October 2024

INTERNATIONAL STUDIES AND EVALUATIONS IN THE FIELD OF

EDUCATIONAL SCIENCES

EDITOR

PROF. DR. ERDAL BAY

SERÜVEN YAYINEVİ

Genel Yayın Yönetmeni / Editor in Chief • C. Cansın Selin Temana

Kapak & İç Tasarım / Cover & Interior Design • Serüven Yayınevi

Birinci Basım / First Edition • © Ekim / October 2024

ISBN • 978-625-6172-40-1

Serüven Yayınevi / Serüven Publishing
Türkiye Adres / Turkey Address: Kızılay Mah. Fevzi Çakmak 1. Sokak
Ümit Apt No: 22/A Çankaya/ANKARA
Telefon / Phone: 05437675765
web: www.seruvenyayinevi.com
e-mail: seruvenyayinevi@gmail.com

Baskı & Cilt / Printing & Volume
Sertifika / Certificate No: 47083

INTERNATIONAL STUDIES AND EVALUATIONS IN THE FIELD OF EDUCATIONAL SCIENCES

October 2024

Editor

PROF. DR. ERDAL BAY

CONTENTS

Chapter 1

EVALUATION OF THE EFFECT OF THE LEARNING STATIONS TECHNIQUE ON THE CONCEPTUAL UNDERSTANDING AND OPINIONS OF SIXTH-GRADE STUDENTS IN THE UNIT OF "CONDUCTION OF ELECTRICITY"[1]

Burak YAVUZ[2]

Nermin BULUNUZ[3]

1 This study was produced from Burak Yavuz's Master's master thesis entitled " Evaluation of the Effect of the Learning Stations Technique on the Conceptual Understanding and Opinions of Sixth-Grade Students in the Unit of "Conduction of Electricity ", completed on 25.09.2023 at Bursa Uludağ University under the supervision of Prof. Dr. Nermin Bulunuz.

2 Science Teacher, Burak YAVUZ, Responsible Author, 80. Yıl Cumhuriyet İmam Hatip Ortaokulu,
ORCID: 0000-0003-3185-5450

3 Prof. Dr. Nermin BULUNUZ, Thesis Advisor, Bursa Uludag University, Faculty of Education, Department of Mathematics and Science Education,
ORCID: 0000-0001- 7891-0379

INTRODUCTION

The main goal of science education is not to provide individuals with a monotonous and rote memorization of knowledge necessary for understanding themselves, their nature, and their surroundings. Instead, it is to cultivate individuals who know how to access information, produce knowledge, and add new meanings. The purpose of science education is to help students develop creative and critical thinking skills, contribute to their understanding of themselves, their environment, and the world, foster socialization through collaborative work, and instill sensitivities aligned with technology (Yağbasan ve Gülçiçek, 2003).

To ensure meaningful and lasting learning, methods in which students take an active role should be preferred. Active learning processes, where the teacher guides and students actively communicate with peers, learn by doing, solve problems, use various materials, and draw conclusions from experiments, result in more permanent learning.

The general expectation from the education process is an increase in the student's academic success. As a result, in recent years, more innovative and diverse techniques have been implemented in education instead of traditional teaching methods to enhance students' academic achievement. One such technique is the hands-on learning stations technique. Through the hands-on learning stations technique, students actively participate in the educational process. This allows them to work with peers, solve problems, communicate socially, conduct experiments, use materials, and experience multiple intelligences in the hands-on learning stations.

The hands-on learning stations technique also provides each student with the opportunity to discover their talents according to their individual differences and learning pace. In this technique, the educational environment is organized according to the student. The instructions for the activities to be carried out in the hands-on learning stations should be prepared clearly and appropriately in advance. Students actively participate in learning based on these instructions. This technique is predicted to make it easier for students to acquire the necessary concepts in science education and internalize them for long-term, permanent learning. In recent years, research on science teaching, science literacy, increasing conceptual understanding in science courses, and the hands-on learning stations technique has gained importance both globally and in our country. This research is also expected to contribute to future studies.

THE HANDS-ON LEARNING STATIONS TECHNIQUE

Specific areas are designated for students to perform educational activities, and materials to be used are pre-planned and placed in these areas. Students then engage in learning through hands-on experiences. These designated places are called "station centers" or "hands-on learning stations" (Benek, 2012). Spaces in classrooms or different environments are provided where students are given the opportunity to learn the objectives of the lesson through group work or individual efforts by engaging in hands-on experiences (Bulunuz, 2006: 278). Before the lesson begins, students are informed about the hands-on learning stations technique and how it will be implemented, and the station centers are carefully prepared in advance. The students in the class are divided into groups based on the characteristics of the subject and the number of students, and stations are set up (Alacapınar, 2009: 138; Sönmez, 2009b: 254; Commission, 2014: 112). For instruction to be carried out with hands-on learning stations, students must be at least at the application level. Additionally, the objectives at this level should be identified in the students at least at the application level (Avcı, 2015, p. 37; Sönmez, 2015, p. 253).

All groups carry out activities in each station in turn, continuing the work from where the previous group left off. Each group works at a station for a predetermined amount of time and then moves to the next station upon the teacher's command. During the application, the teacher acts as a guide, should be involved with each station, and should answer students' questions and provide direction (Kryza et al., 2007). By ensuring that each group works at every station, common products in which everyone contributes are created. The hands-on learning stations technique, which is based on cooperative learning, multiple intelligences, and constructivist learning theories, allows students to carry out individual learning, be active in the learning process, work in groups at station centers, and engage in various activities that address all intelligence areas in these centers (Benek, 2012, p. 8).

With the hands-on learning stations technique, students experience a different type of learning compared to traditional and classical learning methods. The hands-on learning stations actively involve students in the process. Students, who play an active role at the stations, gain experiences with various materials along with their peers at the stations. As a result, students can develop in areas such as problem-solving, completing tasks, socialization, group work, and learning by doing and experiencing. Students have expressed that they become bored with traditional, lecture-based lessons where they are only listeners during the lesson process, leading to decreased interest and attitude toward the lesson. However, they find that instruction conducted with hands-on learning stations is more enjoyable, engaging, and fun, as it actively involves them in the process. At the same time, the hands-on learning stations technique creates a democratic classroom environment, instilling positive values in students by encouraging them to respect different opinions and approaches with tolerance.

The fact that students can make choices during lessons in this technique, work collaboratively in groups, socialize, take responsibility, make effective decisions, manage their time efficiently, solve problems they encounter, explore through trial and error, and take charge of their learning gives them the courage to develop in many aspects (Bottini & Grossman, 2005). The hands-on learning stations technique is a suitable method for enabling students to achieve effective and lasting learning. This technique allows students to participate in the learning process both mentally and physically (Gregory & Hammerman, 2008). Ocak (2015) states that the station technique helps students establish a concrete and fast connection between theory and practice. It provides simultaneous learning opportunities to students.

By conducting activities related to the same topic at different stations, the knowledge learned becomes permanent, students are given simultaneous learning opportunities, and the lesson process becomes more efficient (Demirörs, 2007: 23; Ocak, 2008: 256-257; Tseng, 2008: 10; Erdağı, 2014: 22). In addition, the hands-on learning stations technique is beneficial in teaching students how to use time effectively and plan efficiently. Educators structure the hands-on learning stations to ensure social interaction and individual use of materials, allowing students to actively construct their own knowledge. The study of a subject from multiple perspectives forms the foundation of constructivism, and hands-on learning stations encompass all these principles (Schunk, 2004, p. 287-288). This method can help students acquire skills such as discovering information, conducting experiments, researching, solving problems, constructing knowledge, and collaborative learning. Separate stations can be designed for students with different learning speeds, allowing them to fill in their gaps. Since stations are designed to appeal to all areas of intelligence, they contribute to the development of students' various intelligence areas (Benek, 2012).

Studies Conducted in Turkey:

Albayrak (2016), in his study titled "The Effect of Station Technique on Students' Academic Achievement and Attitudes Toward Astronomy," aimed to determine the impact of hands-on learning stations on students' academic achievement in astronomy and their attitudes toward the subject. The study was conducted with 98 seventh-grade students during the 2015-2016 academic year. A mixed method combining both quantitative and qualitative data was used. The research employed a pre-test/post-test control group model from experimental design. Quantitative data was collected using a "Astronomy Achievement Test" (ABT) consisting of 25 questions to measure the changes in success among students in the experimental and control groups. Additionally, an "Astronomy Attitude Test" (AAT) was administered as a pre-test and post-test to assess students' attitudes towards astronomy. At the end of the implementation process, a significant difference in favor of the experimental group was found in the ABT post-test scores between the experimental and control groups, while the increase in AAT post-test scores, though present in favor of the experimental group, was not statistically significant. Semi-structured interviews were conducted to gather students' opinions about the hands-on learning stations, and their responses indicated that they viewed hands-on learning stations as an easy, efficient, and effective method for learning.

Abasız Tercan (2019) aimed to examine the effect of the learning station technique on high-level cognitive skills in the topic of ratio and proportion in mathematics. In a study conducted with seventh-grade students at a middle school in Ankara, a mixed research method was used with 54 participants. The analysis of both quantitative and qualitative data revealed that the experimental group was more successful. Content analysis showed that students enjoyed the learning station technique, which fostered social interaction, increased self-confidence, and facilitated more concrete and easier learning.

Yıldız (2019) investigated the effect of learning through station technique on student success in the topic of mitosis. In a study conducted with 40 second-year college students majoring in science education, it was determined that the use of the station technique increased students' success, promoted active participation, and enhanced retention.

Eker, Kırçiçek, and Yüksel (2020) researched the effect of the station technique on academic achievement in the course "Science Teaching Laboratory Applications II" with pre-service science teachers. The study, involving 58 students, used a quasi-experimental design. The analysis of achievement test results revealed that students who used the learning station technique had higher success rates.

Aktaş (2021) supported the station technique with concept mapping to examine students' knowledge of heavy metal pollution in water and soil and their attitudes towards a sustainable environment. The study was conducted with 41 pre-service science teachers using a pre-test/post-test experimental design. Quantitative data were obtained using an achievement test and an attitude scale, and results indicated that participants' success increased.

Studies Conducted Abroad:

Bulunuz and Jarrett (2010) sought to explore teacher candidates' ideas about hands-on learning stations in the context of the topic "Earth and Space," focusing on concepts like the phases of the Moon and the formation of seasons. Using six learning centers, the study employed concept maps, open-ended questions, and researcher observations as data collection tools. The results suggested that hands-on learning stations improved understanding of the formation of seasons, earthquakes, and the rock cycle but did not achieve the desired success in teaching the phases of the Moon.

Chien (2017) conducted research with seven teacher candidates to determine the effect of the station technique in English teaching. The study group consisted of an English teacher, 28 elementary school students, and seven graduate students. The research, which lasted 18 weeks, used five different stations. The results showed that both teachers and students in the study group developed positive attitudes towards the station technique. To sum it up, both domestic and international studies on the learning station technique indicate that it has been applied in various subjects and that qualitative, quantitative, and mixed methods were used in research. In general, research results highlight that the technique positively impacts students' academic achievement, fosters social communication and democratic participation, promotes lasting learning, and makes the learning process enjoyable. Students develop positive attitudes towards courses, benefit from collaborative work, and learn from their peers. The technique also encourages respect for others' opinions, develops high-level skills, and contributes to students' success compared to traditional teaching methods. However, potential challenges include group conflicts, noise in crowded classrooms, difficulties in understanding the technique in its initial stages, and complexities in the implementation process.

METHOD

Research Model

In this study, the "pre-experimental" model called the "single group pre-test/post-test model" was used (Karasar, 2014). In this model, an independent variable is applied to one group. In this research, the independent variable is the " hands-on learning stations technique" applied to sixth-grade classes. Both pre-test and post-test measurements were conducted in the model.

Additionally, responses to open-ended questions were analyzed descriptively, and some examples of students' answers were shared within the thesis. Data obtained from semi-structured interview questions conducted at the end of the unit "Transmission of Electricity" were analyzed using content analysis and descriptive analysis methods.

However, in this study, only the descriptive analysis of data from five selected semi-structured interview questions, which were part of the thesis titled "Evaluation of the Effect of the Hands-On Learning Stations Technique on Sixth-Grade Students' Conceptual Understanding Levels and Opinions in the Unit 'Transmission of Electricity'," was used.

This study was conducted with 35 students during the Spring term of the 2022-2023 academic year at Şanlıavşar Hacı Avcı İmam Hatip Middle School in the village of Şanlıavşar, Bozova District, Şanlıurfa Province.

Out of the eight semi-structured interview questions used in the researcher's thesis, five were selected for use in this study. These questions are listed below:

1. In our Science class, we covered some topics in the Electricity unit using hands-on learning stations. What are your thoughts on these lessons conducted with hands-on learning stations?

o What are the positive aspects?

o What are the negative aspects?

2. How did hands-on learning stations contribute to your understanding of electricity-related concepts?

3. What are your thoughts on actively participating in the learning process with your group mates while using this method?

4. Which hands-on learning stations did you find most instructive? Why? Can you explain?

5. Which hands-on learning stations did you find most boring? Why? Can you explain?

In semi-structured interviews, the interview questions must be determined before the implementation. The questions should also be open-ended to allow for detailed responses. Semi-structured interview questions are flexible and are generally expected to be clarified by the participants (Işık ve Semerci, 2019). In this research, the researcher prepared the interview questions before the implementation process. Regardless of the type of interview, the researcher should prepare the questions in accordance with the theoretical framework to ensure a meaningful and productive interview (Baltacı, 2019).

The participants in the interviews were selected by the researcher from two different classes. A total of 9 students were included in the semi-structured interviews, with 3 students each from high, medium, and low achievement levels. The interviews were conducted in a quiet environment where the participants could express themselves calmly and comfortably. The researcher asked 8 interview questions, which were designed in line with the nature of the research and focused on "learning station applications."

