International Journal of Contemporary Educational Research (IJCER)

www.ijcer.net

An Artistic Approach to Secondary School Students' Process of Discovering Scientists: Theater and Science

Erdinç Öcal[1]
[1] Mus Alparslan Unıversıty, 0000-0001-6940-4036

Article History
Received: 30.12.2021
Received in revised form: 05.05.2022
Accepted: 09.05.2022
Article Type: Research Article

To cite this article:

Öcal, E. (2022). An Artistic Approach to Secondary School Students' Process of Discovering Scientists: Theater and Science. *International Journal of Contemporary Educational Research, 9*(2), 395-411. https://doi.org/10.33200/ijcer.1050748

International Journal of Contemporary Educational Research

Volume 9, Number 2, June 2022, Page 395-411 ISSN: 2148-3868

An Artistic Approach to Secondary School Students' Process of Discovering Scientists: Theater and Science*

Erdinç Öcal[1**]

[1] Mus Alparslan Unıversıty

Abstract

The aim of this study was to examine the effects of science theater plays on secondary school students' attitudes towards the subject of science and their views on scientists. The study was conducted with 38 seventh-grade secondary school students over a six-month period. The "Scale of Attitudes Towards the Subject of Science" and the "Opinion Survey About Scientists" were used to collect the quantitative data, and the Wilcoxon signed-rank test was used for the analysis of the obtained data. For the collection of the qualitative data, the compositions written by the students and the researcher's observation notes were used, and the obtained data were subjected to inductive content analysis. In the study, it was concluded that the science theater plays were highly effective in changing secondary school students' attitudes towards the subject of science. On the other hand, it was determined that the activities had no effect on the students' views of scientists. The results obtained from the qualitative data reveal the advantages of science theater plays for students, as well as their contribution to students' personal development. The findings were discussed in the light of the literature and recommendations were made for further research in line with the results.

Keywords: Science, Scientists, Theater, Interdisciplinary Approach

Introduction

Students' attitudes towards science and scientists, which are shaped by the social environment and the education they receive, affect their future career choices by playing a decisive role in their academic achievement and learning motivation (Fung, 2002; Maltese & Tai, 2010; Özel, 2012). Students who have inaccurate and stereotypical ideas about science and scientists may become alienated from science and dislike related courses (Güler & Akman, 2006; Özkan et al., 2017). Dagher and Erduran (2016) stress that scientific activities in schools do not include enough social and cognitive dimensions.

The biographies of scientists, which are among the factors that play a role in the formation of a change-resistant model of scientists in students' minds (Akgün, 2016; Ambusaidi et al., 2015; Karaçam et al., 2014; Zhai et al., 2014), reveal the importance of learning the history of science. Moreover, it is stated that by learning the history of science through experiences, students increase their interest in science positively by acquiring a researcher's perspective (Guerra et al., 2013; McGregor, 2012) and developing a positive attitude towards science lessons (Bennet & Hogharth, 2009; Dawson et al., 2009; Kruse, 2010; Sepel et al., 2009). The history of science also aids comprehension of concepts about the nature of science by demonstrating how scientists endeavour to access information, what stages the knowledge has gone through to reach its current state, and the methods, tools, and materials that they use (Brodie, 2010; Odegaard, 2003). However, in some studies, it has been concluded that the history of science is not sufficiently included in the courses conducted during the teaching process, or that it is used only to enrich the lecture (Laçin Şimşek, 2011; Şeker & Güney, 2012; Wang & Cox-Peterson, 2002; Wang & Marsh, 2002). Besides, Kaya et al. (2008) emphasise that students cannot distance themselves from stereotypes due to the lack of information support related to scientists in science classes. In this context, it is evident that in order to eliminate students' negative attitudes towards science and scientists in their in-school and out-of-school learning experiences, there is a need for studies that give importance to the life stories of scientists, their working styles, how they evaluate the data they obtain, and the conditions of the time period in which they live.

---

* This study was presented as an oral presentation at the 8th International Eurasian Educational Research Congress (EJER Congress) held between 7-10 July 2021.

** Corresponding Author: Erdinç Öcal, *e.ocal@alparslan.edu.tr*

In order to educate individuals who know the history of science and the nature of science in educational environments, learner-focused and interactive methods should be used (Teke et al., 2015). In addition, in science education, activities enriched with the use of different disciplines, methods, and techniques will also ensure the realization of permanent learning (Dhanapal et al., 2014; Idin & Aydoğdu, 2016). Although science and art, which develop by being directly or indirectly influenced by each other in the integrity of the cultures they belong to, appear to be independent from each other, they are in fact disciplines that complement one another. In this context, in science education, a creative and innovative strategy such as theater, where students are motivated by active participation (Segedin, 2017) and reinforce the knowledge they have organised in their minds (Gemtou, 2014), can be mentioned.

The art of theater, which has been one of the channels of communication with society from the past to the present, has been used for many purposes, such as entertaining, enlightening, and informing the audience (Sloman, 2011). Researchers also use the theater, which reflects social change in the environment (Neelands, 2007) and supports individuals' life skills (Fulton & Simpson-Steele, 2016), as a method of conducting their studies and conveying their results to large audiences (White & Belliveau, 2010). The art of theater, which focuses on character and plot, has a story-centred structure. With these features, as well as involving the audience in the process of building knowledge, it can also bring clarity to a complex or abstract issue (Segedin, 2017). Furthermore, theater also offers alternative solutions for making the symbolic language of science more understandable and accessible in terms of cognitive and affective results (Braund, 2015; Dorion, 2009; Hendrix et al., 2012). The collaboration of science with theater has been called "science theater plays" (Amaral et al., 2017). According to the research, students gain experience in science and scientific process skills through theater (Borrow & Russo, 2015; Peleg & Baram-Tsabari, 2011), and science theater plays can be used as an effective communication tool in disseminating scientific culture to large groups of people (Amaral et al., 2017; Lanza et al., 2014).

As a result of the literature reviews, it has been observed that besides the scarcity of systemic studies evaluating theater activities in education (Belliveau & Lea, 2011), there are very few studies aimed at the art of theater, which provides an interactive learning environment, and science and scientists. The effect of examining the lives and works of scientists through the art of theater on students' attitudes towards the subject of science in the light of their previous knowledge is also a matter of curiosity. In our study, important sections of the lives and works of *Al-Khwarizmi, Alpharabius, Avicenna, Al-Biruni, Ali Qushji, Akshamsaddin, Marie Curie, Eratosthenes, Isaac Newton, Albert Einstein,* and *Aziz Sancar* were realistically scripted and staged with the students in the form of short plays. With the students' animations of the scenarios related to the lives and works of the abovementioned scientists and their empathy towards them, a student-centered, social, interactive, imaginative, entertaining, and powerful learning environment was created. Moreover, it was intended that the students would increase their curiosity towards scientists and their work and concretise science in their minds by assuming the roles of scientists in the short theater play animation activities, in which they actively participated in collaboration. Our study differs from this related literature in terms of being a short play and dramatization study about the lives of scientists. Based on all of these situations, the aim of this study is to (1) determine the effects of science theater plays on 7th grade secondary school students' attitudes towards the subject of science and their views on scientists; and (2) examine students' thoughts about the process of teaching about scientists and their works through theater activities. In this context, the main problem of the research was determined as: "What is the effect of science theater plays, in which 7th grade secondary school students actively participate, on their attitudes towards the subject of science and their views about scientists?" In accordance with this main problem, the following sub-problems:

1. Do theater activities involving scientists make a significant difference to secondary school students' attitudes towards the subject of science?
2. Do theater activities related to scientists make a significant difference to secondary school students' views about scientists?
3. What are the thoughts of secondary school students on the process of teaching about scientists and their work through theater activities?
4. What are the recommendations of secondary school students for future studies on scientists and their works with theater activities?

