

Using the Mixed-Meta Method to Assess Portfolios in Science Teaching

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Abstract: The purpose of this research is to assess portfolio studies in science education in Turkey. The mixed-meta method, which comprises meta-analysis and meta-thematic analysis methods, was used to assess quantitative and qualitative data through document analysis. Studies retrieved from certain databases within the scope of specific criteria were examined with the CMA and MetaWin tools for meta-analysis, and the effect size was found to be as great as $g = 1.005$ among the 17 studies included in the analysis. It was concluded that the usage of portfolios in science teaching has a good effect. 13 studies based on document analysis within the framework of the determined criteria were assessed with the Maxqda program using content analysis in the meta-thematic analysis. Themes were created, and certain codes were obtained according to these themes. These are the following themes: the effect of portfolios on academic achievement, classroom environment, and 21st-century skills; negative aspects of using portfolios; and recommendations for using portfolios in science education. It has been concluded that the research findings are consistent, and the usage of portfolios in science education has a favorable impact in a variety of ways.

Science Insights Education Frontiers 2024; 24(1):3895-3918
DOI: 10.15354/sief.24.re399

How to Cite: Yaşar, M. D., Batdi, V., Kiliç B., & Kiliç A. N. (2024). Using the mixed-meta method to assess portfolios in science teaching. *Science Insights Education Frontiers*, 24(1):3895-3918.

Keywords: Meta-Analysis, Meta-Thematic, Portfolio, Science Education

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Conflict of Interests: None

Funding: No funding sources declared.

AI Declaration: The authors affirm that artificial intelligence did not contribute to the process of preparing the work.

Ethics Approval: Ethical approval is not required for this research.

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Introduction

THE CONCEPT of learning in the twenty-first century is updated with an understanding that develops and alters on a daily basis. A learning process that overlaps with lifelong learning is deemed vital in the new education paradigm (Tunca et al., 2015). Its goal is to assist students become individuals who can conduct independent research, question, and assess what they have learned from a critical standpoint. In this sense, both teachers and the evaluation system must be revised (Somuncuoğlu & Yıldırım 1998). Traditional assessment takes a result-oriented approach that attempts to quantify how much knowledge is maintained in memory. It looks to be still popular today due to its practical benefits (time, money, and effort). These assessment methods include fill-in-the-blank questions, short-answer questions, true or false questions, matching questions, open-ended questions, and multiple-choice questions (Demirören et al., 2009). In traditional assessment, students are requested to write down all of their knowledge and skills on a test paper in a certain amount of time while under the supervision of at least one instructor (Şahinkarakaş, 1998). This type of assessment has several drawbacks in that it cannot measure high-level skills. This assessment primarily provides for the examination of lower-level skills, which are tested using achievement assessments. The success scores acquired from these assessments cannot indicate the learners' true learning skills, i.e. their experiential dimension (Öncü, 2009). Furthermore, the danger of students learning exam-oriented subjects solely for the sake of the exam and guiding their learning style toward measurement should not be overlooked (Özen, 2011). These drawbacks of traditional assessment have highlighted the necessity for contemporary evaluation. This resulted in the shift from "test logic" to "evaluation logic." In the evaluation logic, there is an assessment in which both the process and the result are considered together. This procedure assures that the student accepts responsibility for his or her own evaluation, that he or she is active, dynamic, self-critical, and cooperative (Tatar & Ören, 2009).

Unlike traditional assessment and evaluation, alternative measurement and evaluation methodologies have acquired traction in contemporary assessment and evaluation. A portfolio is one of these (Demirören, et al., 2009). A portfolio is an evaluation technique that displays students' work and demonstrates their progress throughout the learning process in relation to the targeted goals. It is the collection and organization of student work into a file. This compilation, on the other hand, includes investigations conducted in accordance with established strategies and criteria (Baki & Bilgin, 2004). In other words, students organize their life experiences and reflect them in the form of a collection (Kaptan & Korkmaz, 2000). Portfolios, as opposed to assignments, reinforce themes taught, reflect