Questions were asked about the aspects of the hands-on learning stations technique that students liked and disliked, the parts of the process they found most challenging, and the similarities and differences between this technique and traditional teaching methods. The researcher added expressions such as "Why? How? Can you elaborate on this?" to encourage participants to provide more detailed responses.

FINDINGS

Findings from Semi-Structured Interview Questions

The researcher chose to conduct paired interviews during the interview stage of the study. The semi-structured interviews with the students were recorded by the researcher and transcribed into written documents. The findings from these interviews are presented in the table below.

1. **In our Science classes, we covered some topics from the Electricity unit using hands-on learning stations. What are your thoughts on these lessons where we used hands-on learning stations?**

o **What are the positive aspects?**

o **What are the negative aspects?**

Table 1 below shows the frequency values of different responses given by students to the first interview question and the percentage values of these different response types compared to the total types of responses.

Table 1

Findings from the First Interview Question

ANSWERS	FREQUENCY	%
I really liked the hands-on learning stations technique because I was able to participate in the lesson more freely in class. At first, it was a bit difficult for me to understand the technique.	5	55,56
The hands-on learning stations technique increased my self-confidence. I was able to work well with my friends, but we experienced some confusion in certain activities.	3	33,33
I realized that with the hands-on learning stations technique, I could follow the flow of the lesson on my own. However, working in groups sometimes made me feel shy.	1	11,11

Total number of respondents: 9

In the semi-structured interviews, the first question was asked to the students. Of the 9 students who responded to the question, 5 answered, "I really liked the hands-on learning stations technique because I was able to participate in the lesson more freely in class. At first, it was a bit difficult for me to understand the technique." Three students answered, "The hands-on learning stations technique increased my self-confidence. I was able to work well with my friends, but we experienced some confusion in certain activities." One student responded, "I realized that with the hands-on learning stations technique, I could follow the flow of the lesson on my own. However, working in groups sometimes made me feel shy."

2. **How did the hands-on learning stations contribute to your understanding of concepts related to electricity?**

In Table 2 below, the frequency values of different responses given to the second interview question and the percentage comparison of these different types of answers are provided.

Table 2

Findings from the Second Interview Question

ANSWERS	FREQUENCY	%
Thanks to the hands-on learning stations technique, I learned the topic much better by actively engaging and concretizing it with materials.	6	66,7
During the group work using the tools and equipment in the hands-on learning stations technique, I understood the concepts better.	2	22,2
I got bored during the activity because of the noise in the group and not being able to get along with my friends. I couldn't focus. It would have been better if the teacher had written on the board, and I could have taken notes.	1	11,1

Total number of respondents: 9

Students were asked the question, "How did the hands-on learning stations technique contribute to your understanding of concepts related to electricity?" Out of 9 students, 6 responded to the second interview question by saying, "Thanks to the hands-on learning stations technique, I learned the topic much better by actively engaging and concretizing it with materials." Two students answered, "The tools and equipment used during group work with the hands-on learning stations technique helped me understand the concepts better." The remaining student gave a negative response, stating, "I got bored during the activity because of the noise in the group and not wanting to communicate with my friends. I couldn't focus. It would have been better if the teacher had written on the board and explained. I would have taken notes."

3. What are your thoughts on actively participating in the learning process with your groupmates while using this method? In Table 3 below, the frequency values of the different responses given by students to the third interview question and the percentage comparison of these different response types with the total types of responses are presented.

Table 3

Findings from the Third Interview Question

ANSWERS	FREQUENCY	%
It was fun and enjoyable to learn the lesson in the way we wanted. I was happy to complete the activities with the materials provided and my groupmates. I wish we could learn all lessons this way.	7	77,8
I felt discouraged because some of my friends were more active, and I ended up staying in the background. I couldn't be as active as I wanted.	2	22,2

Total number of respondents: 9

The question asked to the students was, "What are your thoughts on actively participating in the learning process with your groupmates while using this method?" Seven students responded, "It was fun, enjoyable, and great to learn the lesson in the way we wanted. I was happy to complete the activities with the materials provided and my groupmates. I wish we could learn all lessons this way." The other two students who were interviewed responded, "I felt discouraged because some of my friends were more active, and I ended up staying in the background. I couldn't be as active as I wanted," expressing that they were sad about not being able to participate as actively as they wished.

4. Which hands-on learning stations did you find more instructive? Why? Can you explain?

Table 4 below shows the frequency values of different expressions in students' responses to the fourth interview question and the percentage values compared to the total types of responses.

Table 4

Findings from the Fourth Interview Question

ANSWERS	FREQUENCY	%
The number one learning station was very easy to understand. We placed many everyday objects between conductive wires and determined which were conductive and which were insulating based on whether the bulb lit up or not.	5	55,6
At the number three station, I understood that the bulb has resistance and its relationship with brightness by seeing the changes in the brightness of the bulbs as we connected more bulbs in series to the circuit.	3	33,3
At the number two station, we saw many products used in daily life. We examined why they were made that way by looking at their insulating and conductive parts. The items we also saw at home helped me understand better.	1	11,1

Total number of respondents: 9

Students were asked the question, "Which hands-on learning stations did you find more educational? Why? Can you explain?" Out of the nine students selected for the interviews, five responded, "The number one learning station was very easy to understand. Because we placed many everyday objects between conductive wires and figured out which were conductive and which were insulating based on whether the bulb lit up or not." Three students answered the same question by saying, "At the number three station, as we connected more bulbs in series to the circuit, I understood that the bulb has resistance and its relationship with brightness by observing the changes in the brightness of the bulbs." One student responded, "At the number two station, we saw many products used in daily life. We examined why they were made that way by looking at their insulating and conductive parts. Using items we also saw at home helped me understand better."

5. Which hands-on learning stations did you find more boring? Why? Can you explain?

Below in Table 5, the frequency values of the different expressions given by the students in response to the fifth interview question and the percentage values comparing these different types of answers to the total types of responses are provided.

Table 5

Findings from the Fifth Interview Question

ANSWERS	FREQUENCY	%
The number two learning station was boring. Because we examined parts of some appliances that we already know from home. We tried to understand whether they were insulating or conducting. I wish there had been a station where I could do something different through experimentation.	7	77,8
At the number four station, I got bored while examining conductive wires according to different cross-sectional areas. The station where we added a bulb to understand how resistance affects bulb brightness was much more fun.	2	22,2

Total number of respondents: 9

Students were asked, "Which hands-on learning stations did you find more boring? Why? Can you explain?" Out of the 9 students selected for the interview, 7 answered the question by saying, "Learning station number 2 was boring. Because we examined parts of some devices that we already know from home. We tried to understand whether they were insulators or conductors. I wish there had been a station where I could do something more different through experimentation." The remaining two students expressed their opinions as follows: "I got bored while examining the different cross-sections of the conductive wires at station number 4. The station where we added bulbs to understand how resistance affects bulb brightness was more fun."

RESULTS, DISCUSSION, AND RECOMMENDATIONS

This research aimed to determine whether the use of hands-on learning stations instead of traditional teaching methods during the teaching of the 6th-grade science unit "Transmission of Electricity" had any effect on the meaningful learning of concepts within the unit and on the responses given by students to open-ended assessment questions through pre-test and post-test applications. Additionally, the study sought to identify students' opinions regarding the teaching process conducted using the hands-on learning stations technique. This section presents the findings related to the students' responses to the semi-structured interview questions. Furthermore, the discussion section compares the research results with the literature, and suggestions are made based on these results.

Findings and Discussion from Semi-Structured Interviews

This section discusses the findings related to one of the research questions: "What are the opinions of sixth-grade students learning the unit 'Transmission of Electricity' using the hands-on learning stations method?" Before the implementation of the hands-on learning stations technique, students were accustomed to a teaching process where they primarily learned through traditional methods and did not actively participate in the process, relying solely on the teacher's explanations. Their opinions on the use of the hands-on learning stations technique in lessons were solicited.

The results of the research indicate that the hands-on learning stations technique made the lesson enjoyable, encouraged students to like science class, increased their active participation, motivated them to attend class with more enthusiasm, facilitated easier comprehension of the subject by making it concrete, reinforced the topic, and helped them understand related concepts through hands-on experiences with materials, leading to greater success in exams. Additionally, feedback from students indicated that they wished to conduct more enjoyable lessons using the hands-on learning stations technique in other subjects as well. However, some students expressed that they found the activities in the hands-on learning stations excessive, experienced discomfort due to noise in the classroom at times, found the hands-on learning stations technique boring, and felt demotivated because they did not have enough opportunities to participate in activities due to group dynamics, as well as anxiety about not completing tasks on time.

Bekereci, Şimşek, Hamzaoğlu, and Yazıcı (2020) found that in their study on Mitosis and Meiosis in 7th-grade science classes, the hands-on learning stations technique made the science lesson enjoyable and encouraged students to enjoy science. Çakmak (2018) noted in a study with 6th graders that students expressed their interest in science lessons conducted using the hands-on learning stations technique, thereby gaining a positive outlook.

However, the noise during the activities and some students remaining passive in groups were identified as factors leading to a negative perception of the technique. Koca (2018) found that students had a positive opinion about science lessons regarding the teaching of the cell topic using the stations technique. The results obtained from this study align with the aforementioned studies in the literature.

Arslan (2017) stated that students were bored with the routine, traditional teaching methods and being passive in the process, which decreased their interest in lessons. However, the teaching conducted with the hands-on learning stations technique was found to be more enjoyable because it made students active participants. The variety and differences in the hands-on learning stations captured students' attention and interest. The results of this study show similarities to those studies.

Some of the students participating in the application expressed that they did not get along with some of their group members in the hands-on learning stations. Similarly, in a study conducted by Avcı (2015), it was determined that some students did not want to work with certain group members. Some students' lack of full participation in the activity (Demir, 2008) and the mixing up of tasks during the implementation (Kryza et al., 2007; Batdı ve Semerci, 2012) indicate that there is a parallel between this study and the literature.

Demir (2008) also mentioned that the level of noise in the classroom during the station technique implementation was higher than the normal lesson level. In our study, students indicated that they felt discomfort due to excessive noise and chaos at times. This situation demonstrates that the findings align with the literature.

In the research conducted by Benek and Kocakaya (2012) on student opinions regarding the hands-on learning stations technique, it was found that students viewed the hands-on learning stations technique as a useful method, enjoyed participating in activities at the station centers, and believed that the technique should be applied in other topics of the Science course and in other subjects outside of Science. Based on the information obtained from the semi-structured interview questions in this study, we can say that the findings mirror those of previous research in the literature.

In the semi-structured interview questions, students expressed that they enjoyed the activities, had a more enjoyable lesson experience, achieved increased success with the hands-on learning stations technique, and articulated their desire for other topics in the Science course and even other subjects to be taught using the hands-on learning stations technique. The results of this study parallel existing research. According to the findings in the literature, students view hands-on learning stations as a technique that is beneficial, increases success, and facilitates easy learning through active participation in lessons (Avcı, 2015; Erdağı ve Önel, 2015; Genç, 2013; Köseoğlu et al., 2009; Mergen, 2011).

RECOMMENDATIONS

1. Since the use of the hands-on learning stations technique in the teaching of science contributes positively to students' opinions and interests in the subject, this technique should be utilized more in science classes as well as in other subjects.

2. Given that the control may decrease, and noise and confusion may arise during the implementation of the Hands-On Learning Stations Technique in crowded classrooms, researchers and teachers planning to implement this technique in such settings need to organize activities and timing very well.

3. The hands-on learning stations technique has been shown to promote enjoyment in learning and increase students' willingness to actively participate in the lesson. It has been determined that students learn to work in groups, cooperate, engage in peer learning, and develop communication skills. Therefore, the use of the hands-on learning stations technique is recommended, especially in subjects and topics heavily focused on abstract concepts.

4. In today's world, the limitations of traditional teaching methods in generating the necessary interest in lessons and achieving meaningful learning have been highlighted due to evolving technology and living conditions. It is suggested that teachers receive informative training about these techniques to enhance their application in order to encourage active student participation in the learning process.

REFERENCES

Abasız Tercan, M. (2019). The effect of the station technique on acquiring higher-order cognitive skills in mathematics education. [Master's thesis, Necmettin Erbakan University].

Aktaş, E. (2021). Examination of the effects of concept mapping and the station technique on science teacher candidates' knowledge of heavy metal pollution in water and soil and their attitudes towards a sustainable environment. [Doctoral dissertation, Kastamonu University].

Alacapınar, G., ve Füsun, G. (2009). Student opinions on lesson implementation using the station technique. Abant İzzet Baysal University Faculty of Education Journal, 9(1), 137-147.

Albayrak, H. (2016). The effect of the station technique on students' academic success and attitudes towards astronomy topics. [Master's thesis, Erzincan University].

Arslan, A. (2017). The impact of the use of the station technique in Turkish language teaching on students' academic success, attitudes, and retention. [Master's thesis, Cumhuriyet University].

Avcı, H. (2015). The effect of using the station technique in English language teaching on academic success, attitudes, and retention. [Master's thesis, Fırat University].

Baltacı, A. (2019). Qualitative research process: How to conduct qualitative research? Ahi Evran University Journal of Social Sciences Institute (AEÜSBED), 5(2), 368-388.

Batdı, V., ve Semerci, Ç. (2012). Reflective inquiry of the station teaching method in lessons.

Bartın University Faculty of Education Journal, 1(1), 190-203.

Bekereci, Ü., Şimşek, F., Hamzaoğlu, E., ve Yazıcı, M. (2020). The effect of using the station technique in science classes on students' academic success and attitudes toward science. Anemon Muş Alparslan University Journal of Social Sciences, 8(6), 1779-1786.

Benek, İ. (2012). The effect of the learning technique in stations on the academic success of 7th-grade middle school students in science and technology classes. [Master's thesis, Yüzüncü Yıl University].

Benek, İ., ve Kocakaya, S. (2012). Student opinions on the learning technique in stations. Journal of Educational and Teaching Research, 1(3), 8-18.