Method

Research Design

This study, which examines the effects of science theater plays on secondary school 7th grade students' attitudes towards science and their views about scientists, was designed as an exploratory sequential mixed method design. The procedure in this design is gathering quantitative data first, and then supporting the quantitative results with qualitative data (Clark & Ivankova, 2016; Creswell & Plano Clark, 2014). In the quantitative part of the study, a single group pretest-posttest experimental design, which is used in studies aimed at raising public awareness (Gliner et al., 2015), was used. In the qualitative part of the study, a phenomenological design, which is based on the expression of world views about the relevant phenomenon, was given priority (Merriam, 2015).

In the study, 7th grade secondary school students enacted the play scenarios about scientists prepared by the researcher on the stage after the theater rehearsals. In the first stage of the research, it was quantitatively tested whether this program had an effect on students' attitudes towards the subject of science and their views about scientists. In the second stage, in order to investigate in depth the effects of the implemented programme, the participants' opinions and experiences were obtained through the compositions they wrote. These data were included in the research together with the data obtained from the on-the-spot field notes and video recordings kept by the researcher throughout the process. In the final stage, the data obtained in the quantitative and qualitative processes were combined in a meaningful way and compared, and consistent results were conveyed to the reader.

Participants

The study group of the research consists of 38 seventh grade secondary school students (20 girls, 18 boys) studying in 5 different secondary schools affiliated to the Ministry of National Education in the central district of Muş. The participants were selected using the criterion-based sampling method, one of the purposive sampling types. In this method, participants are selected according to appropriate preset criteria depending on the purposes of the research (Merriam, 2015). In order to inform the participants about the science camp where the activities were to be conducted and to enable them to apply, posters were displayed in the schools and announcements were made. Among the 92 secondary school students who applied, the participants were determined by considering six criteria. The specified criteria were: 1) the student had completed the 6th grade and moved to the 7th grade, 2) the student was a volunteer, 3) the numbers of male and female students in the participant group were similar to each other, 4) they were students from different schools, 5) they were students who had not participated in a similar study before, and 6) the family approval form regarding participation in the camp had been completed.

Data Collection Tools

In collecting the quantitative data for the research, the "Scale of Attitudes Towards the Subject of Science" and the "Opinion Survey About Scientists" were used, while the compositions written by the students were used to collect the qualitative data. The data obtained from the compositions was supported by the researcher's observation notes.

Scale of Attitudes Towards the Subject of Science

In order to determine the impact of the science theater plays applied in the research on the attitudes of the participants towards the subject of science, the Scale of Attitudes Towards the Subject of Science developed by Öcal (2014) for secondary school students was utilized.

The scale, which consists of 21 items and 3 sub-dimensions, namely "Interest, love, hate and fear" (11 items), "Trust" (5 items) and "Importance" (5 items), is scored as "I completely disagree", "I disagree", "I am undecided", "I agree" and "I completely agree". The lowest score that can be obtained from the scale, in which 10 items are reverse-scored, is 21, while the highest score is 105, and it can be interpreted that participants who obtain high scores have a more positive attitude towards the subject of science. In the reliability study that was conducted, the Cronbach alpha reliability coefficient for the whole scale was calculated as.88. For the sub-dimensions, the reliability coefficients were calculated as.90 for "Interest, love, hate, and fear" (11 items),.78 for "Trust" (5 items) and.67 for "Importance" (5 items) (Öcal, 2014). As stated by Thorndike and Thorndike-Christ (2010), based on these reliability coefficients, it can be said that the whole scale is reliable at a good level, while in two of the sub-dimensions, reliability is low due to the small number of items (5 items each).

Opinion Survey About Scientists

In order to determine the effect of science theater plays on students' perceptions about scientists, the "Opinion Survey About Scientists", which was created by Öcal (2007) with the data he obtained from the literature and which was prepared for secondary school students, was used. In the reliability study that was conducted, the

Cronbach alpha reliability coefficient for the opinion survey about scientists, consisting of 47 items, was calculated as.86 (Öcal, 2007). This 5-point Likert-type scale, in which 27 items are reverse scored, ranges from 1 ("I completely disagree") to 5 ("I completely agree"), and consists of 5 sub-dimensions. The sub-dimensions of the scale are: thoughts about scientists' work (11 items), thoughts about scientists' social lives and social activities (7 items), thoughts about scientists' characters, feelings, characteristics, and working life (17 items), thoughts about scientists' place in society (6 items), and thoughts about scientists' relationships with other scientists (6 items). The highest score that can be obtained from the scale is 235, while the lowest score is 47. It can be concluded that participants with high scores have more positive views on the characteristics, works, and social lives of scientists.

Compositions

Following the theater activities, the students were asked to write compositions in order to understand in depth their views about the process of teaching about scientists and their works through theater activities and their perspectives on further studies to be conducted on this subject. Two open-ended instructions were given to the students in order to create space for them to write their compositions and to facilitate their writing. These instructions were determined as: (1) Relate your positive and negative views about examining the lives and works of scientists through theater activities. What did you feel? What did you experience? (2) What suggestions do you have for further studies on the lives and works of scientists through the art of theater? The data obtained from the compositions was also supported by field observations and video recordings made during the process. By enabling data triangulation with the compositions, on-the-spot field observation notes, and video recordings, the internal validity of the study was also strengthened (Fraenkel & Wallen, 2008).

Researcher's Observation Notes

Observation assists in obtaining comprehensive data spread over time about behaviour and phenomena in specified environments (Yıldırım & Şimşek, 2016). Throughout the study, natural and unstructured observations were made in order to evaluate the emotional and behavioral changes in the students during the activities. In the observations, students' reactions, emotions, thoughts, and emerging patterns regarding the science theater activities were taken into account. Moreover, interesting and different situations were observed during the activities, and each observation was recorded with on-the-spot field notes. All implementations were recorded on camera with the permission of the parents and students, accompanied by an assistant. Each recording was examined repeatedly in order to enrich the field notes. The use of camera recordings during the activities allowed the students' behaviors, emotions, and reactions during the activities to be observed again at any time and increased the validity and reliability of the study in terms of interpretation of the findings. With the observations that were made, the participants' perspectives and experiences regarding the implementation process were understood, and their feelings and thoughts about the theater activities and the examination of the scientists' lives and works were revealed in detail.

Implementation process

The study was conducted with 38 seventh grade secondary school students (20 girls and 18 boys) using the technical equipment and locations of Muş Alparslan University.

