.

Findings of the second part of the fifth question of the research

Categories	Sub-categorys	f	% f
positive answers	I learned in detail and clearly	21	68
	I did not have any difficulties	6	19
	course content and materials were sufficient	4	13
	total	**31**	**100**
negative answers	I would prefer to be face to face	5	46
	I understood it a little harder	3	27
	more questions need to be solved	3	27
	total	**11**	**100**

According to Table 5b, students gathered in the sub-category of "I learned in detail and clearly" (68%), mostly a positive opinion about learning the subject of "radioactivity" through emergency remote education. As an example of the answers given by the students about this sub-category as follows; *"we grasped the reason and logic of the things we learned"* (S8), *"when they taught me the basics, I understood all of them easily, I understood that I did not need to memorize and I learned easily"* (S12), *"we learned without memorizing"* (S21, S23), *"because it was detailed and well taught , I understood it very clearly"* (S24). This is followed by the sub-categories "I did not have any difficulties" (19%) (S1, S6, S10, S19, S23, S25) and "course content and materials were sufficient" (13%) (S5, S9, S12, S14). Another sub-category is *"I had no difficulties"* (19%).The following can be given as examples of the answers of the students in this category; *"I did not have much difficulty in distance education because it is a verbal subject"* (S1), *"I thought I would have difficulties at first, but the question and answer teaching method was used in the lessons and we felt like we were in a classroom environment. I realized that it is a very understandable and learnable subject, thanks to the fact that everything related to the subject is explained from the very beginning"* (S23).

It was determined that the answers that had negative opinions about learning "radioactivity" through emergency remote education were mostly in the "I would prefer to be face to face" (46%) (S9, S15, S18, S22, S27) sub-category. This is followed by the sub-categories of "I understood it a little harder" (S15, S20, S22) %) and "more questions need to be solved" (S4, S24, S27) with an equal percentage frequency (27).

After the pre-test applied at the beginning of this study, the students were asked for their opinions on what they learned about radioactivity while in high school. As an example of these opinions of all students: *"We were going to cover these subjects in the 2nd semester in high school but quarantine started in March and the Minister of Education made a statement. He said that only the first level subjects were included in the exam. Therefore, the question on this subject did not appear in the university exam. Therefore, the teachers did not cover this subject. They told the teachers to focus on other subjects since they would not be asked, and they did not teach it. Therefore, only graduates know about this subject" (S4), "We saw bits and pieces in physics, but we didn't remember anything" (S21). "We saw it, but we memorized it, so I don't remember at all" (S28), "We didn't cover the rest of the topics after the restriction. We went back and restudied the topics that would be asked in the exam"* This result of the research is also similar to the results of the studies in the literature.

4. Conclusion and Suggestions

The subject of radioactivity includes many abstract concepts. It is extremely important to concretize the concepts in order to be understood well. For this purpose, the use of computer aided materials can embody many processes that cannot be shown and present them to the student. In this way, both students' misconceptions can be eliminated and possible misconceptions can be prevented (Yumuşak 2013). In addition, computer-assisted instruction increases students' interest in the lesson. Learning shortens the

teacher's time and makes students more active (Kıyıcı & Yumuşak, 2005). Yalçın and Kılıç (2005) determined that at university exams, no conceptual questions were asked about radioactivity and because teachers and students did not give importance to this issue and did not allocate much time in high schools and it was the last subject of the basic chemistry courses in the first year of universities, this subject could not be taught. Similar answers were received when the students were asked about what they learned about radioactivity in high school after the pretest applied at the beginning of this study.

In the first question of the research (Table 1), while the students did not answer this question with the highest frequency (69%) in the pre-test, the frequency of this category (7%) decreased significantly in the post-test. In addition, while 20% of the students had a misconception in the pre-test, there was no response in this category in the post-test. In addition to these, and most importantly, the students could hardly give a correct answer to this question in the pre-test (4%), but gave the correct answer at the rate of 65% in the post-test. In addition, while the answers in the "partially misconception" category were absent in the pre-test, they were found at the rate of 21% in the post-test. Although the answers in this category do not include the correct answer to the question, considering that some of them are accepted as correct, it can be concluded that the students learned the answer to this question correctly largely. In addition, the absence of students with misconceptions supports this result. In this question, students mostly confuse the β^- particle with the electrons orbiting the nucleus. Because the β^- particle is also a high speed electron and is also denoted as ${}_{-1}^{0}e$ or ${}_{-1}^{0}\beta^-$. The β-particle is formed in atoms with n/p > 1 (unstable nucleus) by the disintegration of neutrons into electrons and protons, whereas it is not associated with delocalized electrons circulating around the nucleus (Çelik, 2018; Dolu & Ürek, 2017; Dönmez Usta, 2011; Molu, et al. 2016; Yumuşak, Maraş & Şahin, 2016).