Bottini, M., & Grossman, S. (2005). Center-Based Teaching and Children's Learning: The Effects of Learning Centers on Young Children's Growth and Development. Childhood Education, 81(5), 274.

Bulunuz, N. (2006). Understanding of earth and space science concepts: Strategies for concept building in elementary school teacher preparation. [Ph.D. thesis, Georgia State University], Department of Early Childhood Education, Atlanta.

Bulunuz, N., & Jarrett, O. (2010). The effects of hands-on learning stations on building American elementary school teachers' understanding of earth and space science concepts. Eurasia Journal of Mathematics, Science and Technology Education, 6(2), 85-99. ISSN: 1305-8223.

Chien, Chin-Wen (2017). Undergraduates' implementations of hands-on learning stations as their service learning among elementary school students. Education 3-13, 45(2), 209-226.

Çakmak, M. (2018). The effect of the station technique on student success in the 6th-grade unit of matter and heat, and students' opinions about the technique. [Master's thesis, Dicle University].

Demirörs, F. (2007). Development and implementation of hands-on learning stations for 1st- grade high school students on Ohm's law. [Master's thesis, Hacettepe University].

Demir, M.R. (2008). The effect of the learning model in stations on access to higher-order skills in life skills courses. [Master's thesis, Hacettepe University].

Eker, M., Kırçiçek, H., ve Yüksel, İ. (2020). The impact of laboratory applications based on the station technique on the course success of science teacher candidates. Gazi University Faculty of Education Journal.

Erdağı, S. (2014). The effect of the station technique on academic success in science and technology courses. [Master's thesis, Kafkas University].

Erdağı, S., ve Önel, A. (2015). Evaluation of student opinions and performances related to science and technology courses where the station technique is applied. Journal of Caucasus Educational Research, 2(1), 28-37.

Genç, M. (2013). Pre-service teachers' opinions on the use of the station technique in environmental education. Erzincan University Faculty of Education Journal, 15(2), 188-203.

Gregory, G.H., & Hammerman, E. (2008). Differentiated instructional strategies for science. California: Corwin Press.

Işık, E., ve Semerci, Ç. (2019). Focus group interviews, individual interviews, and observation as data triangulation in qualitative research in education. Turkish Journal of Educational Studies, 6(3), 53-66.

Karasar, N. (2014). Scientific research methods (26th ed.). Ankara: Nobel Publishing Distribution. Commission (2014). Principles and methods of teaching (1st ed.). Anı Publishing: Ankara.

Köseoğlu, P., Soran, H., & Storer, J. (2009). Developing hands-on learning stations for the purification of wastewater. Procedia-Social and Behavioral Sciences, 1(1), 210-214.

Kryza, K., Stephens, S. J., & Duncan, A. (2007). Inspiring Middle and Secondary Learners. Corwin Press: California.

Mergen, H. H. (2011). The effect of the implementation of hands-on learning stations in the 5th-grade social studies course on academic success and retention. [Master's thesis, Afyon Kocatepe University].

Ocak, G. (2008). Principles and methods of teaching. Ankara: Pegem Academy.

Ocak, G. (2015). Principles and methods of teaching. Pegem Academy Publications.

Schunk, D. H. (2004). Learning theories: An educational perspective. Upper Saddle River, NJ: Pearson Prentice Hall.

Sönmez, V. (2009). Principles and methods of teaching (3rd ed.). Anı Publishing.

Sönmez, V. (2015). Principles and methods of teaching (8th ed.). Anı Publishing.

Tseng, Y. W. (2008). Effects of using the learning station model as a phonics remedial program in an elementary school. [Unpublished master's thesis]. National Pingtung University of Education, Pingtung.

Yağbasan, R., ve Gülçiçek, Ç. (2003). Identification of the characteristics of misconceptions in science teaching. Pamukkale University Faculty of Education Journal, 13(13), 102-120.

Yıldız, S. (2019). The effect of teaching supported by the station technique on mitosis on the academic success of science teacher candidates. [Master's thesis, Aksaray University].

ACKNOWLEDGEMENT

We thank to Atacan Bulunuz who has just completed his bachelor's degree on the Translation and Interpretation Department at Bilkent University earns our deep appreciation. Despite his busy curriculum, he translated the entire article from Turkish to English.

Chapter 2

RESEARCH STUDY ON THE EVALUATION OF THE SOCIAL, ECONOMIC AND POLITICAL EFFECTS OF THE POPULATION EXCHANGE (MÜBADELE) PROCESS BETWEEN TÜRKIYE AND GREECE

Hüsniye Merve Bingöl Türkan[1]

1 Bursa Uludag University, Faculty of Education, Turkish and Social Sciences Education, Gorukle, Bursa, Türkiye, mervebingol@uludag.edu.tr ORCID:0000-0001-9849-056X

1-Introduction

In the wake of World War I and the Greco-Turkish War of 1919–1922, there were geopolitical realignments that included the forced, governmental-mandated deportation of Greek Orthodox Christians from Turkey and Muslim Turks from Greece, known as the Greco-Turkish population exchange of 1923. The arrangement, which was formalized on January 30, 1923, in Lausanne through the "Convention Concerning the Exchange of Greek and Turkish Populations," required the evacuation of almost 1.5 million Greeks and 500,000 Muslims. Inspired by growing nationalist hopes and ethnic tensions when the Ottoman Empire fell, the exchange sought ethno-national unity.

The populations involved were diverse, including not just ethnic Greeks and Turks but also Protestant and Catholic Greeks, Arabs, Albanians, Russians, Serbians, Romanians, and Turkish-speaking Greek Orthodox individuals, as well as Muslim communities like Albanians, Bulgarians. Despite intentions to safeguard refugees' properties and provide fair compensation, the process often lacked true voluntariness, with moral, psychological, and economic pressures forcing compliance.

The exchange significantly impacted the social and economic landscapes of both nations. In Greece, it led to major land redistributions and the creation of a new class of small landowners, stabilizing the rural economy but also burdening the country with debt. Culturally, the exchange disrupted established intellectual centers and communities.

The legacy of the 1923 population exchange continues to resonate today, with commemorative events in cities like Izmir and Istanbul reflecting on the historical and emotional impact. Academic studies and exhibitions explore its complex outcomes, emphasizing the human cost of political decisions and the role of cultural memory in shaping national identities. This historical episode remains a significant point of reflection on the implications of forced migrations and ethnic homogenization.

The Greco-Turkish population exchange of 1923 was a compulsory, government mandated mutual expulsion of Greek Orthodox Christians from Turkey and Muslim Turks from Greece. This event was a part of the broader geopolitical reconfigurations that followed World War I and the subsequent Greco-Turkish War of 1919–1922 [1]. The compulsory exchange was formalized through the "Convention Concerning the Exchange of Greek and Turkish Populations," signed at Lausanne on January 30, 1923. The agreement mandated the relocation of Orthodox Christians from Turkey to Greece and Muslims from Greece to Turkey, impacting approximately 1.5 million Greeks and 500,000 Muslims. The exchange was largely a response to the nationalist aspirations and ethnic conflicts that had intensified during and after the collapse of the Ottoman Empire [2].

The populations affected were not homogeneous and included a variety of ethnic and religious minorities. These included Protestant and Catholic Greeks, Arabs, Albanians, Russians, Serbians, Romanians of the Greek Orthodox religion, and Turkish-speaking Greek Orthodox.

This exchange had significant social and economic impacts on the affected populations, as detailed in studies by scholars like Mustafa Suphi Erden and Biray Kolluolu [2] The institutional dynamics behind the making of Greek communities in western Anatolia during the last decades of the Ottoman Empire, characterized by turbulence for non-Muslim populations, were a key factor in the resilience and continued thriving of these communities, despite the pressures of the exchange [3].

The enduring legacy of this population exchange is still felt today, as it altered the demographic landscapes of both Greece and Turkey and left lasting impacts on the identities and memories of the descendants of those who were forced to move [4].

2-The Population Exchange Agreement

A significant attempt was made to end the ethnic conflict between the two countries through the legally sanctioned transfer of populations based on religious and ethnic identity through the population exchange between Greece and Turkey, which was formalized in the Convention Concerning the Exchange of Greek and Turkish Populations at the Lausanne Conference on January 30, 1923 [2, 5]. About two million people had their ancestral homes removed as a result of this arrangement [6].

To create ethnic-national homogeneity in both countries was the exchange's main goal. The percentage of non-Muslims in modern-day Turkey's population fell from nearly 20 percent in 1906 to only 2.6% in 1927, demonstrating how successful the population transfer was in changing the country's demographic makeup [7]. About 1.3 million Anatolian Christians, mostly Greeks, and 354,000 Balkan Muslims, mostly Turks, participated in the exchange [5].

As per the agreement, refugees' personal belongings would be safeguarded, permitting them to bring only moveable items with them. Documentation of other properties would be required for payment. A commission was set up to determine the overall amount that should be paid to people for their real estate, including homes, vehicles, and land [2]. The intention was to supply refugees with items in their new settlements that were equal to what they had left behind, with any excess value to be divided between the two nations [2].

Despite the agreement's formal intentions, ensuring true voluntariness in the migration process was challenging. Historical transfers often did not mandate compulsory movement but created strong moral, psychological, and economic pressures that made staying behind difficult for the affected populations [5]. This inherent coercion underscores the complex dynamics of such population exchanges and raises questions about the feasibility of achieving genuine consent in similar contexts.

The population exchange not only redrew the ethnic and religious maps of Greece and Turkey but also left a lasting legacy on the descendants of those affected.

While younger generations may view the term "mübadele" (population exchange) as archaic, the elderly who lived through or directly experienced the exchange remember it vividly and sometimes bitterly [6]. This historical episode underscores the profound human impact and the enduring memories of displacement that such policies engender.

3-Implementation

The implementation of the population exchange between Turkey and Greece in 1923 involved multiple steps and complex negotiations facilitated by various international bodies. A key player in this process was the Mixed Commission, which was responsible for determining the nationality of individuals liable for exchange and verifying their establishment in accordance with Article 2 of the Convention [8]. This body held exclusive jurisdiction over these matters, a decision affirmed on April 4, 1924, without protest from either government involved [8].

To formalize the Treaty and bring it into force, ratifications from the signatory powers were required. The initial process verbal of ratifications was to be drawn up once Turkey and at least three other major powers (the British Empire, France, Italy, and Japan) had deposited their instruments of ratification [9]. The Treaty would then come into effect between these High Contracting Parties, with subsequent signatories becoming bound by it upon their own ratifications [9].

Specific articles within the Treaty laid out detailed provisions regarding various aspects of the implementation. For instance, Article 7 addressed the distribution of rolling stock for divided railway lines, stipulating that such matters be settled by friendly agreement or, failing that, by arbitration [9]. Article 109 established reporting protocols for the Pilgrimage Coordination Commission, which would liaise with the League of Nations, the International Office of Public Health, and interested governments [9].

A crucial humanitarian component was the immediate repatriation of prisoners of war and interned civilians, as specified in Article 119. The exchange of these individuals between Greece and Turkey was governed by a separate agreement signed at Lausanne on January 30, 1923. Additionally, Article 120 mandated the rapid restoration of property to original owners, with compensation for third parties adversely affected by this restitution being handled by ordinary courts or specified procedures [9].

Logistical aspects of the exchange, such as the transit of travellers and goods between Greece and Turkey via the Oriental Railways, were covered under Article 12, ensuring exemption from duties, tolls, and certain formalities A Commissioner appointed by the League of Nations was tasked with overseeing the enforcement of these stipulations [9].

4-Impact on Greece

The population exchange of 1923 between Turkey and Greece had profound effects on Greek society, economy, and territorial configurations. Following the military disaster in 1922, largely attributed to the lack of support from France and the UK, Greece faced significant challenges in integrating the influx of Greek refugees from Asia Minor. This integration was primarily achieved through a large redistribution of land, which dismantled large landholdings (latifundias) and created a substantial class of small landowners who became the economic backbone of Greece for many years. However, the concept of the Megali Idea in Greek foreign policy was left unattainable, lingering more in ideological discourse than in actionable reality [10].

Economically, the influx of refugees and the subsequent land reform were double-edged swords. On one hand, the creation of small landowners spurred agricultural productivity and stabilized the rural economy; on the other hand, the country was burdened with debt, primarily to the UK, which was essential for Greece's victory in the Balkan Wars The land reform and economic restructuring marked a significant shift in the country's socioeconomic landscape. Culturally and intellectually, the population exchange had lasting repercussions.The departure of many established Greek scholars from Istanbul, along with the forced relocations, significantly impacted the intellectual and cultural life of both Greece and Turkey [3].

Diplomatically, the first official contact between Greece and the Ottoman Empire dates back to 1830, with consular relations established in 1834. A Greek embassy was opened in Istanbul in 1853 but was moved to Ankara in 1923 following the formation of the Republic of Turkey [11]. This historical diplomatic engagement underlines the long-standing and complex relationship between the two nations, which has seen periods of both cooperation and conflict.

5-Impact on Turkey

The 1923 population exchange between Turkey and Greece had profound and lasting impacts on Turkey's social, economic, and political landscape. The compulsory exchange uprooted hundreds of thousands of people from their homes, resulting in significant demographic shifts and contributing to the shaping of national identities in both countries [3].

6-Social and Cultural Consequences

The cultural and intellectual life of the towns on both sides of the Aegean was profoundly impacted by the population flow. Investigations of the effects of the trade on Asia Minor's major cities, especially Smyrna and Ayvalık, have been conducted in Turkey. After the administration of Istanbul was transferred from the Allies to the new Turkish state, the Greek community of Istanbul, which was spared from the exchange, came under intense pressure, and many prominent Greek professors left for Greece. This led to a fall in the Greek Literary Society in İstanbul, which had been a focal point of Greek intellectual activity in the last decades of the Ottoman Empire [3].