The implementation process was carried out as shown in Table 1:

Table 1. Implementation process

Date	Theme	Activities
12.02.2018 - 04.05.2018	Preparing scenarios about scientists	*Literature review *Writing scripts *Final revisions
07.05.2018 - 25.06.2018	Summer science camp announcement Determining participants	*Examining applications *Selecting participants *Announcing selected participants *Receiving volunteer participation forms *Obtaining family permission forms
10.07.2018	Implementation of pretests	Pretest-implementations of * Scale of attitudes towards the subject of science and

		*Opinion survey about scientists
11.07.2018 - 12.08.2018	Al-Khwarizmi, Alpharabius, Avicenna, Al-Biruni, Ali Qushji, Akshamsaddin, Marie Curie, Eratosthenes, Newton, Einstein, Aziz Sancar	*10 hours of rehearsal for each scientist theatre play *Staging of plays (2 hours) *Researcher's observation notes *Video recordings
13.08.2018	Implementation of posttests	Posttest implementations of * Scale of attitudes towards the subject of science and * Opinion survey about scientists *Compositions

The researcher, who was directly involved in the process of writing and staging the scenarios, has 16 years of professional experience in writing, directing, drama teaching, and acting in a city theater. In the study, the scenarios of the science theater plays acted on stage were prepared by the researcher before the implementation phase. The first step taken into consideration in the preparation of these scenarios was to ensure that they were realistic. For this purpose, in the first stage, a literature review was carried out regarding the important sections of the lives and works of the scientists (*Al-Khwarizmi, Alpharabius, Avicenna, Al-Biruni, Ali Qushji, Akshamsaddin, Marie Curie, Eratosthenes, Isaac Newton, Albert Einstein, and Aziz Sancar*) examined in the study, and the relevant documents were collected. Other points taken into consideration during the writing phase were: during the staging process, scenes in which there may have been problems in terms of decor, costume, and technique were not written, the scenarios were suitable for the age and developmental level of the 7th grade of secondary school; and the lines in the scripts were written in a simple and understandable language. By observing these criteria, important sections of the lives and works of the scientists were examined and scripted. The views of two playwrights and two science education experts were obtained regarding the scripts of the short plays that were written. Interviews were held with the writers and experts under the headings of the duration of the scenarios; the adequacy of the contents related to the relevant scientists; and how the history of science and science subjects are related. The necessary revisions were made in line with the interviews and feedback, and the play scripts to be used in the study were given their final form (Table 1).

Within the scope of the quantitative section of the study, which was planned according to a single-group pretest-posttest design, the pretest measurements were carried out by applying the "Attitude Scale Towards the Subject of Science" and the "Opinion Survey About Scientists" before the implementation (Table 1). Afterwards, the students were briefed about the art of theater, the scientists, and our study. Then, the scenarios prepared about the scientists and their works were animated with the active participation of the students. During the implementation process, the participants were divided into 2 groups, and the rehearsals were carried out by the distribution of roles in both groups. The 2 groups acted out the same scenario on the staging day. While the play of the first group was being performed on the stage, the second group was the audience; while the second group was performing the animation, the first group was the audience. Thus, by ensuring that the students were both the actors and the audience, the message-transmitting and message-receiving quality of theater was exploited. In order to determine whether these activities had an effect on students' attitudes towards the subject of science and their views about scientists, the two scales administered in the pretest were also administered as a posttest after the implementation (Table 1).

During the implementation, observations were made and on-the-spot field notes were kept in order to investigate the effects of the programme in depth. In this context, field notes were kept between the dates of 11.07.2018-12.08.2018, during the period of implementation. Video recordings were made in order to make the data obtained through observation more detailed and to examine the reactions occurring in the observed environment more deeply and repeatedly. Each recording was examined repeatedly in order to enrich the field notes. Following the implementations, the students wrote compositions in which they wrote their thoughts on the process of teaching about scientists through science theater plays and on future studies to be conducted on this subject (Table 1). The results obtained from the qualitative data were compared with the data obtained from the quantitative data and were integrated in the results of the study.

The implementation stage of the study, which was carried out over a total of 24 weeks, continued every day for 4 weeks. During the implementation stage, the play performed for each scientist was rehearsed for 2 days. On the following third day, the play was staged in the form of two separate groups. In this context, it can be said that the theater activities for one scientist took 3 days in total. An average of 5 hours of work was carried out on each rehearsal day and an average of 2 hours on the staging day. The implementation period of the study, which included 22 days of rehearsals and 11 days of staging, lasted 132 hours over a total of 33 days (Table 1).

Data analysis

Quantitative Analysis

To test whether there is a significant difference between the means of two repeated measurements (pretest-posttest) taken on the same group, the t-test for dependent (related) samples or the Wilcoxon signed-rank test can be used (Pallant, 2015). In the study, skewness and kurtosis values were examined to determine whether or not the data showed a normal distribution. The mean, skewness, and kurtosis values for the pretest and posttest data of the "Attitude Scale Towards the Subject of Science" (ASTSS) and the "Opinion Survey About Scientists" (OSAS) are presented.

Table 2. Mean, skewness, and kurtosis values of the data (ASTSS and OSAS)

	ASTSS Pretest	**ASTSS Posttest**	**OSAS Pretest**	**OSAS Posttest**
Mean ($\bar{X}$)	91.16	96.16	172.87	172.97
Skewness	-1.23	-2.12	-.61	-.32
Kurtosis	1.22	4.85	-.64	-.92

The fact that skewness and kurtosis coefficients range between the (+1,-1) limits indicates that the distribution does not deviate excessively from the normal (Büyüköztürk, 2008; Çokluk, Şekercioğlu & Büyüköztürk, 2012). When analytical findings were analyzed, it is seen that the skewness and kurtosis values of the pretests and posttests of the ASTSS and OSAS scales were not between the (+1,-1) limits (Table 2). In addition to the skewness and kurtosis values, the Shapiro-Wilk test values were examined to determine whether or not the data met the normality assumption. The Shapiro-Wilk test is the normality test recommended to be applied in cases where the sample size is less than 50 (Büyüköztürk, 2008).

Table 3. Shapiro-Wilk test results for the data (ASTSS and OSAS)

	ASTSS Pretest	**ASTSS Posttest**	**OSAS Pretest**	**OSAS Posttest**
Statistic	.88	.74	.94	.96
N	38	38	38	38
P	.001	.000	.036	.165

As a result of the analyses, it is understood that all scales showed a heterogeneous distribution, except for the OSAS post-test data. Accordingly, since the data set obtained from the ASTSS and OSAS scales used in our study did not provide normality, the Wilcoxon signed-rank test, which is one of the nonparametric techniques, was used in the analysis of the quantitative data (McKillup, 2012; Mertler & Vannatta, 2005). The Wilcoxon signed-rank test is a non-parametric alternative to the repeated measures t-test (Pallant, 2015) and is used in cases where the obtained data do not have a normal distribution (Büyüköztürk, 2008). For all statistical analyses conducted within the scope of the research, the significance level was considered to be.05. The data analysis was carried out using the SPSS 26.00 statistical software tool.

Quantitative Analysis

Data from the compositions, observations and video recordings were analysed in depth in order to reveal the students' experiences in the science theater activities and their effects on the integration of interactive theater art with science. The inductive content analysis technique was utilised in the analysis of the research data. Inductive content analysis involves coding, categorizing, determining the relationships between these categories, and creating themes (Patton, 2014; Saldana, 2019). Interpretations made by the researcher include associating the emerging themes, making sense of them, and forming future inferences (Yıldırım & Şimşek, 2016).

For the coding of the data, to give the researcher a general idea, firstly, all the compositions and field observation notes were read several times, and the video recordings were examined repeatedly. All opinions and recordings determined to be relevant to the research questions were combined under the same code. By working on the

categories that emerged as a result of the coding, themes that were appropriate for the purpose of the research and that constituted a meaningful whole were determined. The researcher read all the data several times at different times and checked for coding and themes.