Considering the pre-test of the second question of the research (Table 2), it was determined that there were frequency values for each category. In the pre-test, it was seen that the highest frequency was in the category of "no response " (38%). For this situation, it can be said that students do not have much knowledge about the answer to this question. As stated above, the statements made by the students in the oral interviews with the students after the pre-test support this situation. In addition, in Table 2, it is seen that there were "correct" and "misconception" categories with equal frequency (24%) in the pre-test. This is followed by the “partially misconception (10%) and “irrelevant” categories. It is noteworthy that in the post-test, all of the answers were only in the "correct" category. The fact that all students who participated in the research answered the question about "radioactivity" taught through computer-assisted distance education were correct can be explained by the fact that all students learned this concept correctly. Yumuşak (2013) also determined in his study that computer-assisted instruction was effective in eliminating students' misconceptions about radioactivity. In addition, the reason why most students have misconceptions about this question is that they think of the atom as excited because gamma rays are very energetic. (Colclough, Lock & Soare, 2011; Çelik, 2018; Dönmez Usta, 2011; Tezcan & Erçoklu, 2010). In the literature, there are several studies which indicate misconceptions of the students about radioactivity (Cardoso, Nunes, Silva, Braghittoni & Trindade, 2020; Hull & Hopf, 2020; Ioannis, & Konstantinos, 2021; Siersma, Pol, van Joolingen & Visscher, 2021)

Although there was no response in the "correct" answer category in the pre-test to the third question of the research, it is a pleasing result that this category had the highest frequency value (70%) in the post-test. It can be said that none of the students answered this question correctly in the pre-test, and they were not sure about the answer to this question before, but they had partial knowledge. In addition, while the highest value of the answers given by the students in the pre-test was in the category of "partly correct" (45%), the decrease in this value to 30% in the post-test can be explained by the fact that the answers turned into correct. In addition, while the highest frequency was in the "no response " category (31%) in the pre-test, this category was not found in the post-test. While there were answers to the categories "misconception" (14%) and "Irrelevant" (10%) in the pre-test, the absence of these categories in the post-test supports this result. It can be said that the computer-assisted distance education made here is effective

and similar misconceptions are eliminated. In addition, students often confuse the stability of nuclear reactions with the stability of chemical reactions in this question. In nuclear reactions, stability is n/p=1 and energy is minimum (Dolu & Ürek, 2017). Stability in chemical reactions, on the other hand, is the completion of the valence electrons in the last layer of atoms to the octet (Mortimer, 2004, p.89). Morales López and Tuzón Marco, (2021) point out that students have confusion about chemical reactions and radioactivity, adding that the students think radioactivity of the substances is due to the nuclei, electron number, atomic structure, chemical composition and stability of the electrons. There are studies in the literature that examine similar misconceptions. (Erçoklu, 2001; Kılıç & Yalçın, 2004; Nakiboğlu & Bülbül Tekin, 2006; Prather & Harrington, 2001; Tezcan & Erçoklu, 2010; Yalçın, 2003).

According to the results of the first part obtained from the fourth question of the research (Table 4a); it was determined that a very large percentage of students (52%) had both positive and negative opinions about emergency remote education. This situation can be explained by the answers of the students talking about both the advantages and disadvantages of distance education. In addition, this result shows that students look at distance education from a broad perspective. This result of the study is also similar to the results of the studies in the literature (Bayram et al., 2019; Bostan Sarıoğlan, Şen & Altaş, 2021; Gürleyik & Akdemir, 2018; Keskin & Özer, 2020; Orhan, 2016; Şimşek, T. İskenderoğlu, M. İskenderoğlu, 2010; Türküresin, 2020). Besides, it is also seen that there are students who think only negatively about distance education (38%) and students who think only positively (10%). Akyol (2020) determined that although students receiving tourism education at the associate degree level generally had positive opinions about distance education applications during the Covid-19 pandemic period, the fact that the exams applied with the classical method forced the students. This result is similar to the result of the research conducted.

According to the results of the second part obtained from the fourth question of the research (Table 4b); it is noteworthy that students have more negative thoughts (f=42) about emergency remote education compared to positive opinions (f=20). Similar results to this result are also found in the literature (Benzer & Akkaya, 2021; Karatepe et al., 2002; Türküresin, 2020). In addition, the number of subcategories of the negative category is eleven, which is more than the number of positive subcategories (eight). This shows that the expressions given to the negative answers are more diverse. In the explanations of the students who think positively, the sub-category of "watching the course recording again" constitutes 50% of the answers. In this subcategory, students state that as they can have an access to their course records whenever they want if they cannot attend the lesson, they can repeat the lesson as much as they want. This contributes greatly to the better learning of the lesson. Moreover, in Table 4b; it is seen that the sub-categories of “comfort”, “being with a family” and “productivity” have the same frequency (10%).In addition, it is seen that there are student answers in the sub-categories of "saving time", "more opportunities", "practicality" and "creating a classroom environment" at the same frequency (5%). Akyol (2020) also determined a similar result in his study and associate degree tourism students stated that their expenses decreased because they were with their families during the distance education process. As a result of their study, Ojo and Olakulehin (2013) remark that students carry positive opinions about distance education since they have flexibility during learning and learning becomes easier with the use of a wide range of course materials. In addition, similar results were obtained in the literature (Aksoy, Bozkurt, & Kurşun, 2021; Bozkurt ve Sharma 2020b; Türküresin, 2020; Fidan, 2016; Moore & Kearsley, 2011)