7-Economic Adjustments

Turkey faced numerous economic and financial challenges in the aftermath of the population exchange. The allocation of properties left behind by the exchanged populations did not proceed smoothly, with many properties not ending up in the hands of the intended recipients. The Mixed Commission overseeing the property allocation process failed to fulfill its prime function, leading to a lack of proper compensation schemes [3].

8-Political Repercussions

The political impact of the population exchange was deeply intertwined with Turkey's national identity and its geopolitical stance. The event marked a significant step towards consolidating the ethnic and national homogeneity of Turkey, which was crucial for the newly established Turkish Republic. The emergent official discourse in Turkey conceptualized the exchange as a favorable step toward national unity, a sentiment echoed by the political elites and scholars of the time [3].

Turkey's strained relations with Greece and its challenges with the European Union also trace back to this period. Greece's opposition to Turkey's admission to the EU, despite policy changes in the mid-1990s, and concerns over Turkey's developmental and demographic imbalances, as well as human rights issues, were perceived in Turkey as being influenced by religious biases within the EU [11].

The population exchange and its aftermath have had a lasting influence on Turkey's political landscape, shaping its relations with neighboring countries and its position in broader geopolitical contexts.

9-Reactions and Controversies

The population exchange between Turkey and Greece in 1923 elicited a wide range of reactions and controversies from various quarters. One of the most notable reactions came from Ismet Pasha, who showed a resistant attitude during negotiations to force another revision of the treaty. This ploy led to the breakdown of talks, compelling all parties to return to their respective capitals without an immediate resolution [12].

In early March 1923, a Turkish note proposed new terms addressing the unresolved financial, economic, and judicial issues. Curzon accepted these proposals but ruled out any further changes to the territorial clauses, leading to a series of expert meetings in London between 21 and 27 March 1923 to discuss the Allied criteria for settling these issues [13].

Historically, the idea of population transfer as a means to resolve conflict was accepted, albeit with significant ethical and legal concerns. The principle of voluntariness was rarely satisfied, as treaties often imposed strong moral, psychological, and economic pressures on the affected populations, despite ostensibly offering them options [5].

Over the 20th century, there was a substantial shift in the perception of international law regarding population transfer. Prior to World War II, bilateral treaties and international organizations like the League of Nations frequently backed these transfers. But the post-World War II forcible relocation of Germans from Central and Eastern Europe, approved by the Allies in the Potsdam Declaration, exposed the high human cost and logistical difficulties connected to such measures. The magnitude of these expulsions greatly worried the American and British delegations at Potsdam [5].

10-Results

The legacy of the population exchange between Turkey and Greece in 1923 is still felt today, nearly a century after the events took place. This exchange, formalized by the Treaty of Lausanne, led to significant demographic and cultural shifts in both countries, effectively changing their social fabrics and urban landscapes.

In Turkey, cities like Izmir and Istanbul commemorate the exchange with annual events that include panels, exhibitions, and symbolic reenactments. In Izmir, located across the Aegean Sea from Greece, the local municipality hosts various activities to remember the plight of past generations, reflecting on the historical impact of the exchange. Similarly, in Istanbul's Büyükçekmece district, commemorative events include actors in period costumes, photo exhibitions, and ceremonial flower offerings at the sea, marking the departure points of those who were exchanged [6].

The remembrance activities serve as a national mourning process, recognizing the hardships and emotional toll on those who were forced to leave their homes [14].

These commemorations also provide a platform for contemporary discussions on ethnic homogenization and its consequences, allowing society to reflect on historical grievances and their modern-day implications [15].

The population exchange is also studied and discussed in academic and cultural contexts. Exhibits like those created by the University of Michigan Library highlight the complex outcomes of the Treaty of Lausanne, offering an in-depth analysis of how the exchange shaped the nation-building processes of both Greece and Turkey [15]. Scholars emphasize the importance of understanding these events to grasp the broader historical narratives of nationalism and ethnic conflict [16].

Moreover, the cultural heritage left behind by the exchanged populations continues to be a subject of interest. Architectural expressions and urban transformations in places like Northern Greece reveal the long-lasting impact of these demographic shifts on the region's spatial planning and built environment [17]. These transformations are often studied to understand the broader implications of population transfers on urban development and cultural heritage preservation.

The legacy of the Greco-Turkish population exchange remains a poignant reminder of the human cost of political decisions and the enduring importance of cultural memory in shaping national identities.

References

[1] Greco-Turkish War (1919–1922). Son erişim tarihi: 20.07.2024, Erişim adresi: https://www.hellenicaworld.com/Greece/History/en/GrecoTurkishWar19191922.html#google_vignette

[2] 1923 population exchange between Greece and Turkey. Son erişim tarihi: 20.06.2024, Erişim adresi: https://albanianstudies.weebly.com/population-exchange.html

[3] Yıldırım, O. (2023). New Critical Approaches to the Greek-Turkish Population Exchange: Introduction. Turkish Historical Review, 14(2-3), 145-152. https://doi.org/10.1163/18775462-14020001

[4] In Turkey and Greece, the legacy of the 1923 'population exchange' lives on in the memories of descendants. Son erişim tarihi: 10.06.2024, Erişim adresi: https://theworld.org/segments/2024/04/04/in-turkey-and-greece-the-legacy-of-the-1923-population-exchange-lives-on-in-the-memories-of-descendants

[5] Population Redistribution and Development in South Asia. Springer Science & Business Media. 2012. p. 6. ISBN 978-9400953093. Retrieved 7 September 2017.

[6] Descendants remember Greek-Turkish population exchange. Son erişim tarihi: 15.07.2024, Erişim adresi:https://www.dailysabah.com/turkey/descendants-remember-greek-turkish-population-exchange/news

[7] Kritikos, Giorgos (1999). "Motives for compulsory population exchange in the aftermath of the Greek-Turkish War: (1922-1923)". Bulletin of the Centre for Asia Minor Studies. 13 (13): 212.

[8] Exchange of Greek and Turkish Populations. Son erişim tarihi: 25.07.2024, Erişim adresi:https://jusmundi.com/en/document/decision/en-exchange-of-greek-and-turkish-populations-advisory-opinion-saturday-21st-february-1925#decision_1866

[9] Treaty of Peace with Turkey Signed at Lausanne, July 24, 1923, The Treaties of Peace 1919-1923, Vol. II Son erişim tarihi: 25.06.2024, Erişim adresi: https://wwi.lib.byu.edu/index.php/Treaty_of_Lausanne

[10] Megali Idea" and Greek Irredentism in the Wars for a Greater Greece, 1912–1923. Son erişim tarihi: 26.07.2024, Erişim adresi:https://global-politics.eu/megali-idea-greek-irredentism-1912-1923/

[11] SERT, Deniz Ş.; TRAVLOS, Konstantinos (2018). "Making a Case over Greco-Turkish Rivalry: Major Power Linkages and Rivalry Strength". Uluslararası İlişkiler / International Relations. 15 (59): 105–127. doi:10.33458/uidergisi.525071. ISSN 1304-7310. JSTOR 26605022. S2CID 188677490.

[12] Hanioglu, M. Sukru (2008). A Brief History of the Late Ottoman Empire. Princeton University Press.

[13] Fromkin, David. 1989. A peace to end all peace: creating the modern Middle East,

1914-1922. New York, NY: H. Holt. ISBN 9780805008579.

[14] The Death of a Dream: Developing a Modern Greek Identity. Son erişim tarihi: 10.05.2024, Erişim adresi: https://apps.lib.umich.edu/online-exhibits/exhibits/show/greco-turkish-war/national

[15] Nation Building and the Lives It Changed Forever: A Reflection on the 100th Anniversary of the Greco-Turkish War. Son erişim tarihi: 14.06.2024, Erişim adresi https://apps.lib.umich.edu/online-exhibits/exhibits/show/greco-turkish-war

[16] The Greco-Turkish War. Son erişim tarihi: 05.07.2024, Erişim adresi https://origins.osu.edu/milestones/may-2019-greco-turkish-war-smyrna-sakarya-kemal-ottoman?language_content_entity=en

[17] Monioudi-Gavala, D. (2019) Rebuilding Greece, 1830-1920. Ambitions and Realities. Advances in Historical Studies, 8, 199-214. doi: 10.4236/ahs.2019.85015.

Chapter 3

WHY IS PHYSICS STILL DESCRIBED AS DIFFICULT IN THE 21ST CENTURY?

Imran ORAL[1]

Nilufer CERIT BERBER[2]

1 Necmettin Erbakan University, Türkiye
oralimran@erbakan.edu.tr
https://orcid.org/0000-0002-5299-5068
2 Necmettin Erbakan University, Türkiye
ncberber@erbakan.edu.tr
https://orcid.org/0000-0002-8458-7181

INTRODUCTION

Physics is essential for understanding the events that happen around us. Many of the situations we face in our everyday lives are connected to principles of physics (Angell et al., 2004; Ornek et al., 2008). Forexample, walking, eating, carrying anything, all kind of electronics, optical tools, vehicles, planes, ships, spaceships, space, earth, planets, communication tools, micro and makro world etc., whole of these, and their working princples are related with physics laws. Thus, this highlights the significance of physics education. It's crucial for future physics educators to have a strong grasp of the subject.

As a foundational science, physics is vital for propelling a country toward a knowledge-based economy and enhancing its competitiveness in the 21st century. It's crucial not to let physics be sidelined; in fact, it may require even greater emphasis than other scientific fields, as it serves as the fundamental language of technology and engineering. Over the past 60 years, societies around the world have become increasingly dependent on science and technology. However, public perceptions of science have been declining during this period. This negative attitude among students towards physics and a broader disinterest in science have resulted in low enrollment in high school physics classes, which in turn affects university physics courses and degrees in the physical sciences.

In recent years, it can be stated that the enrollment of students in physics programs at the tertiary level in developed countries (such as USA, Germany, Ireland, Mexico, Netherland, England, Australia, Northern Ireland, and South Korea) (Hill & Johnson, 2004; Lyons, 2006; OECD, 2006; Physics, 2001; Sheila & Frans, 1999).

Physicists play a crucial role in helping a country advance economically, as their skills in innovation, problem-solving, and critical thinking are highly valued (Smith, 2008). Low enrollment in university physics programs will directly impact the development of technological expertise in a country. This could lead to significant shortages of industrial talent, technology-focused scientists, and qualified physics educators, all of which would have adverse effects on the nation's economy.

In the related literature, it has been shown that one of the reasons for low success in physics, is related with attitudes towards physics. Students' attitudes toward science are influenced by their real-world experiences, as well as by their parents, peers, teachers, and the media. These attitudes affect their expectations for university science courses, their approach to learning science, and their views on science careers(Redish et al., 1998). Research on the link between students' attitudes toward science and their academic achievement extends beyond just high school and undergraduate populations. For instance, Singh and Mason (2009) found that graduate students' attitudes toward science can significantly impact their problem-solving strategies as well.Therefore investigating the main reasons what cause this situation is so important.

Web Based Discussion Forums

Online discussion forums are widely utilized asynchronous communication tools within Learning Management Systems (de Lima et al., 2019). Individuals generate new knowledge while collaborating in an asynchronous online environment(Gilbert & Dabbagh, 2005). Therefore, an effective educational forum is an important tool for contributing to the learning process, facilitating the exchange of information and perspectives, and connecting students with one another(Benbunan-Fich & Hiltz, 1999). Online forums play a crucial role as one of the many effective communication methods on the Internet. They provide a space for people worldwide to share their opinions and discuss various topics. One of the key advantages of these online message boards is their accessibility to a large and diverse audience. Meanwhile, Facebook, Youtube and Twitter can be defined as the most popular social media forums too. These big players of social media are advancing as the digital age continues to grow and flourish. Many people have Facebook pages, Youtube and Twitter accounts, to make their advertisements and share their ideas to a very big audience. Because these pages are extremely popular and frequently visited. There are some of the benefits of joining Internet forums. Just look at the following benefits: Free Knowledge, Cost Saving, Mentorship, Advertising products and Early Guidance. These examples coud be increased. Additionally, online discussion forums provide numerous pedagogical benefits aligned with the principles of social constructivism. Their asynchronous, text-based format fosters reflection, analysis, and higher-order thinking. These forums are particularly valuable for expressing and exploring a variety of perspectives on a wide range of topics.

Participants of on-line discussion forums can easily share their ideas about any topic without any fear, worry and anxiety. Therefore, it can be said that sometimes the data obtained from on-line discussion forums is more reliable than the data obtained through surveys, interviews or observations. Because of that the possibility of objectively answering the questions of the survey will be poor if the individuals participating in scientific study are not awarded with a positive reinforcement like some money, any gifts, marks etc. For this reason, the reliability of the survey results will be reduced.

The members of discussion forums participate in discussion forums by their own desire, so they share their ideas about various topics. So, it is believed that the data obtained from online discussion forums will be more reliable. Because of this expectation in this study physics forums were used to learn the main reason what make physics difficult in the 21st century.

The Problems of Physics Education at 21 st Century

Whole of us had heard how hard physics was or is. Is it really, right? What makes this? Various studies have highlighted that students experience difficulties in physics classes (Christopher et al., 2003; Gebbels et al., 2010; Ornek et al., 2008; Politis et al., 2007; van der Veen, 2012; Xu et al., 2012). According to study was done by Angell et al. (2004), students perceive physics as challenging due to the need to simultaneously engage with various representations, including experiments, formulas, graphs, and conceptual explanations. Similar to the study conducted by Angell et al. (2004), the study by Bray and Williams (2020) determined the perceptions of first-year physics students at Rhodes University towards physics. Within the scope of the study, a questionnaire was created by interviewing the academicians in the department and this questionnaire was applied to the first-year students. According to the results of the study, it was determined that there was a high relationship between study skills and students' comprehension and problem-solving abilities, while emotional problems affected the students' perception of physics the most. In the study conducted by Bray and Williams (2020), four important main factors (Subjet Domain, Affective Doamin, Conitive Domain, and Study Skills) affecting students' physics learning and the sub-factors related to these main factors are seen in Figure-1.