To ensure reliability, two academicians, who are experts in qualitative research , independently coded the data according to the created codes and created themes. In order to verify the themes and categories that were formed independently of each other and to remove them from subjective judgements, new themes and categories were created by discussing the codes with the experts whose opinions were sought. The most frequently repeated and most important codes were chosen, and some codes were revised. According to the final situation, the codes created by the researcher and two experts were compared, and a 90% level of agreement was achieved. In this respect, 80% agreement in coding is considered sufficient (Miles & Huberman, 1994). The final forms of the analyses of the obtained data were organized under research questions by determining the relations between the themes. The findings were defined by reaching consensus, and they were transformed into tables and presented by interpretation. For each theme and code, direct quotations from composition data or field observations have been provided to assure internal dependability.

Credibility and Ethics

The study process was enriched by using a series of data collection techniques. In this process, the science theater activities that were carried out, the scenarios that were used, and the implementation method and reporting of the study were evaluated by expert academicians at every stage. In order to ensure the credibility of the study, various measures were taken in four dimensions: reliability, transferability, consistency, and confirmability (Yıldırım & Şimşek, 2016).

In the reliability dimension of the study, it is noteworthy that the researcher has professional experience in the field of theater and drama as well as being an expert in science education. He carried out long-term interaction with the students in the study, and he made in-depth observations by taking field notes and video recordings. In the dimension of transferability, it was observed that the whole study process and the obtained findings were given in detail and that the participants were determined by the criterion-based sampling method, which is one of the possible types of sampling. In the consistency dimension, the data analysis was carried out with consensus reached by comparing the codes and themes obtained in the data analysis with the coding of two qualitative research experts with doctoral degrees and by giving direct quotations regarding the codes from the researcher's observation notes and compositions. In the dimension of confirmability, internal validity was increased by diversifying the data sources and data collection methods (triangulation) through composition, observation, and video recording analysis (Merriam, 2015). The goal was to eliminate any potential flaws in the data collection tools by confirming whether or not the data matched.

Legal permission to conduct the study was obtained from Muş Alparslan University Ethics Committee and Muş Provincial Directorate of National Education. Within the scope of the study, cooperation was made with the 7th grade secondary school students and their parents and teachers. The principle of voluntariness was adhered to in the selection of the participating students. At this point, students were asked to fill in the voluntary participation form that was prepared. The reason for the study, its duration, what kind of data would be obtained, and where and for what purpose it would be used were clearly explained to the students, their teachers, and their families. A parental consent form was developed for the students' participation in the study, and the parents of the selected participant students were asked to fill it out. In this way, written consent was obtained from the students and their parents regarding participation in the study and taking video recordings in the study. To ensure the confidentiality of the participants' identities, codes (S1, S2, S3,…S38) were used instead of their real names.

Findings

The findings of the study, in which scientists and their works are analyzed through theatrical activities, are presented in two sections as quantitative and qualitative findings, with sub-problems considered.

Quantitative Findings

In line with the research objectives stated, findings regarding the effect of the implemented programme on the attitudes of the secondary school students towards the subject of science and the views of the same students regarding scientists are presented.

Impact of the implemented programme on students' attitudes towards the subject of science

In the first sub-problem of the quantitative part of the research, the effects of theatrical activities related to scientists and their works on the attitudes of secondary school students towards the subject of science were investigated. To analyse whether there was a statistically significant difference between the pretest and posttest mean scores of the secondary school students regarding the scale of attitudes towards the subject of science with the implementations that were made, the Wilcoxon signed-rank test was used, and the results are provided in Table 4:

Table 4. Wilcoxon Signed-Rank Test Results for Scale of Attitudes Towards the Subject of Science

Attitude Scale	Ranks	N	Mean Rank	Rank Sum	Z	p
Posttest - Pretest	Negative Ranks	8	13.13	105.00	-3.293	.001
	Positive Ranks	26	18.85	490.00		
	Equal Ranks	4				
	Total	38				

The difference between the students' total scores on the scale of attitudes towards the subject of science before and after the implementations shows that there was a statistically significant increase ($Z = -3.293$, $p<.05$). This finding shows that the experimental study's program was highly effective in improving secondary school students' attitudes toward science.

Effect of the implemented programme on students' opinions about scientists

In the second sub-problem of the quantitative part of the research, the effect of theater activities related to scientists and their works on the views of secondary school students about scientists was investigated. The Wilcoxon signed-rank test was used to analyse whether there was a statistically significant difference between the pretest and posttest mean scores of the secondary school students regarding their opinions about scientists with the implementations that were made. The findings are presented in Table 5:

Table 5. Wilcoxon Signed-Rank Test Results for the Opinion Survey About Scientists

Attitude Scale	Ranks	N	Mean Rank	Rank Sum	Z	p
Posttest - Pretest	Negative Ranks	19	18.92	359.50	-.160	.873
	Positive Ranks	19	20.08	381.50		
	Equal Ranks	0				
	Total	38				

It was determined that the difference between the students' total scores for their opinions about scientists before and after the implementations was not statistically significant ($Z=-.160$, $p>.05$). This finding shows that the research program had no significant impact on secondary school students' perceptions of scientists.

Qualitative Findings

In the qualitative part of the study, the themes, codes, and sample opinions obtained from the analyses of the researcher's observation notes and the composition data are presented in the form of tables. In addition, the details of the researcher's observation notes are also included in the comments section. It is thought that this will make it easier for readers to interpret the tables by making use of the data.

Secondary school students' thoughts on the process of teaching about scientists and their works through theater activities

In the first sub-problem of the qualitative part of the research, the aim was to examine the students' thoughts on the process of teaching about scientists and their works through theater activities. Accordingly, the participating

students were asked to answer the question, "Relate your positive and negative views about examining the lives and works of scientists through theater activities. What did you feel? What did you experience?" in the compositions that they wrote. The results were examined under the themes of "positive thoughts" and "negative thoughts". Tables 6 and 7 show the results of coding the researcher's observation notes and the students' responses in their compositions:

Table 6. Positive thoughts of secondary school students regarding the process of teaching about scientists and their works through theater

Category	Code	Repeating Students	Sample Opinions
Personal Development	**Getting to know oneself through theatre**	1,8,15,17,22,25,27, 30,31,37	***S15:*** *"…While playing the roles of the scientists on the stage, we learned how to move, how to act, how to use our gestures and facial expressions. We got to know ourselves better. I wish it had never ended…"* ***S27:*** *"…Of course, there were things I could and couldn't do while working on the scenarios about the scientists. In this way, I got to know myself better. I feel like I can act on stage now.*
	Increasing self-confidence	1,3,18,19,20,30	***S20:*** *"…When I was in kindergarten, some of my friends laughed at me and some of them cried because I cried on stage while reading the poem I wrote to my mother on mother's day. I have been afraid ever since. But this study made me overcome my fear and trepidation. Therefore, I am very happy."*
	Acquiring theatre skills	4,8,9,16,19	***S4:*** *"…Our acquaintance with the scientists through theatre not only gave us drama skills, but also entertained and instructed us."* ***S9:*** *"…I personally did not think that I had any theatrical skills, be it an animation or a voice change. But when we act out the scenario and I see my success, I think that maybe I can advance in this field. So I think I will be able to participate in various activities."*
	Developing imagination/creativity	16,32,34	***S16:*** *"…While we were acting in the theatre activities about scientists, it seemed to us like a theatre play watched by a thousand people. We use our intelligence and imagination in the scenarios. The activities were lots of fun. Our creativity has also improved."*
	Gaining different perspectives	2,33	***S2:*** *"…I felt as if I was inside the lives of all the scientists. Thanks to the theatre, people look at life through not one but thousands of windows. So the area we call perspective is changing."*
	Socialisation	21	***S21:*** *"…Here, you get to know the scientists and learn about them through theatre, and this is more memorable because in such an activity, you can meet people you don't know and do drama. This can enable you both to learn about scientists and to socialise. There were also some shy friends among us. We were able to establish social relationships with them as well."*
Learning	**Learning by having fun**	1,2,3,4,5,7,8,9,11,12, 13,14,15,16,17,19, 20,21,22,24, 25,26,28,29,36	***S8:*** *"…Time passed so quickly and so beautifully during my time on the stage that I didn't even realise that I was learning something. But then I realised that theatre has encoded many things and even many people into my memory. It is a truly indescribable feeling, emotion and pleasure at the same time. I am glad that this activity was organised with theatre and art."*