Students negatively state that they mostly experienced "focus / understanding problems" (36%) and that they encountered "internet problems" (17%). In addition, when looking at the answers in the "reducing memorability" (12%) sub-category, the students stated that fewer examples were solved and less number of applications and experiments were performed. Besides, at the same frequency (9%), they state that they had "communication difficulties" with their friends and teachers, and that it was "boring" to listen to lectures because they were at home and in front of the screen. In a similar way, at equal frequency (5%), they state that they "could not feel like a university student", "had to work harder", "exam times were

short" and they were "tired" (2%) psychologically and physically (S27). Benzer and Akkaya (2021) in their studies with science teaching candidates graduate and doctorate students determined that the participants mostly expressed the negative aspects of distance education as systemic problems such as internet connection problems and audio-video disorders. Moreover, conducted research demonstrates that the participants' negative perceptions stem from the absence of face to face interactions between students and teachers and the quality of education is reduced by the incorrect applications during examinations (Ojo & Olakulehin, 2013; Ukwueze, 2016). Besides, in their study, Bozkurt and Sharma (2020b) the use of digital tools during online education influence both students and teachers negatively and causes fatigue. Those negative influences are listed as staring at the screen constantly, difficulties in focusing, problems in adapting to online timing, inconsistencies between real and virtual world, disconnections between body and mind which bring burnout. This result is similar to the result of the study. In addition, similar results were obtained in the literature (Aksoy, Bozkurt, & Kurşun, 2021; Altuntaş Yılmaz, 2020; Bostan Sarıoğlan, et al., 2020; Jeffery & Bauer, 2020; Kaumba, Mphahlele, Muleya & Simui, 2021; Önal & Özdemir, 2021; Petillion & McNeil, 2020; Sandi-Urena, 2020; Şenyuva, 2007; Van Heuvelen, Daub & Ryswyk, 2020).

According to the results obtained from the fifth question of the research (Table 5): it was determined that students' opinions about learning "radioactivity" through emergency remote education were mostly positive (79%). On the other hand, it is a satisfactory result that the number of negative opinions that students had while teaching this subject is low (7%). It is seen that the explanations of the students who think positively are mostly gathered in the sub-category of "I learned in detail and clearly" (68%). This is followed by the "course content and materials were sufficient" (13%) sub-category. The simplification of the course content and utilization of materials during the instruction process also support this result. Similar results were obtained in the literature. (Akçay et al., 2007; Bayram et al., 2019; Gares, Kariuki & Rempel, 2020; Rapanta et al., 2020; Tigaa & Sonawane, 2020; Uşun, 2004).

While the students mostly answered negatively (38%) to the fourth question of the research, it is pleasing that they gave a negative answer at a very low rate (7%) when they learned the subject of "radioactivity" through emergency remote education. In addition, while the percentage frequency value of positive answers to the fourth question of the research is 10%, the value in this category increases to 79% in the fifth question. For this situation, it can be said that students learned the subject of "radioactivity" largely through distance education. In addition, it was determined that the negative answers were mostly in the sub-category "I would prefer the lessons to be face-to-face" (46%). This is followed by the sub-categories of "I understood a little harder" and "more questions need to be solved" with an equal percentage frequency (27%). Similar results are also found in the literature (Aksoy et al., 2021; Türküresin, 2020; Şenyuva, 2007)

5. Suggestions

In the light of these results obtained from the study, the following recommendations were made:

- The research is about the subject of "radioactivity" and only three questions were asked about this subject. For this reason, both the subject and the research questions can be diversified.
- Bilateral meetings can be held with the students in order to enrich the studies.
- Alternative measurement techniques can be applied to students.
- The research was carried out only in a university located in the west of the Marmara region. However, it can also be performed on different university students.

6. Limitations of the Study

This study is limited to the students studying at the department of science teaching at university in the Marmara region, and access was granted to these students. However, within the scope of this study, it was

not possible to reach a sample that could represent the whole of Turkey. Since this subject was taught to the students through emergency remote education, the data were collected on the internet and the data collection questionnaire was sent online to the participants. The students completed this questionnaire online. The research is limited to the subject of "radioactivity". However, the categories determined not only show whether the students learned some concepts related to radioactivity through emergency remote education but also reflect their opinions on emergency remote education.

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