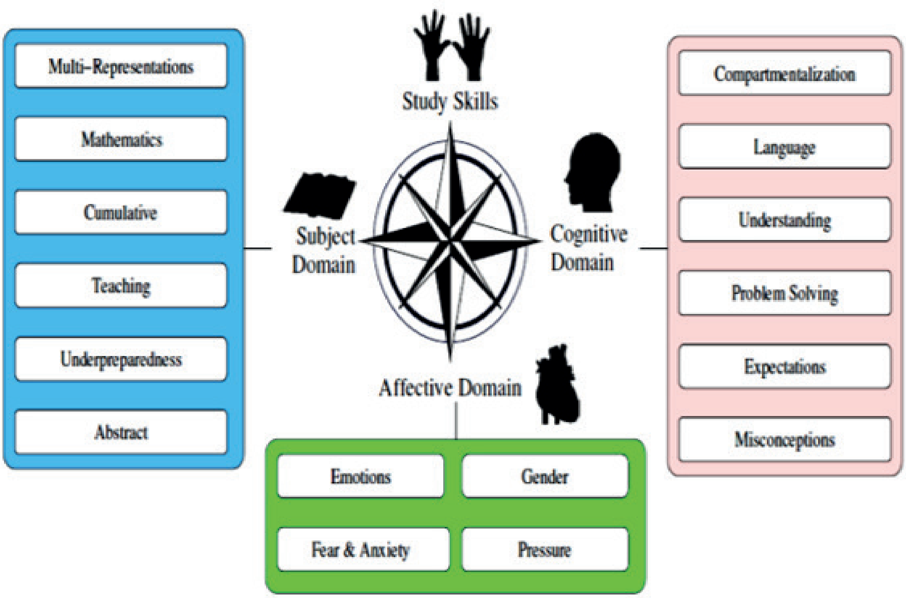

Figure1. *Main factors affecting students' physics learning and the sub-factors related to these main factors (Bray & Williams, 2020)*

According to a study conducted by Oon and Subramaniam (2011) in Singapore, physics teachers believe that students have a bias that physics is difficult. Students perceive the subject as too abstract to grasp. Research involving secondary school students in the UK by Barmby and Defty (2006) indicated that students generally prefer chemistry and biology over physics. The findings suggested that this preference stems from students having lower expectations of their ability to succeed in physics tasks, which may reflect their existing biases. Also, Spall et al. (2004) reported that in England and Wales physics is much less popular than biology. One of the forehead experts of physics education Redish had explained the reason, why students define physics as difficult, as given below:

> *"Physics as a discipline requires learners to employ a variety of methods of understanding, and to translate from one to the other--words, tables of numbers, graphs, equations, diagrams, maps. Physics requires the ability to use algebra and geometry and to go from the specific to the general and back. This makes learning physics particularly difficult for many students" (Redish, 1994).*

Physics educators—such as lecturers, teaching assistants, faculty members, and teachers—should be aware of students' perceptions regarding physics courses, as they are also responsible for their learning. Additionally, educators need to recognize how their views differ from those of their students. This understanding can help them grasp the reasons behind students' difficulties in physics. Otherwise, as Carter and Brickhouse (1989) note, "students, faculty, and teaching assistants will live in different worlds and it will be difficult to communicate because they speak different languages". Gathering students' perspectives on their challenges with physics can offer valuable insights for course instructors. This information can help them design the curriculum, select appropriate textbooks, and implement teaching strategies that reduce students' difficulties in understanding and learning physics. Also, Carter and Brickhouse (1989) had stated that, faculty perceptions of difficulties also impact their choices regarding the curriculum, its implementation, and the evaluation methods used in physics courses.

We think that education is a process which includes teaching staff, school staff, parents, educational environment and pupils. We also believe that students' own insights can play a crucial role for physics educators. Therefore, in this study we tried to learn the opinions of physics pupils and lecturers from Physics Education Department at Necmettin Erbakan University, and on-line physics forums' members from different countries on all over the World, to find out the reasons of difficulties in physics courses and solutions to overcome these difficulties.

MATERIALS AND METHODS

Research Design

The triangulation method also known as "mixed method" research is used in this study. Triangulation is generally a method used to enhance the validity and reliability of research or the evaluation of findings (Golafshani, 2003). Triangulation involves combining multiple research methods to examine a single topic. These methods may overlap, sometimes complementing each other and at other times presenting contrasting perspectives. This approach helps to balance the strengths and weaknesses of each method, resulting in richer and, ideally, more accurate findings.

There are five types of triangulation: data triangulation, investigator triangulation, theory triangulation, methodological triangulation, and environmental triangulation (Guion et al., 2011). Methodological triangulation, which involves employing various qualitative and/or quantitative methods to examine the program, was utilized in this study. Therefore surveys, interviews and scanning on-line physics forums methods were used as methodological triangulation. The benefits of triangulation include "boosting confidence in research data, fostering innovative methods of understanding a phenomenon, uncovering unique insights, challenging or integrating theories, and offering a clearer comprehension of the issue"(Thurmond, 2001). These advantages primarily arise from the variety and volume of data available for analysis.

The Sample

The sample of the study was included 136 physics undergraduate pupils (64 females and 72 males) from Türkiye, 5 Physics lecturers and 129 persons from the on-line physics forums. Table 1 provides more detailed information about the sample of study.

Table1. *Detailed information related to the physics undergraduate pupils*

Variables	Groups	Frequency	Percent (%)
Gender	**Female**	64	47.1
	Male	72	52.9

It can be seen that 52,9 % (72 pupils) of the physics undergraduate pupils who contributed their views to our study were male while 47,1% (64 pupils) were female.

Data Collection

The data of this study were collected in a three steps way. At first step, we administered a survey which has 9 questions related with physics and physics subjects to 136 undergraduate pupils from Türkiye. The survey contained nine closed questions. The closed questions had a common format with a Likert scale from 1 to 5. At the second step, we conducted interviews with 5 pupils who were selected randomly. We asked pupils, If they like introductory physics or not? And "Why do they like it or not?"

On the other hand, we made interviews with 5 physics lecturers, and asked them "What makes physics difficult?" We recorded the responses of both pupils and lecturers. After the interviews, we wrote the responses of pupils and lecturers. At the third step, we tried to find the answer of "What makes physics difficult?" by a scanning of on-line physics forums by using searching engines like Google, Yahoo, Yandex and Bing. After this on-line scanning, we separated the most common replies into eight categories which were given in Figure1.

Data Analysis

Descriptive statistics, using SPSS version 22, were used to evaluate the datas obtained from the participants of study. Responses to closed questions were analyzed quantitatively using the statistics program SPSS. The responses from interviews and the scanning of online physics forums were categorized, coded, and then analyzed statistically, as described earlier. After on-line scanning of Physics Forums, we selected some examples from the responses of on-line physics forums' members which were given in Table 11.

RESULTS

In this part of the study, the data collected by survey from 136 physics undergraduate students were presented and commented.

Results of Survey

Undergraduate physics students were asked to indicate their level of agreement with several statements regarding physics. Physics undergraduate pupils' responses are given in Table2.

Table2. *Physics undergraduate pupils' degree of agreement to various statements about physics.*

	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	f	%	f	%	f	%	f	%	f	%
Physics is difficult.	11	8,1	18	13,2	8	5,9	69	50,7	30	22,1
Physics is interesting.	0	0	0	0	7	5,1	62	45,6	67	49,3
Physics requires work.	0	0	3	2,2	3	2,2	40	29,4	90	66,2
Physics should be taught well.	1	,7			4	2,9	35	25,7	96	70,6
Physics science is only for most capable persons.	3	2,2	19	14,0	26	19,1	45	33,1	43	31,6

Physics is required to understand the world	1	,7	4	2,9	8	5,9	56	41,2	67	49,3
Physics is necessary to understand everyday phenomena.	2	1,5	3	2,2	16	11,8	53	39,0	62	45,6
Experiments are important in physics.	2	1,5	3	2,2	2	1,5	48	35,3	81	59,6

**It indicates total percentage of agree+strongly agree*

As seen from Table 2, All physics pupils mostly agree that physics is difficult (72,8 %*). Also, a big number of physics pupils agree that physics should be taught well (96,3 %*), requires to work (95,6 %*), interesting (94,9 %*), is about understanding the world (90,5 %*), and everyday phenomena (84,6 %*) and experiments are important in physics (94,9 % *).

As seen from these results, according to physics undergratuate students; Physics is difficult and requires working hard so it should be taught well. But it is interesting, and it is necessary to understand everyday phenomena. Similar findings have been reported in study was done by Brian (1994). Osborne and Collins (2001) discovered that British 16-year-olds highlighted the significance of science in comprehending the world and explaining concepts to others. Dolin (2002) argued that physics seems challenging because it demands that students handle various forms of representation—such as experiments, graphs, mathematical symbols, and verbal descriptions—simultaneously, and manage the transitions between them. Additionally, Carlone (2003) and van der Veen (2007) also addressed the prevalent traditional perception of physics as difficult, intimidating, and objective.

Physics undergraduate pupils were asked to rate various aspects that might pose problems to pupils in physics courses and Pupils responses were given in Table 3 below.

Table 3. *Physics undergraduate pupils' ratings regarded what might pose problems in physics courses to them.*

	Non problematic		Slightly problematic		Neutral		Problematic		Very Problematic	
	f	%	f	%	f	%	f	%	f	%
Many new concepts	1	,7	12	8,8	21	15,4	60	44,1	42	30,9
Using laws in solving problems	7	5,1	20	14,7	15	11,0	61	44,9	33	24,3
Using mathematics to describe physical phenomena.	5	3,7	25	18,4	19	14,0	47	34,6	40	29,4
Using mathematics in solving problems	6	4,4	29	21,3	13	9,6	49	36,0	39	28,7

Fast progression in Physics course	9	6,6	26	19,1	32	23,5	41	30,1	28	20,6
Extensive curriculum	5	3,7	20	14,7	18	13,2	56	41,2	37	27,2
Doing experiments	27	19,9	33	24,3	16	11,8	36	26,5	24	17,6
Seeing connections to everyday life	24	17,6	38	27,9	11	8,1	33	24,3	30	22,1

**It indicates total percentage of problematic+very problematic*

Table 3 shows that many new concepts (75,0 %*), using laws in solving problems (69,2 % *), and extensive curriculum (68,4 %*) are what pupils see as the main problems. Also, using mathematics to describe physical phenomena (64.0 %*) and in solving problems (64,7 %*) were also rated as aspects which are problematic in physics as well.

It appears to be a common issue that teachers express concerns about the mathematical skills of physics students (EVA, 2001; Gill, 1999; Neuschatz & McFarling, 1999) and inadequate preparation in mathematics is recognized as a challenge in higher education, particularly in science and engineering (Orton & Roper, 2000). However, the students in our study did not perceive a lack of mathematical skills as a significant problem in their physics studies. Faculty members and teaching assistants agree that a solid mathematics background is essential for learning physics. They believe that strong mathematical skills are necessary to grasp the subject. In contrast, students feel that lacking a strong foundation in mathematics does not necessarily make physics difficult (Ornek et al., 2008). As indicated by the results above, students in our study did not perceive a lack of mathematical skills as a primary issue in their physics studies. This result is similar to results of Angell et al. (2004).

In the survey, undergraduate physics students were asked to express their interest in various topics from the curriculum, as well as their enthusiasm for experimental work and the historical and philosophical aspects of physics. The percentage rating of pupils about physics topics was given in Table 4.

Table 4. *The percentage rating of undergraduates about physics topics.*

	Not interesting		Slightly interesting		Neutral		Interesting		Very Interesting	
	f	%	f	%	f	%	f	%	f	%
Astrophysics	3	2,2	8	5,9	38	27,9	36	26,5	51	37,5
Quantum physics	5	3,7	6	4,4	13	9,6	32	23,5	80	58,8
Relativity	3	2,2	7	5,1	18	13,2	42	30,9	66	48,5
Electromagnetism	12	8,8	20	14,7	26	19,1	52	38,2	26	19,1
Thermo physics	13	9,6	21	15,4	46	33,8	37	27,2	19	14,0
Atomic and nuclear physics	6	4,4	6	4,4	27	19,9	42	30,9	55	40,4
Electricity	4	2,9	22	16,2	36	26,5	50	36,8	24	17,6
Light and waves	5	3,7	14	10,3	33	24,3	48	35,3	36	26,5
Force and motion	9	6,6	30	22,1	30	22,1	43	31,6	24	17,6
Experiments	3	2,2	13	9,6	31	22,8	40	29,4	49	36,0
Physics history and philosophy	21	15,4	14	10,3	26	19,1	35	25,7	40	29,4

As seen from Table 4, It is significant that 15,4 % of pupils had not found physics history and its philosophy interesting. Also, there is a big ratio of pupils who have not found Thermophysics (9,6%) and Electromagnetism (8,8%) subjects which are very important in our daily life as interesting. Meanwhile, Quantum physics (58,8 %), Relativity (48,5 %) and Atomic, and Nuclear Physics (40,4 %) scored highest of all. Likewise, astronomy and space were found to evoke widespread enthusiasm among British 16-year-olds (Osborne & Collins, 2001).

In the survey, Physics undergraduate pupils were asked to rate the importance of various aspects of physics. Pupils' responses were given in Table 5.

Table 5. *Undergraduates' evaluations regarding the significance of different aspects of physics.*

	Not important		Slightly important		Neutral		Important		Very important	
	f	%	f	%	f	%	f	%	f	%
Doing calculations from basic laws	1	,7	3	2,2	17	12,5	60	44,1	55	40,4
Understanding everyday phenomena	0	0	3	2,2	13	9,6	60	44,1	60	44,1
Learning to use measuring equipments	2	1,5	3	2,2	19	14,0	60	44,1	52	38,2
Understanding everyday technology	2	1,5	3	2,2	11	8,1	51	37,5	69	50,7

Experiencing exciting experiments	2	1,5	4	2,9	18	13,2	46	33,8	66	48,5
Getting to know the history of science	6	4,4	14	10,3	34	25,0	42	30,9	40	29,4
Forming opinions about nuclear power etc.	1	,7	8	5,9	16	11,8	54	39,7	57	41,9
Understanding the world	1	,7	4	2,9	8	5,9	58	42,6	65	47,8

Table 5 displays the frequency of various categories of responses to this open question from those who participated. Students highly rated aspects related to understanding the world and everyday phenomena. These results are the same of Angell et al. (2004).