		S17: *"…What contributed more than anything to my acquaintance with the scientists was that the students went out and did drama. I had a lot of fun during this summer vacation."* ***S22:*** *"…It was very, very entertaining to play and watch the scientists through theatre in this study. I will talk about this place always and everywhere."*
Retention of learning	2,3,5,8,9,10,11,12,13, 14,15,16,17,18,19,20, 21,26,28,30,32,33,35, 38	***S3:*** *"It was very instructive to get to know the scientists through theatre. We learned by having fun and this benefited us a lot. If you had just made do with narrating or writing, maybe we would have forgotten it after a few days. But like this, it was so permanent."* ***S35:*** *"It was a nice activity in general. I am against the rote system. When we come across this, it is easier for me to remember the theatre play we performed instead of just memorising."*
Learning about scientists	2,17,23,26	***S17:*** *"…Also, theatre helped me get to know scientists more."* ***S23:*** *"…In this way, we brought science and art together and learned about scientists whose names we would not have heard of even once in our lifetime."*
Learning by assuming a role	19,30	***S19:*** *"…While we are learning, we explore our talents together with the teachers. We can draw inspiration from that scientist. When I act, it's almost as if I'm not me. If I'm Aziz Sancar, say, I feel like Aziz Sancar, not like Ahmet or Ömer… So if I'm Aziz Sancar, it's as if I'm saying 'it's enough, I'm learning by myself.' "* ***S30****: "…Animating scientists through theatre enables people to remember a scientist they can take as an example and enables retention. Whatever role we play, we get to know that scientist closely and take him as an example."*
Visual learning	25,28	***S28:*** *"…We learn visually through drama and theatre."*
Learning by experiencing	10	***S10:*** *"…When theatre and science are combined, it becomes more permanent. If we wanted, could we learn about these scientists with long slides and ongoing conversations? Would two days be enough for us to learn the information? Definitely not. Because we learn by experiencing. We remember everything we experienced in the theatre, because we experienced it and transmitted it."*

The students' positive thoughts about the implementation process were grouped under the categories of "Personal Development" and "Learning". Under the category of Personal Development, the codes "Getting to know oneself through theater" (n=10), "Increasing self-confidence" (n=6), "Acquiring theater skills" (n=5), "Developing Imagination/Creativity" (n=3), "Gaining different perspectives" (n=2) and "Socialisation" (n=1) were formed (Table 6). The researcher's observation notes also support these codes:

"Day by day, the students can express themselves more easily on stage. This gives strength to their play. They have begun to enjoy themselves while playing the roles of scientists. It is observed that the daily increase in their friendship relations and getting to know each other better increases their sense of ease on the stage. This has also enabled them to generate comfort. They make additions to the scripts. They make improvisations. I don't interfere with these improvisations as long as they don't break the lines of the scripts. The fact that they produce and have fun on stage contributes to their success. Even students who approach the theater with prejudice want to act. I can say that their energy has increased. Perhaps they have also discovered themselves and gotten to know themselves, and this is reflected on the stage." (Researcher's notes: 19.07.2018)

Under the learning category, the codes "Learning by having fun" (n=25), "Retention of learning" (n=24), "Learning about scientists" (n=4), "Learning by assuming a role" (n=2), "Visual learning" (n=2) and "Learning by experiencing" (n=1) were formed (Table 6). It is seen that the students who studied the lives and works of scientists through theater especially learned by having fun and emphasised the permanence of what was learned. The findings obtained from the researcher's observation notes also contribute to the learning process by providing a fun code:

"Today, I observed that the students felt happy and were motivated when they were applauded at the end of their play. They are working more willingly. They loved the theatrical texts and animations about scientists. They state that they had a lot of fun. At the end of the play, I thanked them for their performances. They also thanked me. They are very happy to be part of the project. It's so obvious that they're having fun... They never get distracted." (Researcher's notes: 24.07.2018)

It is seen that the students not only had fun in the science theater activities, but that they also learned more permanently.

Table 7. Negative thoughts of secondary school students regarding the process of teaching about scientists and their works through theater

Category	Code	Repeating Students	Sample Opinions
Technical	**Food**	4,20,35	***S4:*** *"…The subject of food is not very pleasant. The same breakfast, lunch in the dining hall, dinner again in the dining hall every day. The food was terrible, always the same dishes appeared. This was rather boring."*
	Obligation to act collectively	11,33	***S11:*** *"…Our teachers are excellent. The only problem is, they say that when we want to get some air, we have to act together."*
Content	**The leading roles are males**	11	***S11:*** *"…Men were always in the leading roles. Only once was there a female lead."*

The students' negative thoughts about the implementation process were grouped under the categories of "Technical" and "Content". Under the technical category, the codes "Food" (n=3) and "Obligation to act collectively" (n=2) were formed. Under the content category, the code "The leading roles are males" (n=1) was formed (Table 7).

Suggestions of secondary school students for further studies on using theater activities to teach about scientists and their works

In the second sub-problem of the qualitative part of the research, the goal was to receive the students' suggestions for future studies on scientists and their works with theater activities. Accordingly, the participating students were asked to answer the question "What are your suggestions for future studies on the lives and works of scientists with the art of theater?" in the compositions that they wrote. The researcher's observation notes and the students' answers in their compositions were coded, and the results are presented in Table 8:

Table 8. Suggestions of secondary school students for future studies on teaching about the lives and works of scientists with theater activities

Category	Code	Repeating Students	Sample Opinions
Technical	**The activity should be repeated next year**	4,5,9,11,13,15,16, 22,25,27,29,30	***S11:*** *"...I want this project to take place next year as well."* ***S13:*** *"...Please let this activity be held next year as well. Let's learn about scientists by having fun again."*
	It should be an overnight activity	11,13,27	***S11:*** *"...This study should be an overnight activity next year. Let it be like a camp."*
	More people should take part	13, 37	***S37:*** *"...Let's do it again next year. It should be held in primary schools as well, and there should be 80 of our friends. Not just us, let our friends come and see it, too. Let others join in, let them learn, have fun, act and teach those who don't know how to have fun."*
	It should be held in different cities as well	25	***S25:*** *"...It was a lot of fun to learn about scientists through theatre. We are very lucky. This activity should be held in other cities as well, and it should spread all over our country."*
Content	**Sporting activities should be added**	36	***S36:*** *"...I loved the activity very much. I learned about scientists through art. Next year I want there to be sports like swimming football, basketball, etc., too."*
	Energy-expending activities should be added	12	***S12:*** *"...There should be a programme that will release energy when it is held next year. There wasn't this year. We wanted to travel in order to discharge, but the teachers did not allow it."*