them in the form of posters or activities, file them, and provide feedback to students (Kutlu, et al., 2008). This is substantially different from previous techniques of attaching files. Because the portfolio exposes all aspects of what the students have done, from the first piece of work to the correction paper, it reflects the learner's own style (Öncü, 2009). In this respect, a portfolio is an achievement bank that reflects students' worksheets, activities they carried out within the scope of the subjects, experiments, project reports, performance notes, evaluation reflective diaries, and other learning skills they acquired during the learning process (Şenol & Güzeller, 2007; Turan & Sakız, 2014). Furthermore, it contains video recordings, images, personal drawings, written notes, audio tapes, and stunning audio-visual materials (Turan & Sakız, 2014). Thus, the portfolio enables both the teacher and the student to track their own progress through the educational process. It not only allows students to review their work with honesty and demonstrate how it can reflect their own beliefs, but it also allows their classmates to examine these files and see alternative perspectives (MoNE [Minister of National Education], 2006). With samples from their work, the portfolio illustrates what pupils know and how they know it. This supports the premise that students should approach their education with a creative and critical mindset in order to promote their future learning. Portfolios boost self-esteem by empowering students to take charge of their own education (Betty, 2012). Furthermore, the portfolio fosters and documents high-level cognitive skills. Based on this, it might help to make critical decisions by establishing which areas the student is talented in through the studies he or she submits (Turan & Sakız, 2014).

Duschl and Gitomer (1997) investigated the impact of portfolios on science education in their project. They studied how portfolios may be constructed and used in science classes for secondary school students in their project termed Project SEPIA (Science Education through Portfolio Instruction and Assessment). During this process, they came to the conclusion that "the teacher's activities and decisions" are the most essential factors in establishing quality and success in teaching. Feedback is an essential component of portfolio-based teaching in science education. According to Oğan-Bekiroğlu (2004) providing feedback on the material learnt is more crucial than repeating and comprehending it. Because it is assumed that information is organized in this manner. Therefore, a portfolio technique without feedback is nothing more than a collection of files containing completed work (Kutlu et al., 2008). Portfolios must be evaluated and monitored at regular intervals within the framework of a specific plan. Again, the teacher should notify the students of their progress in the portfolios they are following because the mutual interaction between teacher and student is essential in this method. Correct and effective feedback helps

the student see her or his shortcomings, mistakes, and weaknesses, as well as her or his strengths (Turgut & Baykul, 2011).

The portfolio contains a wide range of research. Portfolios, according to a Deniz-Kan (2007) study, allow students to make self-criticism, which in turn allows them to develop self-esteem, self-confidence, and self-evaluation. Thus, it was determined that a preschool child's individual achievement improves. Birgin (2008) used a portfolio, an alternative evaluation approach, to assess pupils in the seventh grade of primary school in mathematics courses. It was determined that the students provided positive comments as a result of the portfolio application. Simultaneously, it was determined that the student offered thorough information to herself or himself and her or his teacher, as well as establishing dynamic communication between teacher and student. Gülbahar-Güven and Köse (2006) explored the effects of adopting electronic portfolios in the evaluation of education for prospective teachers in their study. An e-portfolio was employed in a project-based teaching style course for teacher candidates. The candidates' comments were gathered, and it was found that this technique had numerous advantages. Bahçeci and Kuru (2008) studied the impact of portfolio application on undergraduate students' self-efficacy and life skills. In this study, contemporary and conventional assessment methods were contrasted. As a result, it was determined that the portfolio technique used in the human anatomy course is beneficial for teaching. İzgi and Güçlüm (2012) employed a quasi-experimental technique on 66 eighth grade primary school pupils in their study. They sought to look into the impact of portfolio assessment in science education on exam anxiety and learning retention. According to the study's findings, there is a statistically significant association between the persistence of learning and test anxiety in the experimental group *v.s.* the control group to whom the portfolio was applied. Looking at all of these researches, it is clear that the impact of portfolios on science education cannot be overlooked.