In the survey, pupils were asked what they saw as most characteristic of physics as a subject. The responses to this question were given in Table 6 below.

Table6. *Responses regarding what physics students consider to be the most defining characteristics of the subject*

	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	f	%	f	%	f	%	f	%	f	%
Formulas, laws, calculations, mathematic	2	1,5	5	3,7	23	16,9	52	38,2	54	39,7
Experiments	2	1,5	4	2,9	14	10,3	63	46,3	53	38,9
Explaining the world	1	,7	4	2,9	24	17,6	46	33,8	61	44,9
Interesting	1	,7	6	4,4	16	11,8	50	36,8	63	46,3
Requirement	4	2,9	3	2,2	23	16,9	56	41,2	50	36,8
Difficult	5	3,7	18	13,2	29	21,3	48	35,3	36	26,5

**It indicates total percentage of agree+strongly agree*

According to Table 6 results, it seems that experiments are seen as the most characteristic in physics courses. Because 85,2* % of pupils have chosen experiments as an aspect what they see as most characteristic of physics. Another important result from Table6 is that 61,8*% of pupils see physics as difficult. This result is significant because all the pupils who participated in this study are going to be physics teachers. As we know each of these pupils are the candidates for physics teaching. They will affect their pupils' opinions about physics courses, negatively.

To gain insight into the dynamics of an average physics classroom and students' perceptions, the survey included a question asking students to indicate how often various teaching strategies were utilized in their current physics course. Additionally, students were asked to specify how frequently they would prefer these strategies to be implemented if given the choice. The pupils' responses to these questions were given below in Table 7.

Table 7. *Students' descriptions of what occurs in the physics classroom ("how it is") compared to what they would like to see happen ("what students wish")*

		Never		Rarely		Moderate		Often		Very often	
		f	%	f	%	f	%	f	%	f	%
Teacher presents new material on blackboard	How it is			2	1,5	15	11,0	47	34,6	72	52,9
	What pupils wish	1	,7	1	,7	14	10,3	48	35,3	72	52,9
Teacher demonstrates problem-solving on blackboard	How it is			1	,7	24	17,6	49	36,0	62	45,6
	What pupils wish	1	,7	2	1,5	12	8,8	52	38,2	69	50,7
Emphasis on mathematical presentation of concepts	How it is	1	,7	7	5,1	19	14,0	59	43,4	50	36,8
	What pupils wish			8	5,9	16	11,8	56	41,2	56	41,2
Emphasis on qualitative presentation of concepts	How it is	3	2,2	8	5,9	38	27,9	57	41,9	30	22,1
	What pupils wish			2	1,5	15	11,0	61	44,9	58	42,6
Use pupils' suggestions in instruction	How it is	24	17,6	40	29,4	31	22,8	31	22,8	10	7,4
	What pupils wish	1	,7	6	4,4	7	5,1	48	35,3	74	54,4
Demonstration to illustrate concepts/ phenomena	How it is	5	3,7	17	12,5	38	27,9	53	39,0	23	16,9
	What pupils wish	2	1,5			7	5,1	47	34,6	80	58,8
Experiments: cookbook	How it is	17	12,5	19	14,0	25	18,4	44	32,4	31	22,8
	What pupils wish	48	35,3	23	16,9	22	16,2	24	17,6	19	14,0
Experiments: Pupils choose problems and method	How it is	49	36,0	44	32,4	12	8,8	18	13,2	13	9,5
	What pupils wish			10	7,4	33	24,3	51	37,5	42	30,9
Discuss difficult problems/ concepts in class	How it is	19	14,0	49	36,0	31	22,8	25	18,4	12	8,8
	What pupils wish	1	,7			13	9,6	51	37,5	71	52,2
Discuss difficult problems/concepts in groups	How it is	18	13,2	37	27,2	32	23,5	35	25,7	14	10,3
	What pupils wish	5	3,7	4	2,9	26	19,1	44	32,4	57	41,9
Work with physics problems individually	How it is	5	3,7	15	11,0	36	26,5	55	40,4	25	18,4
	What pupils wish	12	8,8	19	14,0	32	23,5	35	25,7	38	27,9
Work with physics problems in groups	How it is	12	8,8	27	19,9	46	33,8	36	26,5	15	11,0
	What pupils wish	9	6,6	11	8,1	23	16,9	51	37,5	42	30,9
Use project work	How it is	21	15,4	38	27,9	25	18,4	30	22,1	22	16,1
	What pupils wish	4	2,9	2	1,5	19	14,0	47	34,6	64	47,1
Use other books in addition to coursebook	How it is	14	10,3	27	19,9	25	18,4	38	27,9	32	23,5
	What pupils wish	5	3,7	4	2,9	15	11,0	39	28,7	73	53,7

As seen from Table 7, There are important results related what happens in the physics classrooms and what pupils wish. As a summary of the results above it can be stated that the lecturers only use traditional teaching methods. However, from the results above, pupils do not only want to use these traditional teaching methods. When "how it is" and "what pupils wish" results compared to each other. It is seen easily that They want lecturers to use student centered teaching methods.

According to Table 7. If the results of what happens in physics courses are compared with results of what pupils wish, it will be seen that using pupils' suggestions in instruction, demonstration to illustrate concepts/phenomena and using project work are very insufficient and explaining experiments like cookbook is not a situation desired by pupils.

To determine if the instructional methods in physics classrooms differ from those used in other subjects, students were asked to respond to a question about how frequently lecturers present new material on the blackboard in their area of specialization, as well as how often they would prefer this to occur. All data related to this question were given in Table8 below.

Table8. *Physics undergraduate students' views on the way instructors conduct their different courses and their expectations.*

		Never		Rarely		Moderate		Often		Very often	
		f	%	f	%	f	%	f	%	f	%
Physics	How it is	4	2,9	6	4,4	14	10,3	43	31,6	69	50,7
	What pupils wish	3	2,2	0	0	10	7,4	29	21,3	94	69,1
Chemistry	How it is	5	3,7	17	12,5	29	21,3	39	28,7	46	33,8
	What pupils wish	3	2,2	6	4,4	21	15,4	38	27,9	68	50,0
Biology	How it is	11	8,1	27	19,9	30	22,1	36	26,5	32	23,5
	What pupils wish	7	5,1	13	9,6	22	16,2	39	28,7	55	40,4
Mathematic	How it is	10	7,4	22	16,2	13	9,6	36	26,5	55	40,4
	What pupils wish	5	3,7	14	10,3	12	8,8	35	25,7	70	51,5
Social sciences	How it is	35	25,7	49	36,0	17	12,5	29	21,3	6	4,4
	What pupils wish	21	15,4	34	25,0	30	22,1	26	19,1	25	18,4
English	How it is	33	24,3	29	21,3	34	25,0	29	21,3	11	8,1
	What pupils wish	19	14,0	21	15,4	24	17,6	38	27,9	34	25,0

**It indicates total percentage of often+very often*

As seen from Table 8, According to students, the method of "lecturers presenting new material at the blackboard" is used more frequently in the natural sciences (excluding biology) than in English or social sciences. Also, the method "lecturers present new material at the blackboard" is used mostly in Physics courses (82.3%*).

Results of Interviews with Undergraduate Students and Physics Lecturers

As, it was stated before at the second step of this study an interviewing process was done with 5 undergraduate pupils and 5 lecturers who were selected randomly from the Physics Education Department of Necmettin Erbakan University. In the first step of the study, it was found that most pupils define physics courses as a difficult course. It is interesting that pupils who have chosen physics department by their own desire describe physics as a difficult course (Table 2 and Table 6). Because of this, we taught that maybe physics pupils do not like physics, and this causes them to define physics as difficult.

For learning whether physics pupils like physics courses or not. One pupil was randomly selected from each grade and an interview was conducted with each pupil for ten minutes and these interviews were recorded. The pupils were asked the question "Do they like physics or not? And why do they like or not?"

On the other hand, to learn lecturers' opinions about "why pupils do define physics as difficut", five physics lecturers were asked the question "What makes physics difficult to pupils? The answers of both pupils and lecturers were recorded and the data of these 10-minute interviews were given in Table 9 and Table 10 below.

Table9: *The responses of five pupils to the question "Do they like physics or not?" And "Why do they like or not?"*

Pupil's grade	Answer
Grade 1	*Yes. I like physics courses. Because physics teaches events happening in the world by causation and physics makes life easier. It helps us to understand the environment around us.*
Grade 2	*Yes. I like physics courses. The rigor results in physics and experiments make physics easy and understandable. I know that a lot of events around us in our daily life are related to physics, so this makes physics attractive to me. I learn a lot of events' reasons in physics course so I can understand a lot of events around me which I can see in my daily life like light, electricity, motion laws, gravity, momentum, optical subjects vs. For example, after I learnt angular momentum, I learnt also why a figure skater closes to her arms when she wants to make faster cycles.*
Grade 3	*Yes. I like physics courses. Because joining physics courses and learning new information is a pleasure for me. I think physics is everywhere. I follow physics courses not only as a course which I must participate in also as life school which teaches us a lot of information about daily life.*

Grade 4	*Yes. Because it is a numerical and logical course I like physics courses. We can see physics at every part of our life. By learning new things in physics, I can understand my environment better and see the reason of differences around me. However, I think in our country the attention being given to physics and physicists is not enough. If we take care of physics and physicist more we can be a powerful country in the world.*

As it is seen in Table 9, all the physics undergraduate pupils like physics. They are aware of daily life events that occur around them and the relationship with physics. So, this awareness causes them to love physics. This is an expected result because all the pupils were members of the physics department and had chosen the physics department by their own desires. This means that the reason "why they define physics difficult" is not related with their attitude towards physics course.

Table10: *The responses of five lecturers to the question "What makes physics difficult?"*

Lecturers	Answer
Lecturer 1	*There are various reasons that make physics courses dislike and difficult. For example:* - *if students do not have mental competence* - *if students do not like their physics lecturer* - *if physics subjects are not taught according to students' mental competence level.* - *If it is not mentioned the relationship between physics subjects and daily life.* - *If he could not understand the importance of physics in his life.* - *If the wrong bias about physics is a very hard course that can affect their thinking about physics.* - *If the teaching process does not support by experiment sufficiently.*
Lecturer 2	*I think the most important reason that makes physics difficult for students is not having sufficient mathematical basement. The other reason is the lecturers who know physics well but could not know how to teach physics well. The other important reason is that they could not transfer the physics knowledge to their daily life and could not make a relationship with their daily life. Because of these reasons physics and its instructor have become frightful for students. After this They will not like physics and want to participate to physics courses too.*
Lecturer 3	*I think the main reason that makes physics difficult for students is mathematics. If the students have not got a sufficient mathematic basement, they could not solve any physics problems. They can explain the solving way but because of the insufficient mathematic knowledge They will not not solve the physics problems. Therefore, they believe that physics is a difficult course. The other important reason is the lecturers because that I experienced many times that the students sayt: "our physics lecturers do not know how to teach or the right way to transfer the physics knowledge to us. They say: Some of their lecturers do not make a good communication with us". Therefore, I think the most important problem is incompetent physics lecturers. They can make physics courses likeable or not likeable.*

Lecturer 4	*There are various reasons that make physics courses dislike and difficult.* - *The lecturers' negative behaviour towards students.* - *Giving the lecture without physical examples related to subject.* - *The lecturers do not transfer the physics subject to real life without explaining the relationship between physics subjects and application of that subject in their daily life.* - *The extensive curriculum and the scarcity of weekly physics course hours.* - *The participation of pupils in physics courses just for getting enough grades to pass it.*
Lecturer 5	*According to me, the main reason that makes physics so difficult to students is that they do not understand it because of the bias related with physics which comes from their background of physics. First, meeting a student with physics is so important. If student's teacher helped him to understand physics That student will like it. Unfortunately, if Studenetl had a bad experience at first meeting and could not understand it then Physics and Its instructor will be frightful for him. After this, Student will not like physics and want to participate to physics courses too.*

From the summary of Table10, it can be stated that according to physics lecturers the main reasons makes physics difficult are physics educators insufficient teaching talent and communication with their pupils, insufficient mathematics basement and the wrong bias related with physics.

Results Related with Opinions of On-Line Physics Forums' Members

As it is stated before, on-line forums are important because they are one of the various effective forms of communication on the Internet. This is where people from around the world share opinions and discuss their thoughts about anything. There are a lot of benefits (Free Knowledge, Cost Saving, Early Guidance and many pedagogical advantages etc.) of joining Internet forums. One of the most important benefits is that participants of on-line discussion forums can easily share their ideas about any topic without any fear, worry or anxiety. Therefore, it can be said that sometimes the data obtained from on-line discussion forums is more reliable than the data obtained through surveys, interviews or observations. Because of this idea for improving the reliability of this study, for supporting the survey and interviews' results, we tried to make a scan of physics forums to learn the reasons "What makes physics difficult?"

When we made a scanning about this question from most popular search engines like Google, Yahoo, Yandex and Bing. We reached a lot of physics forums which had opened discussion topics as "what makes physics difficult?", "Why do you think physics is so hard?" or "Do you believe that physics is so hard?" etc. After the scanning of these forums, we reached to 129 peoples who had joined the discussion about "What makes physics difficult?" After then, the responses to these questions were categorized and the responses' summary was given in Figure2 below.