The categories "Technical" and "Content" were used to group students' suggestions for future studies on scientists and their work with theater activities. Under the technical category, the codes "The activity should be repeated every year" (n=12), "It should be an overnight activity" (n=3), "More people should take part" (n=2) and "It should be held in different cities as well" (n=1) were formed. Under the content category, the codes "Sporting activities should be added" (n=1) and "Energy-expending activities should be added" (n=1) were formed (Table 8). In the data obtained by examining the camera recordings, too, it is seen that during the activities, the participants made inquiries and had discussions among themselves about the scientists' lives and works. In addition, it is observed in these recordings that the students were active and willing to act out the roles given to them, and that they were generally happy, excited, and entertained during the activities. The researcher's observation notes also support these data:

"The children's energy is a little low today. The fact that it was the last activity day and that they were going to leave their friends and trainers and the theater made everyone feel sad. The best way to motivate them is to say that they will be doing the activity next year and that they will be invited again. When I say this, they all embrace the activity happily and do their best." (Researcher's notes: 02.08.2018)

It can be said that the parents also thought that the activity was beneficial for the students. The researcher's observation note for this interpretation is as follows:

"Today, we held a meeting with the parents of the participating students before the activity. We listened to their ideas and suggestions about our study. In general, they all thanked me and my team for conducting such an activity. One of the parents said that their child came home very happy and energetic from this activity and enthusiastically told them about all the activities they had done. I was very happy to receive positive feedback from all the parents. We are on the right track." (Researcher's notes: 07.08.2018)

Conclusion and Discussion

Important conclusions have been reached in this study, which aims to examine in depth the effects of science theater plays on 7th grade secondary school students' attitudes towards the subject of science, their views about scientists and their works, and their thoughts about the implemented programme.

When the results were examined, it was revealed that there was a significant positive difference in the students' attitudes towards the subject of science before and after the theater activities related to scientists. Studies show that when science is integrated with art, attitudes towards science increase positively (Danckwardt-Lilliestrom et al., 2020; Ong et al., 2020). In other conducted studies, it was concluded that students had an active and intellectual learning experience with interactive role-playing activities in science education and that this situation had a positive effect on students' attitudes towards science (Bennet & Hogharth, 2009; Braund, 2015; Dawson et al., 2009; Mc Gregor, 2012; Odegaard, 2003). Learning about the history of science, the lives of scientists, and how they accomplish their work increases the positive interest of students who are not interested in science (Kruse, 2010). Moreover, looking at the qualitative findings of the study, it was observed that the students were able to comprehend science subjects more easily by concretising them through theater. It is thought that this situation will lead to an increase in motivation and facilitate learning in students. In addition, it is seen that the students stated that they learned science subjects by having fun with drama and that this knowledge was maintained. Parallel to these results, Sepel et al. (2009), in their study in which students played the roles of scientists and animated the discovery of the microscope, concluded that the students were able to look at science from a historical perspective and that the animation activities positively motivated students to acquire scientific knowledge. In other conducted studies, the importance of different disciplines and methods in realising permanent and meaningful learning in science education is emphasised (Dhanapal et al., 2014; Idin & Aydoğdu, 2016). It is also stated that in science education, integration and enrichment of learning will be enabled by establishing connections between different disciplines (Tripp & Shortlidge, 2019; Shen & Wang, 2020). In this context, it can be said that the findings regarding learning by having fun and easy and permanent learning, which were obtained by the interdisciplinary integration of science and art, support the previous studies conducted on the subject.

In the quantitative results of the study, it was found that in the opinion survey about scientists, there was no significant difference before and after the implemented programme. The fact that the students obtained the highest scores that they could from this survey before the implementation may have prevented the creation of a significant difference. Moreover, in the qualitative results of the study, it was observed that the students created discussion environments among themselves about the lives and work of the scientists. In addition, in the analysis of the composition documents written by the students, the codes of "*learning about scientists*" and "*learning by assuming a role*" were formed. In the analysis of the observation and document data, it was seen that the students also supported the idea that "*this activity should reach more students*", since they learned about the works of scientists by having fun, and by doing and experiencing, and they found the activity useful. Based on these findings obtained from the qualitative data, it can be said that the students' views towards scientists were positively affected by the implemented programme. Brodie (2010) stated that the nature of science and the working styles of scientists can be understood by recreating the life stories of scientists. Students who experience the animation of scientists and develop an idea about their lives through role play build a critical interaction with the past in their minds and perceive scientific processes more easily by empathizing with scientists, according to other conducted studies (Amaral et al., 2017; Borrow & Russo, 2015; Dorion, 2009; Hendrix et al., 2012; Odegaard, 2003).

The results obtained from the qualitative data of the study not only reveal the advantages of science theater plays but also demonstrate their contributions to students' personal development. It is understood that the participating students especially had the opportunity to discover themselves during the application process. In addition, the students stated that their self-confidence increased, their imagination and creativity developed, they gained different perspectives by exchanging ideas during the implementation process, during which their cooperation and collaboration increased, and they socialised by establishing communication with the group. Artistic activities in science education not only ensure the concretisation of abstract concepts by enabling the active use of examination, observation, discovery, and communication skills (McGregor, 2012), they also support daily life skills (Fulton & Simpson-Steele, 2016). It is stated that students improve their communication skills through science theater activities and that these activities also contribute to body control (Amaral et al., 2017; Borrow & Russo, 2015). Moreover, it is stated that science theater plays are creative and innovative activities that have the ability to motivate and to convey messages (Segedin, 2017), and that through science theater plays, participants experience a socialization process (Braund, 2015) and gain different perspectives (Dawson et al., 2009; Braund, 2015).

When the qualitative findings were examined, students suggested that the activity should be repeated; that it should be an overnight activity; that more students should participate; and that the activity should be held in different cities. Considering the contributions to students' personal development and their suggestions regarding the implementation process, it is seen that the science theater activities made students love science, provided an opportunity for them to learn by having fun with their peers, and provided them with effective and meaningful instruction, especially in science subjects. It was determined that the students tried to understand the steps in scientific studies by empathising with scientists and that they made progress in this regard. Previous research has revealed that science theater plays are an effective teaching tool in conveying what science is (Amaral et al., 2017), that students have a powerful experience of science with theater (Lanza et al., 2014), and that scientific concepts are understood more deeply and clearly through theater activities in science by associating ideas with prior knowledge (Hendrix et al., 2012).

Based on these results, it can be said that science theater plays are an effective communication tool that demonstrates a meaningful relationship with science through roles that focus on interpersonal interactions and that enables a permanent understanding of the history of science by establishing empathy with scientists. In our study, the science theater plays had a positive and decisive effect in increasing secondary school students' motivation towards science by providing an entertaining and educational environment. Furthermore, the results of our study show that science theater plays are a supportive and effective resource that facilitates educators in drawing attention to scientists and their works.

Limitations and Recommendations

In this study, it was concluded that theater activities created with the life stories of scientists enabled students to concretise knowledge, learn meaningfully, easily and by having fun, and had an increased effect on their attitudes towards the subject of science. The study has some limitations. Based on the results and limitations of the study, some suggestions for further studies are offered.