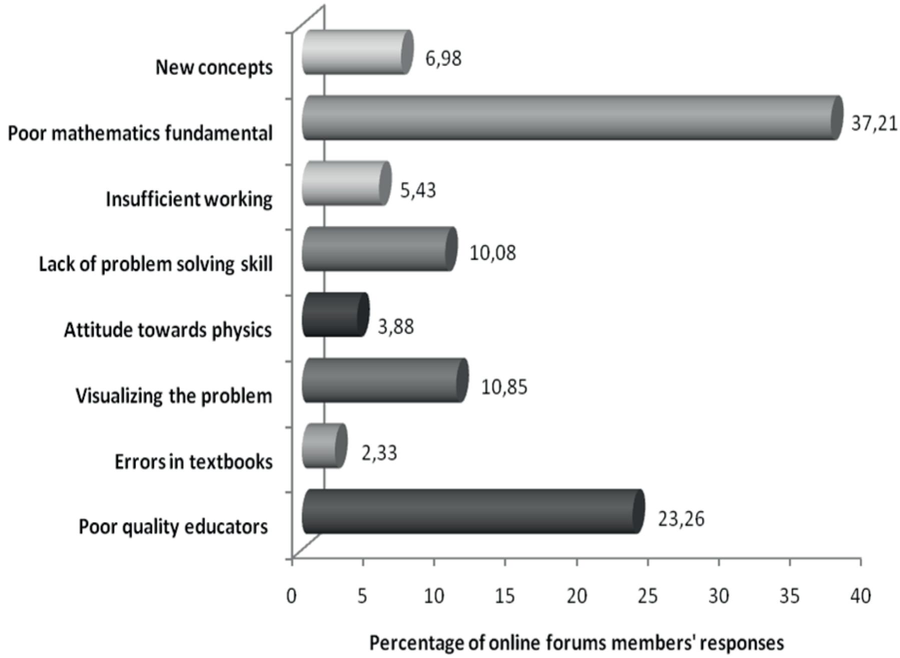

Figure 2. *Categorized responses' summary of on-line forums' peoples.*

As is seen from Figure 2, The poor mathematics fundemental (37.21 %), poor quality educators (23.26%), visualizing the problem (10.85%) and lack of problem-solving skill (10.08%) are stated as the main reasons that makes physics difficult to physics forums members.

From the on-line forums scanning, it is found that according to physics forums members there are different kinds of reasons that make physics difficult. Some examples of these reasons were explained as given by on-line physics forums' members in Table11 below.

Table11: *Some answers of on-line forums' members related with "What makes physics difficult?"*

Occupation of online forum members	*Views of online forums' members*
Bachelor of Technology	*"Physics is hard because mathematics is hard"(Quora, n.d.).*
Physics Teacher	*"I believe that a great deal of this comes down to poor pedagogy. Here are some of the factors that contribute to it. Lack of Laboratory work and Demonstrations that allow students to consolidate big ideas on a visual/hands-on level" (Quora, n.d.).*

Private tutor	*"Here are some most known and common reasons why learning physics is hard:* ✓ *Physics requires enhanced problem-solving skills.* ✓ *Students need to have very critical thinking while practicing certain concepts of physics.* ✓ *Solving physics equations, problems, and numerical also requires a strong command of mathematics.* ✓ *Students need to have a very clear understanding of theorems and the laws of physics.* *Physics is very abstract."(Austin, July 01 ,2022).*
Retired physics theacher	*"Here are a few reasons why physics is not loved too much:* ○ *Every concept/topic involves thinking at many levels* ○ *Deal with numerous units of physical quantities* ○ *Interpretation of graphs* ○ *Too many formulas to learn* ○ *Too much theory — laws, hand rules, treating quantities as vectors or scalars, dealing with concepts that are not 'obvious.* *Some topics in physics are abstract and maybe student cannot relate with those immediately, like quantum mechanics and atomic physics"(Tekwani, January 7, 2020).*
Physics tutor	*"Applying the concepts is not easy". "Transferring a problem to its mathematical form is tricky". "Physics is highly mathematical"(Kumar, July 30th, 2023).*
Educator	✓ *"Here are three major reasons why students consider physics a difficult subject:* ✓ *While studying discipline, learners not only study physics. They must also know everything from the basics of trigonometry, algebra, calculus, and a lot of mathematical concepts to make sense of the subject.* *Memorizing thumb rules and equations, and keeping them in memory to apply them in real-time is a fundamental requirement when learning a subject like physics" (Sruthi, October, 2022).*
Physics Tutor	*"Here are a few reasons why physics is not loved too much:* ○ *Conceptually more demanding.* ○ *Calculations of errors in results* ○ *Deal with numerous units of physical quantities* ○ *Representing results numerically and graphically* ○ *Interpretation of graphs* ○ *Tables of numbers like trigonometric and logarithmic tables* ○ *Give reasons that tally with physical, real-world observations* *Remember definitions and laws"(Tekwani, October 8th, 2021).*
Science Advisor	*"I think learning physics is hard compared to mathematics because in a physics textbook, a minimum of explanation is usually given to justify an equation"(Physicsforums, February 7th, 2006).*
Science Advisor	*"The conceptual aspects of physics can be a challenge, but for most students, especially at the undergraduate level, it is the mathematics that they struggle with more often than not, not the physics"(Physicsforums, October 28th, 2014).*
Physics student (Pcuscuna)	*"I used to think Math and Physics were difficult subjects. I almost failed Calculus and did terrible at physics...now they are my favorite subjects. How? The reason you find it difficult is because you are failing to grasp the "big picture". I found out that there are NOT an infinite number of math or physics problems. They usually fall into one category. They may have different numbers and circumstances but if you recognize the TYPE of problem, it is you will ace the test. If you follow this plan you will succeed. After I understood this I retook calculus and other advance math and physics and aced the courses in the high 90s"(Pcuscuna, October 1st, 2010).*
Physics student (Vectronix)	*"In my experience, physics was only hard after I left high school because my "teacher" was a weirdo and didn't know how to teach, and I didn't take the initiative to learn everything on my own. Also, the course material was "dumbed down" and the problems were harder to solve in my opinion without vector calculus"(Vectronix, October 2nd, 2010).*

As it is seen from the expalanations in Table 11 and Figure 2, as the most improtant reasons make physics difficult are lack of mathematics basement, weak physics instructors (Lecturers, Teachers and TAs) and lack of problem-solving skill.

DISCUSSION

From the results of the first part of our study, we can conclude that most physics undergraduate pupils agree that physics is difficult, should be taught well, requires to work and is interesting (Table 2). The strong, traditional view of physics as difficult was also discussed in many researches too(Angell et al., 2004; Carlone, 2003; Oon & Subramaniam, 2011; Sahin & Yagbasan, 2012; Stefan & Ciomos, 2010; van der Veen, 2007). Redish et al. (1998) demonstrated that students' attitudes toward physics decrease significantly after taking a standard introductory college physics course. It is important, If Physics instructors understand what pupils think about physics courses or about physics itself, and how pupils approach physics. They can prepare or use a curriculum that assists pupils to learn physics concepts, and to learn and improve physics problem solving. In addition, the physics instructors should learn how to reach their pupils and how to make physics concepts understood by their pupils even if they are really sophisticated in their field.

According to our Physics department pupils, many new concepts, using laws in solving problems, and extensive curriculum are what pupils see as the main problems. Using mathematics to describe physical phenomena and in solving problems were also rated as aspects which are problematic in physics too (Table 3). But it is interesting that physics department pupils in our study did not see lack of mathematical skills as a serious problem for them in physics. Ornek et al. (2008) and Angell et al. (2004) had figured out the similar results. However, according to Physics lecturers and on-line physics members opinions, one of the most important problems that makes physics difficult is the lack of mathematics skill (Table10, Table11 and Figure2). The poor preparation in mathematics is shown as a problem in many educational studies(EVA, 2001; Gill, 1999; Neuschatz & McFarling, 1999; Oon & Subramaniam, 2011; Orton & Roper, 2000; Stefan & Ciomos, 2010).

As it is seen from Figure2, with the poor mathematics fundemental, one another significant result is the weakness of physics instructors to teach physics subjects. Numerous studies have pointed to the essential influence of the instructors on pupils' attitudes to the subjects and learning process(Nolen, 2003; Osborne & Collins, 2001; Sadler & Tai, 2001).

We must consider that each pupil who comes to the classroom is like a flower plant. So, it means there are different kinds of flower plants that meet in the same class. Because that They have different kinds of capillaries, leaves and flowers. They need different amounts of water, minerals and sun. Also, they need to be fed in different ways to get enough sun, water and minerals too. Like this example, it is so important to know the characteristics of the pupils.

Identifying students' learning styles help educators to understand how people perceive and process information in different ways(Cerit Berber & Oral, 2012). Instructors should know the characteristics of their pupils and according to these characteristics, the course plans should be prepared. Because all of us know that every person has different abilities. Danish physics pupils expressed that variation was essential in good physics instruction(EVA, 2001). Seidel and Prenzel (2002) saw instructional quality as "an orchestration of various didactic approaches" and claimed that a wide repertoire of teaching methods used flexibly was a relevant indicator for student learning. Kempa and Diaz (1990), based on variations in pupil motivational traits, similarly recommended greater variation in instructional methods. For example; van der Veen (2012) suggested to use interdisciplinary strategies to making students' appreciation of mathematics and physics and see these subjects as meaningful in their own lives. The integration of arts and sciences in education was suggested, to improve gender and racial integration in physics and engineering or, at least, reduce fear of physics and mathematics and thus improve science literacy in general(van der Veen, 2012).

Educators identify individual differences through careful observation and activities that reveal strengths, preferences, and abilities. Once these differences are identified, instruction can provide support for students who learn in different ways. Educators should attempt to create a bridge between students' current understanding and the new material to be learned. An educator's purpose is not to create students in his own image, but to develop students who can create their own image. A good educator should be like a candle which consumes itself to light the way for others.

As seen from Table 4, It is difficult to understant why pupils had not found physics history and its philosophy as interesting. Because if you can learn the history of anything. You can learn the development story of that field. We know that knowledge is a kind of snowball. If you can understand the history of snowball, then you can make it bigger. Also, the high interest in Quantum Physics did not confuse us as a popular subject nowadays too.

Table 5 showed that Physics course is for understanding the world, everyday phenomena and everyday technology. This results supports the results of study was done by Angell et al. (2004).

According to physics undergaruate pupils, experiments were seen as the most characteristic in physics courses (Table6). Another improtant results is that a big percentage of pupils see physics as difficult. This result is significant because all the pupils who participated in this study are going to be physics teachers. Because of this the wrong bias of physics teacher candidates about physics can affect their pupils' opinions related to physics course, negatively. Therefore, it is fatal crutial to destroy the bias of preservice teachers before being a teacher.

As seen from Table 7, it can be stated that the lecturers only use traditional teaching methods. However, from the results above, pupils do not only want to use these traditional teaching methods. When "how it is" and "what pupils wish" results compared to each other. It is seen easily that they want lecturers to use student centered teaching methods. Stokking (2000) found that physics pupils in the Netherlands wanted a stronger orientation of physics towards everyday life and teaching methods that supported active participation. Likewise, in the study was done by EVA (2001), physics pupils had expressed that variation was essential in good physics instruction. Kempa and Diaz (1990), based on variations in pupil motivational traits, similarly recommended greater variation in instructional methods. From these results it can be stated that greater variation in instructional methods in teaching physics should be an obligatory process.

According to physics undergraduate pupils the method "lecturers present new material at the blackboard" is more frequently used in the natural sciences (except biology) than in english or social science (Table8). However, it is seen that new material at the blackboard" is used mostly in Physics courses, pupils desire to see new materials at the blackboard much more. It is important that pupils want to see new materials on the blackboard much more in all subjects. In recent decades, the constructivist perspective on learning has become prominent in the science education community. This viewpoint highlights the active role of the learner, while positioning the teacher primarily as a facilitator of the students' learning process.

From the results in Table 9, It can be understood that the reason of defining physics as difficult, is not related with their attitude towards physics because that all the physics undergraduate pupils had stated that they like physics. Also, from their explanations it can be concluded that they are aware of daily life events that occur around them and their relationships with physics. So, the other reasons are that physics must be focused on comprehensively.

As is seen in Table10, physics lecturers who joined this study are aware of the problems that make physics difficult for pupils. For instance, they had stated that physics lecturers or educators' insufficient teaching abilities and communication with their pupils, students' insufficient mathematics basement, insufficient understanding of relationship between physics and everyday events which occur around them, the extensive curriculum and scarcity of weekly physics course hours and the wrong bias related to physic pupils' background are the main reasons that make physics difficult.

From Figure2 and Table11 results, according to physics forums' members the poor mathematics fundemental, poor quality educators and visualizing the problem are the main reasons that makes physics difficult to them. The results of Table 11 are very important because every member of on-line forums has shared their ideas without any anxiety and have explained the reason what make physics difficult according to them, freely. This explains why we used this way of collecting data. When we compared the data of physics pupils, physics lecturers and physics forums members, it was seen that opinions of physics forums members and physics lecturers were like each other whereas physics pupils were not. This shows the importance of online forums scanning after surveying and interviews. Therefore, it can be stated that using triangulation methods has improved relibility of the results.

The scanning results of on-line forums are also so important because that the people who joined and explained their ideas are from different countries on all over the World. There were some members from Türkiye, USA, China, India, Germany, UK, Nigeria, Russia, Norway, Egypt, South Korea etc. Therefore, these results show that defining physics as difficult and the reasons for it are the same. Also, this showed that this is an international problem too.