The research is limited to a participant group of 38 students (20 girls and 18 boys) selected from 7th grade secondary school students studying in the province of Muş, Turkey. Discussions can be conducted by comparing the obtained findings with the current research findings by conducting similar studies on science theater activities at different educational levels and with larger study groups. In addition, new studies can also examine students' socio-economic status, their parents' educational level and economic status, whether students have received education in theater or dramatic arts before, and cultural dimensions. In new studies, interviews can be conducted with students during or at the end of the implementation. By analyzing these interviews, more detailed information about students' perceptions can be obtained. Another important point is that although it is seen in the study that theater has a positive potential in science education, a follow-up study and research on the long-term effects of the implemented programme have not been conducted. Besides, the students' experiences of science theater activities over a four-week period may also have turned out to be insufficient for the desired effect on their views of scientists to occur. Plans can be prepared aimed at conducting experimental studies on the long-term effects of science theater activities on students' attitudes towards science, scientists, and science education, and on the permanence of the obtained results.

Another limitation of the study is that only one of the 11 scientists whose lives and inventions were examined through theater activities was a female scientist. In future studies, the life stories of female scientists should also be included, with an interdisciplinary perspective that brings science and art together. In addition, implementations can be made by using different artistic tools related to the lives of different scientists.

The third limitation of the study is the short implementation period. Accordingly, only important sections of the lives and works of the scientists examined in the study could be dealt with in the theater activities. This period may have been insufficient to create the desired effect. A similar study can be planned with a longer-term experimental study with a control group during the formal education period, and the obtained results can be compared with the results of the current study.

Interdisciplinary projects can be created in schools for students to learn about scientists, their lives, and their works. In these projects, the discussion of science-related issues among students can open new horizons. Students can acquaint themselves with science and scientists more easily with discussions such as these. Important sections of the life stories of scientists can be converted into science theater scenarios and transferred to textbooks. With these scenarios, which students will enjoy reading and can be animated in classroom or out-of-class activities,

more effective and permanent learning can be achieved. In order to create a positive perception and attitude towards scientists and an interest in these careers, trips to various institutions, organisations, and study areas can be organised so that students can become acquainted with science and scientists at a concrete level.

Acknowledgements

This study was carried out with the "Science on the Stage" project numbered 118B249, which was supported within the framework of the TÜBİTAK 4004 Nature Education and Science Schools programme. I would like to express my gratitude to my colleagues, Assoc. Prof. Dr. Ayça KARTAL, Assoc. Prof. Dr. Bekir YILDIRIM and Research Asst. Furkan ATMACA, who contributed to the study with their valuable ideas at every stage of the research and whose moral support I have always felt.

Ethical Approval

Ethical permission (17/01/2018 - E.4811) was obtained from Muş Alparslan University Ethics Committee for this research.

References

Akgün, A. (2016). Investigation of the Secondary School Students' Images of Scientists. *International Journal of Progressive Education*, 12 (1), 64-72. https://eric.ed.gov/?id=EJ1090811

Amaral, S. V., Montenegro, M., Forte, T., Freitas, F., & Teresa Girao da Cruz, M. (2017). Science in theatre – An art project with researchers. *Journal of Creative Communications*, 12(1), 1–18. https://doi.org/10.1177/0973258616688966

Ambusaidi, A., Al-muqeemı, F., & Al-salmı, M. (2015). Investigation into Omani Secondary School Students' Perceptions of Scientists and Their Work. *International Journal of Instruction*, 8(1), 173-188. https://doi.org/10.12973/iji.2015.8113a

Belliveau, G., & Lea, G.W. (2011). Research-based theatre in education. In S. Schonmann (Ed.) *Key concepts in theatre/drama education* (pp.333-338). Netherlands: Sense Publishers.

Bennett, J., & Hogarth, S. (2009). Would you talk to a scientist at a party? High school students "attitudes to school science". *International Journal of Science Education*, 31(14), 1975–1998. https://doi.org/10.1080/09500690802425581

Borrow, J., & Russo, P. (2015). A blueprint for public engagement appraisal: Supporting research careers. Cornell University, 1–17. https://arxiv.org/abs/1510.02017v1

Braund, M. (2015). Drama and learning science: An empty space? *British Educational Research Journal*, 41(1), 102–121. https://doi.org/10.1002/berj.3130

Brodie, E. (2010). Learning science through history. Primary Science, (111), 25–27. https://www.ase.org.uk/resources/primary-science/issue-111/learning-science-through-history

Büyüköztürk, Ş. (2008). *Data analysis for social studies (10th edition).* Pegem Academy.

Clark, V. L. P., & Ivankova, N. V. (2016). *Mixed Methods Research: A Guide to the Field* (1st ed.). Thousand Oaks: SAGE Publications, Inc.

Creswell, J. W., & Plano Clark, V. L. (2014). In Y. Dede, & S. B. Demir (Eds.), *Designing and conducting mixed methods research.* Anı Publishing.

Çokluk, Ö, Şekercioğlu, G., & Büyüköztürk, Ş. (2012). *Multivariate statistics for social sciences: SPSS and LISREL applications (Vol. 2).* Pegem Academy.

Dagher, Z. R., & Erduran, S. (2016). Reconceptualizing the nature of science for science education. *Science and Education*, 25(1–2), 147–164. https://doi.org/10.1007/s11191-015-9800-8

Danckwardt-Lilliestrom, K., Andrée, M., & Enghag, M. (2020). The drama of chemistry – supporting student explorations of electronegativity and chemical bonding through creative drama in upper secondary school. *International Journal of Science Education*, 42(11), 1862–1894. https://doi.org/10.1080/09500693.2020.1792578

Dawson, E., Hill, A., Barlow, J., & Weitkamp, E. (2009). Genetic testing in a drama and discussion workshop: Exploring knowledge construction. *Research in Drama Education*, 14(3), 361–390. https://doi.org/10.1080/13569780903072174

Dhanapal, S., Kanapathy, R., & Mastan, J. (2014). A study to understand the role of visual arts in the teaching and learning of science. *Asia-Pacific Forum on Science Learning and Teaching*, 15 (2), 1–25. https://eric.ed.gov/?id=EJ1053328

Dorion, K. R. (2009). Science through drama: A multiple case exploration of the characteristics of drama activities

used in secondary science lessons. *International Journal of Science Education,* 31(16), 2247–2270. https://doi.org/10.1080/09500690802712699

Fraenkel, J. ve Wallen, N. (2008). *How to design and evaluate research in education. (7th Ed.).* USA: McGraw-Hill Companies, Inc.

Fulton, Lori A., & Simpson-Steele, J. (2016). Reconciling the Divide: Common Processes in Science and Arts Education. *The STEAM Journal,* 2(2), 1-8. https://doi.org/10.5642/steam.20160202.03

Fung, Y. Y. H. (2002). A Comparative Study of Primary and Secondary School Students' Images of Scientists. *Research in Science & Technological Education,* 20(2), 199-213. https://doi.org/10.1080/0263514022000030453

Gliner, J. A., Morgan, G. A., & Leech, N. L. (2015). *Research methods in practice: An approach that integrates pattern and analysis.* (Translation Editor: Turan, S.). Nobel Publishing.

Gemtou, E. (2014). Exploring the possibilities of postdramatic theater as educational means. *International Journal of Education & the Arts*, 15(12), 1-15. https://eric.ed.gov/?id=EJ1045916

Guerra, A., Braga, M., & Reis, J. C. (2013). History, philosophy, and science in a social perspective: A pedagogical project. *Science and Education,* 22(6), 1485–1503. https://doi.org/10.1007/s11191-012-9501-5

Güler, T., & Akman, B. (2006). 6 Year Old Children's Views on Science and Scientists. *Hacettepe University Journal of Education*, 31(31), 55-66. https://dergipark.org.tr/tr/pub/hunefd/issue/7807/102395

Hendrix, R., Eick, C., & Shannon, D. (2012). The integration of creative drama in an inquiry-based elementary program: The effect on student attitude and conceptual learning. *Journal of Science Teacher Education,* 23(7), 823–846. https://doi.org/10.1007/s10972-012-9292-1

Idin, S., & Aydogdu, C. (2016). Opinions of 7th Grade Students about Enriched Educational Practices in the Scope of Science Course. *International Journal of Research in Education and Science (IJRES),* 2(2), 345-358. https://eric.ed.gov/?id=EJ1105122

Karaçam, S., Aydın, F., & Digilli, A. (2014). Evaluation of Scientists Represented in Science Textbooks in Terms of Stereotype Scientist Image. *Ondokuz Mayis University Journal of Faculty of Education*, 33(2), 606-627. https://dergipark.org.tr/tr/pub/omuefd/issue/20279/214946

Kaya, N. O., Doğan, A., & Öcal, E. (2008). Turkish elementary school students' images of scientists. *Eurasian Journal of Educational Research*, 32, 83-100.

Kruse, J. W. (2010). Historical short stories in the post- secondary biology classroom: Investigation of instructor and student use and views. *Doctor of Philosophy*, Iowa State University, Ames, Iowa.

Laçin Şimşek, C. (2011). Science and technology teachers' situation of integrating history of science into their lessons. *International Online Journal of Educational Sciences,* 3(2), 707-742. https://www.acarindex.com/dosyalar/makale/acarindex-1423904395.pdf

Lanza, T., Crescimbene, M., & D'Addezio, G. (2014). Bringing earth ınto the scene of a primary school: A science theatre experience. *Science Communication,* 36(1), 131–139. https://doi.org/10.1177/1075547012473841

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interes in science. *International Journal of Science Education,* 32(5), 669–685. https://doi.org/10.1080/09500690902792385

Mc Gregor, D. (2012). Dramatising science learning: Findings from a pilot study to re-invigorate elementary science pedagogy for five-to seven-year olds. *International Journal of Science Education,* 34(8), 1145–1165. https://doi.org/10.1080/09500693.2012.660751

McKillup, S. (2012). *Statistics explained: An introductory guide for life scientists (Second ed.).* United States: Cambridge University Press.

Merriam, S. B. (2015). In S. Turan (Ed.), *Qualitative research: A guide to pattern and practice.* Nobel Publishing.

Mertler, C. A., & Vannatta, R. A. (2005). *Advanced and multivariate statistical methods: Practical application and interpretation (third edition).* United States: Pyrczak Publishing.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: SAGE Publications.

Neelands, J. (2007). Taming the political: The struggle over recognition in the politics of applied theatre. *Research in Drama Education*, 12(3), 305-317. https://doi.org/10.1080/13569780701560388

Odegaard, M. (2003). Dramatic science: A critical review of drama in science education. *Studies in Science Education,* 39(1), 75–101. https://doi.org/10.1080/03057260308560196

Ong, K. J., Chou, Y. C., Yang, D. Y., & Lin, C. C. (2020). Creative drama in science education: The effects on situational interest, career interest, and science-related attitudes of science majors and non-science majors. *Eurasia Journal of Mathematics, Science and Technology Education,* 16(4), 1–18 https://doi.org/10.29333/ejmste/115296

Öcal, E. (2007). Image and views of primary school 6th, 7th and 8th grade stıudents on scientists. Unpublished Master Dissertation. Gazi University, Ankara.

Öcal, E. (2014). The impact of drama method and puppet / Karagöz applications in teaching the topic of our body systems on student success and attitude. Unpublished Doctoral Dissertation. Gazi University, Ankara.

Özel, M. (2012). Children's images of scientists: Does grade level make a difference? *Educational Sciences:*

Theory& Practice, 12 (4), 3187–3198. https://eric.ed.gov/?id=EJ1003011

Özkan, B., Özeke, V., Güler, G., & Şenocak, E. (2017). Undergraduate Students' Images of Scientist and Some Variables Affecting Their Images. *Erzincan Üniversitesi Journal of Faculty of Education,* 19(1), 146-165. https://doi.org/10.17556/erziefd.308669

Pallant, J. (2015). In S. Balcı, & B. Ahi (Eds.), *SPSS user manual.* Nobel Publishing.

Patton, M. Q. (2014). In M. Bütün, & S. B. Demir (Eds.), *Qualitative research and evaluation methods.* Pegem Academy Publishing.

Peleg, R., & Baram-Tsabari, A. (2011). Atom surprise: Using theatre in primary science education. *Journal of Science Education and Technology,* 20(5), 508–524. https://doi.org/10.1007/s10956-011-9299-y

Saldana, J. (2019). In A. T. Akcan, & S. N. Şad (Eds.), *Handbook for qualitative researchers.* Pegem Academy Publishing.

Segedin, L. (2017). Theatre as a vehicle for mobilizing knowledge in education. *International Journal of Education & the Arts*, 18(15), 1-12. https://eric.ed.gov/?id=EJ1140611

Sepel, L. M. N., Loreto, E. L. S., & Rocha, J. B. T. (2009). Using a replica of leeuwenhoek's microscope to teach the history of science and to motivate students to discover the vision and the contributions of the first microscopists. *CBE-Life Sciences Education,* 8(4), 338–343. https://doi.org/10.1187/cbe.08-12-0070

Shen, J., & Wang, C. (2020). *Interdisciplinary science learning International encyclopedia of Education (4th ed.).* Elsevier.

Sloman, A. (2011). Using participatory theatre in international community development. *Community Development Journal,* 47(1), 42-57. https://doi.org/10.1093/cdj/bsq059

Şeker, H., & Güney, B. G. (2012). History of science in the physics curriculum: A directed content analysis of historical sources. *Science & Education,* 21(5), 683-703. https://eric.ed.gov/?id=EJ962195

Teke, H., Dogan, B., & Duran, A. (2015). Influence of the simulation method on 7th grade students' achievements in science and technology lessons. *International Journal of Research in Education and Science (IJRES),* 1(2), 111-118. https://files.eric.ed.gov/fulltext/EJ1105195.pdf

Thorndike, R. M., & Thorndike-Christ, T. (2010). *Measurement and evaluation in psychology and Education (eighth edition).* Pearson Education.

Tripp, B., & Shortlidge, E. E. (2019). A framework to guide undergraduate education in interdisciplinary science. *CBE—Life Sciences Education,* 18(3), 1–12. https://doi.org/10.1187/cbe.18-11-0226

Wang, H. A., & Cox-Petersen, A. M. (2002). A comparison of elementary, secondary and student teachers' perceptions and practices related to history of science instruction. *Science & Education,* 11(1), 69-81. https://doi.org/10.1023/A:1013057006644

Wang, H. A., & Marsh, D. D. (2002). Science instruction with a humanistic twist: teachers' perception and practice in using the history of science in their classrooms. *Science & Education,* 11(2), 169-189. https://doi.org/10.1023/A:1014455918130

White, V., & Belliveau, G. (2010). Whose story is it anyway? Exploring ethical dilemmas in performed research. *Performing Ethos International Research Journal,* 1(1), 85-95. https://doi.org/10.1386/peet.1.1.85_1

Yıldırım, A., & Şimşek, H. (2016). Qualitative research methods in the social sciences (10th edition). Seçkin Publishing.

Zhai, J., Jocz, J. A., & Tan, A. L. (2014). Am I like a scientist? : Primary children's images of doing science in school. *International Journal of Science Education,* 36(4), 553-576. https://doi.org/10.1080/09500693.2013.791958