The Physics Education at 21st Century

The 21st century demands a new type of student and a fresh approach to assessment. Traditional time constraints and classroom environments no longer engage the new generation, and the concept of graduation feels outdated when knowledge becomes obsolete in just a few years. Education requires a complete transformation. Current strategies that do not address the limitations of time and space will fall short. We need daring, innovative changes for all students. This means embracing lifelong learning. The field of orientation and mobility must evolve or risk becoming irrelevant. Outdated definitions of professions will shift, and foundational skills can be taught in a single lesson. Beyond that, focus should shift to problem-solving, adapting to new environments, and community experiences that reinforce these essential skills in real-world contexts. Orientation will remain a crucial skill for students; without it, achieving independence becomes challenging. Future workplaces will demand advanced problem-solving abilities, which are intertwined with strong orientation skills. Therefore, problem-solving and analytical thinking should be central to our lesson plans. Additionally, students must develop skills in information gathering and assessment. They will need to navigate the internet and embrace the communications age. Emerging technologies will enhance visual experiences, but effective use of these tools will rely on adequate training. We must critically evaluate our methods of delivering visual training, with and without magnification aid, as our students prepare for a high-tech future. If students receive the right training, the future can be less daunting. They must learn to adapt to constant change and remain flexible, as rigid thinking will be a disadvantage. Future students will approach problems from multiple perspectives, employing creative and energetic solutions. They will be self-directed learners, skilled in gathering, organizing, analyzing, and swiftly responding to the flow of global information. Ultimately, the students of tomorrow will be knowledge workers with strong communication skills.

As a result of a summary of 21st physics education and physics pupils we can recommend a single physics teaching program which should include all physics subjects for all age groups in all languages that are spoken in the world. So, it means for our future we recommend one world, one teaching system which gives opportunity to every nation, race and genders.

Based on the findings of the study, the following recommendations were made:

1- A unified physics programme (UPP) in all languages, which includes and supports all kinds of teaching methods and aided with all kinds of technological educational tools, should be prepared by a group which has participants from all over the world.

2- Physics educators should implement cooperative learning strategies as an effective way to improve students' attitudes toward the subject.

3- Laboratory work is an essential component of learning physics, as it can ignite students' interest and shape their attitudes toward the subject.

4- For making the subject less demanding and work-intensive compared to other subjects, the number of topics should be reduced.

5- Seminars, workshops, and conferences should be organized for physics teachers to familiarize them with cooperative learning strategies and the integration of information technologies.

6- Participants in scientific studies should be awarded positive reinforcement like money, any gifts, foods, marks etc.

7- Pupils' mathematic levels should be checked before enrolling in any physics courses and if it is insufficient then they should be helped to improve their mathematics skills.

8- Physics educators should investigate and learn their students' views about their difficulties with physics and characteristics of their students before preparing a physics course plan.

9- Physics educators should design the course curriculum, select appropriate textbooks, and implement the curriculum in a manner that alleviates students' challenges in understanding and learning physics.

Conclusion

According to physics undergraduate pupils, physics lecturers and on-line physics forums members, the main reasons that make physics are the lack of mathematics basement, insufficient physics educators (lecturers, teachers and TAs), lack of visualizing the problem, extended curriculum, many new concepts and lack of problem-solving skill.

Our research clearly shows that the quality of educators is the most important school-level factor affecting students' learning. Nearly all these reasons can be stated that because of physics' structure, it requires working hard for being successfull.

The 136 physics pupils and 5 physics lecturers who responded to this study do not represent the total population of physics pupils and lecturers in Türkiye. Also 129 on-line physics forums members do not represent the total population of physics forums members on all internet forums. Our findings must therefore be read in this context. This study is also unique by using on-line physics forums' scanning and using a triangulation method for collecting data of study too.

In conclusion, 21st century physics educators must creatively adapt to the curriculum and teaching requirements to engage students effectively. They should also be capable of transforming business-oriented software and hardware into tools suitable for diverse age groups and abilities. Furthermore, educators need to embrace a dynamic teaching experience, ensuring that the class continues smoothly even when technology fails. New generation physics educators should recognize and implement various learning styles, adapting their teaching methods to accommodate different modes of learning. In recent decades, the constructivist approach to learning has gained prominence in the science education community. This perspective highlights the learner's active role, while positioning the educator primarily as a facilitator in the students' learning journey. Therefore, physics educators should prepare their lesson plans as student centered. Instead of merely teaching the subjects to their students, they must teach them "learning to learn!"

REFERENCES

Angell, C., Guttersrud, Ø., Henriksen, E. K., & Isnes, A. (2004). Physics: Frightful, but fun. Pupils' and teachers' views of physics and physics teaching. *Science education*, *88*(5), 683-706.

Austin. (July 01 ,2022). *Why is physics so hard? Effective tips to improve learning!* Retrieved 15 September 2024 from https://ksa.mytutorsource.com/blog/why-is-physics-so-hard/

Barmby, P., & Defty, N. (2006). Secondary school pupils' perceptions of physics. *Research in Science & Technological Education*, *24*(2), 199-215. https://doi.org/10.1080/02635140600811585

Benbunan-Fich, R., & Hiltz, S. R. (1999). Impacts of Asynchronous Learning Networks on Individual and Group Problem Solving: A Field Experiment. *Group Decision and Negotiation*, *8*(5), 409-426. https://doi.org/10.1023/A:1008669710763

Bray, A., & Williams, J. (2020). Why is physics hard? Unpacking students' perceptions of physics. *Journal of Physics: Conference Series*, *1512*(1), 012002. https://doi.org/10.1088/1742-6596/1512/1/012002

Brian, E. W. (1994). Why students choose physics, or reject it. *Physics Education*, *29*(6), 368-374. https://doi.org/10.1088/0031-9120/29/6/006

Carlone, H. B. (2003). Innovative science within and against a culture of "achievement". *Science education*, *87*(3), 307-328.

Carter, C. S., & Brickhouse, N. W. (1989). What makes chemistry difficult? Alternate perceptions. *Journal of Chemical Education*, *66*(3), 223. https://doi.org/10.1021/ed066p223

Cerit Berber, N., & Oral, I. (2012). The investigation of physics pre-service teachers' social learning styles in terms of various variables. *Energy Education Scıence and Technology: Part B*, *4*(3), 1689-1702.

Christopher, W., Martin, S., Katie, S., Eddie, B., & Dominic, D. (2003). Why aren't secondary students interested in physics? *Physics Education*, *38*(4), 324-329. https://doi.org/10.1088/0031-9120/38/4/306

de Lima, D. P. R., Gerosa, M. A., Conte, T. U., & de M. Netto, J. F. (2019). What to expect, and how to improve online discussion forums: the instructors' perspective. *Journal of Internet Services and Applications*, *10*(1), 22. https://doi.org/10.1186/s13174-019-0120-0

Dolin, J. (2002). *Fysikfaget i forandring.("School physics in a process of change")* Roskilde University]. Roskilde, Denmark (in Danish only).

EVA. (2001). *Fysik i skolen – skolen i fysik. Evaluering av fysik i det almene gymnasium ("Physics in school---school in physics. An evaluation of physics in upper secondary school").*

Gebbels, S., Evans, S. M., & Murphy, L. A. (2010). Making science special for pupils with learning difficulties. *British Journal of Special Education*, *37*(3), 139-147.

Gilbert, P., & Dabbagh, N. (2005). How to structure online discussions for meaningful discourse: A case study. *British Journal of Educational Technology*, *36*, 5-18. https://doi.org/10.1111/j.1467-8535.2005.00434.x

Gill, P. (1999). The physics/maths problem again. *Physics Education*, *34*(2), 83.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report*, *8*(4), 597-607.

Guion, L. A., Diehl, D. C., & McDonald, D. (2011). Triangulation: establishing the validity of qualitative studies: FCS6014/FY394, Rev. 8/2011. *Edis*, *2011*(8), 3-3.

Hill, S. T., & Johnson, J. M. (2004). *Science and Engineering Degrees: 1966-2001*. D. o. S. R. S. National Science Foundation. https://wayback.archive-it.org/5902/20150629122608/http://www.nsf.gov/statistics/nsf04311/pdf/nsf04311.pdf

Kempa, R., & Diaz, M. M. (1990). Students' motivational traits and preferences for different instructional modes in science education-Part 2. *International Journal of Science Education*, *12*(2), 205-216.

Kumar, P. (July 30th, 2023). *Why is Physics so hard?* Retrieved 12 September 2024 from https://www.myengineeringbuddy.com/why-is-physics-so-hard/

Lyons, T. (2006). The puzzle of falling enrolments in physics and chemistry courses: Putting some pieces together. *Research in science education*, *36*(3), 285-311.

Neuschatz, M., & McFarling, M. (1999). *Maintaining momentum: High school physics for a new millennium* (AIP-R-427). A. I. o. Physics. https://files.eric.ed.gov/fulltext/ED466386.pdf

Nolen, S. (2003). Learning environment, motivation and achievement in high school science. *Journal of Research in Science Teaching*, *40*(4), 347-368. https://doi.org/10.1002/tea.10080

OECD. (2006). *Development Co-operation Report 2005: Efforts and Policies of the Members of the Development Assistance Committee*. O. Publishing. https://doi.org/10.1787/dcr-2005-en

Oon, P. T., & Subramaniam, R. (2011). On the declining interest in physics among students—from the perspective of teachers. *International Journal of Science Education*, *33*(5), 727-746. https://doi.org/10.1080/09500693.2010.500338

Ornek, F., Robinson, W. R., & Haugan, M. P. (2008). What makes physics difficult? *International Journal of Environmental and Science Education*, *3*(1), 30-34.

Orton, T., & Roper, T. (2000). Science and mathematics: A relationship in need of counselling? *Studies in Science Education*, *35*, 123-154.

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education*, *23*(5), 441-467.

Pcuscuna. (October 1st, 2010). *Why is physics so hard? Advice to improve*. Retrieved 18

September 2024 from https://www.physicsforums.com/threads/why-is-physics-so-hard-advice-to-improve.433990/

Physics, I. o. (2001). *Physics, Building a Flourishing Future: Report of the Inquiry Into Undergraduate Physics*. Institute of Physics.

Physicsforums. (February 7th, 2006). *Why do people think physics is so hard?* Retrieved 15 August 2024 from https://www.physicsforums.com/threads/why-do-people-think-physics-is-so-hard.109738/

Physicsforums. (October 28th, 2014). *Why is physics so hard? Understanding the challenge of college level physics*. Retrieved 17 August 2024 from https://www.physicsforums.com/threads/why-is-physics-so-hard-understanding-the-challenge-of-college-level-physics.778655/#google_vignette

Politis, Y., Killeavy, M., & Mitchell, P. I. (2007). Factors influencing the take-up of physics within second-level education in Ireland—the teachers' perspective. *Irish Educational Studies*, *26*(1), 39-55. https://doi.org/10.1080/03323310601125229

Quora. (n.d.). *Why is physics hard for most people?* Retrieved 10 September 2024 from https://www.quora.com/Why-is-physics-hard-for-most-people

Redish, E. F. (1994). Implications of cognitive studies for teaching physics. *American Journal of Physics*, *62*(9), 796-803.

Redish, E. F., Saul, J. M., & Steinberg, R. N. (1998). Student expectations in introductory physics. *American Journal of Physics*, *66*(3), 212-224.

Sadler, P. M., & Tai, R. H. (2001). Success in introductory college physics: The role of high school preparation. *Science education*, *85*(2), 111-136.

Sahin, E., & Yagbasan, R. (2012). Determining which introductory physics topics pre-service physics teachers have difficulty understanding and what accounts for these difficulties. *European Journal of Physics*, *33*(2), 315.

Seidel, T., & Prenzel, M. (2002). *"Can everybody look to the front of the classroom, please"—Patterns of instruction in physics classrooms and its implications for students' learning* NARST, New Orleans, USA.

Sheila, T., & Frans, A. J. B. (1999). Who will study physics, and why? *European Journal of Physics*, *20*(6), 365-372. https://doi.org/10.1088/0143-0807/20/6/302

Singh, C., & Mason, A. (2009). Physics graduate students' attitudes and approaches to problem solving. AIP Conference Proceedings,

Smith, D. S. (2008). Why Physics? *School Science Review*, *89*(328), 41-42.

Spall, K., Stanisstreet, M., Dickson, D., & Boyes, E. (2004). Research report. *International Journal of Science Education*, *26*(7), 787-803. https://doi.org/10.1080/0950069032000097442

Sruthi, S. (October, 2022). *Why is physics considered a difficult subject? Here are 5 tips to ımprove teaching the subject.* Retrieved 24 September 2024 from https://thetutor.me/blog-detail/3/why-is-physics-considered-a-difficult-subject-here-are-5-tips-to-improve-teaching-the-subject

Stefan, M., & Ciomos, F. (2010). The 8th and 9th grades students' attitude towards teaching and learning physics. *Acta Didactica Napocensia*, *3*(3), 7-14.

Stokking, K. M. (2000). Predicting the choice of physics in secondary education. *International Journal of Science Education*, *22*(12), 1261-1283. https://doi.org/10.1080/095006900750036253

Tekwani, M. (January 7, 2020). *Why is physics considered to be a difficult subject?* Retrieved 1 September 2024 from https://mukeshntekwani.medium.com/why-is-physics-considered-to-be-a-difficult-subject-ed4bd05a5c2f

Tekwani, M. (October 8th, 2021). *Why is physics so hard?* Retrieved 26 August 2024 from https://scitechgen.com/2021/10/08/why-is-physics-so-hard/

Thurmond, V. (2001). The point of triangulation. *Journal of Nursing Scholarship 33*(3), 253-258. https://doi.org/10.1111/j.1547-5069.2001.00253.x

van der Veen, J. (2012). Draw your physics homework? Art as a path to understanding in physics teaching. *American Educational Research Journal*, *49*(2), 356-407. https://doi.org/10.3102/0002831211435521

van der Veen, J. K. (2007). *Symmetry and aesthetics in introductory physics: An experiment in interdisciplinary physics and fine arts education* [Unpublished doctoral dissertation, University of California]. Santa Barbara.

Vectronix. (October 2nd, 2010). *Why is physics so hard? Advice to improve*. Retrieved 11 September 2024 from https://www.physicsforums.com/threads/why-is-physics-so-hard-advice-to-improve.433990/

Xu, J., Coats, L. T., & Davidson, M. L. (2012). Promoting student interest in science: The perspectives of exemplary African American Teachers. *American Educational Research Journal*, *49*(1), 124-154. https://doi.org/10.3102/0002831211426200