The Importance of the Research

The conditions demanded by the new era include not only having information and abilities, but also transferring and applying these knowledge and skills in one's life. Therefore, in today's educational paradigm, ideas like communication skills, technological literacy, argumentation, and so on come to the fore. These new ideas prompted the development of new programs, methodologies, and, as a result, a new measurement-evaluation functions. Different evaluation procedures, *i.e.*, alternate measurement and evaluation, were required in this case (Ünal, 2019). A portfolio is one of these different assessments. Portfolios have evolved and changed throughout time. While it was once merely one of several alternative measuring and assessment procedures, it has gradually evolved into an instructive method. Instead of

relying solely on the assessment of the student, this method considers the student's activity in the educational environment as well as the quality of instruction (Challis, 2001). This alteration in the portfolio has also received attention in the sphere of science education. According to Duschl and Gitomer (1997) with the recent acceleration of change in the field of science education, it is critical that students acquire high-level abilities and that education emphasizes this. It was stressed in this regard that present teaching methods should be examined, and portfolios should be used for this purpose. As a result, presenting the current situation of the studies in the portfolio will allow us to see the advantages and disadvantages in their entirety. In this approach, it is hoped that future research will be more qualified and will contribute to instructional evaluation efforts.

Purpose of the Research

The purpose of this research is to assess portfolio studies in science education in Turkey. For this purpose, answers were sought to the following questions.

- (1) In the research included in the meta-analysis, what is the effect of portfolio applications in science education on students' academic success?
- (2) According to the participants' views on PBL uses in science education, what are:
 - The effect of portfolios on academic achievement?
 - The effect of portfolios on the classroom environment?
 - The effect of portfolios on 21st-century skills?
 - Negative aspects of the portfolio?
 - The recommendations for the portfolio?

Method

A mixed-meta method with two stages was employed in this research to investigate the effectiveness of portfolio use in science education. It was used to determine the effectiveness of portfolio application in science education, with meta-thematic in the qualitative dimension and meta-analysis in the quantitative dimension. The mixed-meta method is one that employs both verbal and numerical data. In other words, it is a method that combines the quantitative method with numerical data with the qualitative method with verbal data (Alkan et al., 2019). In the mixed-meta method, quantitative data is analyzed using CMA/MetaWin tools, and qualitative data is analysed using Nvivo/Maxqda programs. It provides the opportunity to combine and examine the products obtained from the programs (Batdı, 2020, p.3). The mixed-meta method is a combination of meta-analysis and meta-

thematic methods based on document analysis (Batdı, 2021, p.1218). The analysis approach in this research, which used the mixed-meta method, is divided into two categories: meta-analysis and meta-thematic analysis.

Meta-Analysis Process

Meta-analysis is used to create the same and similar research in addition to performing a thorough literature review. As a result, it is possible to integrate various study data and synthesize them using an objective manner (Göçmen, 2013).

Data Collection Process

In this research, the Higher Education Council (HEC) and Google Scholar databases in English and Turkish were searched using keywords such as “portfolio use in science education, the effect of portfolio use on success in science education” to find studies on the use of portfolios in science education in the literature. Certain inclusion criteria were taken into account in the screenings. In this context, it was critical that the research be published at the national level to investigate the influence of portfolio use in science education and on learners’ academic achievement. In addition to these criteria, the arithmetic mean, number of samples, and standard deviation (\bar{x} , n , SD) values required for meta-analysis were carefully considered. Those who did not match these requirements were excluded from the study. As a result of taking specific criteria into account, a total of 42 studies—24 theses and 18 articles—were reached, and 13 out of 24 theses and 4 out of 18 articles—a total of 17 studies—were included in the meta-analysis. The process of including these studies in the analysis is presented in the PRISMA flow diagram in **Figure 1**, together with the studies included in the meta-thematic analysis.

Several researches on the use of portfolios in science teaching were discovered when scanning various databases. A total of 42 studies were identified for meta-analysis, with 30 studies for meta-thematic analysis. Meta-thematic analysis took into account the databases, year range, and study publication status that were considered in the context of meta-analyses. However, in the meta-thematic analysis, qualitative studies based on participant opinions regarding the use of portfolios in science education were included in the analysis.

Due to duplication, 25 of the studies accessed were excluded from the meta-analyses. The remaining 17 studies were analyzed. For meta-thematic analysis, 17 papers were removed because their topics were irrelevant, whereas 13 studies were included. The remaining studies were

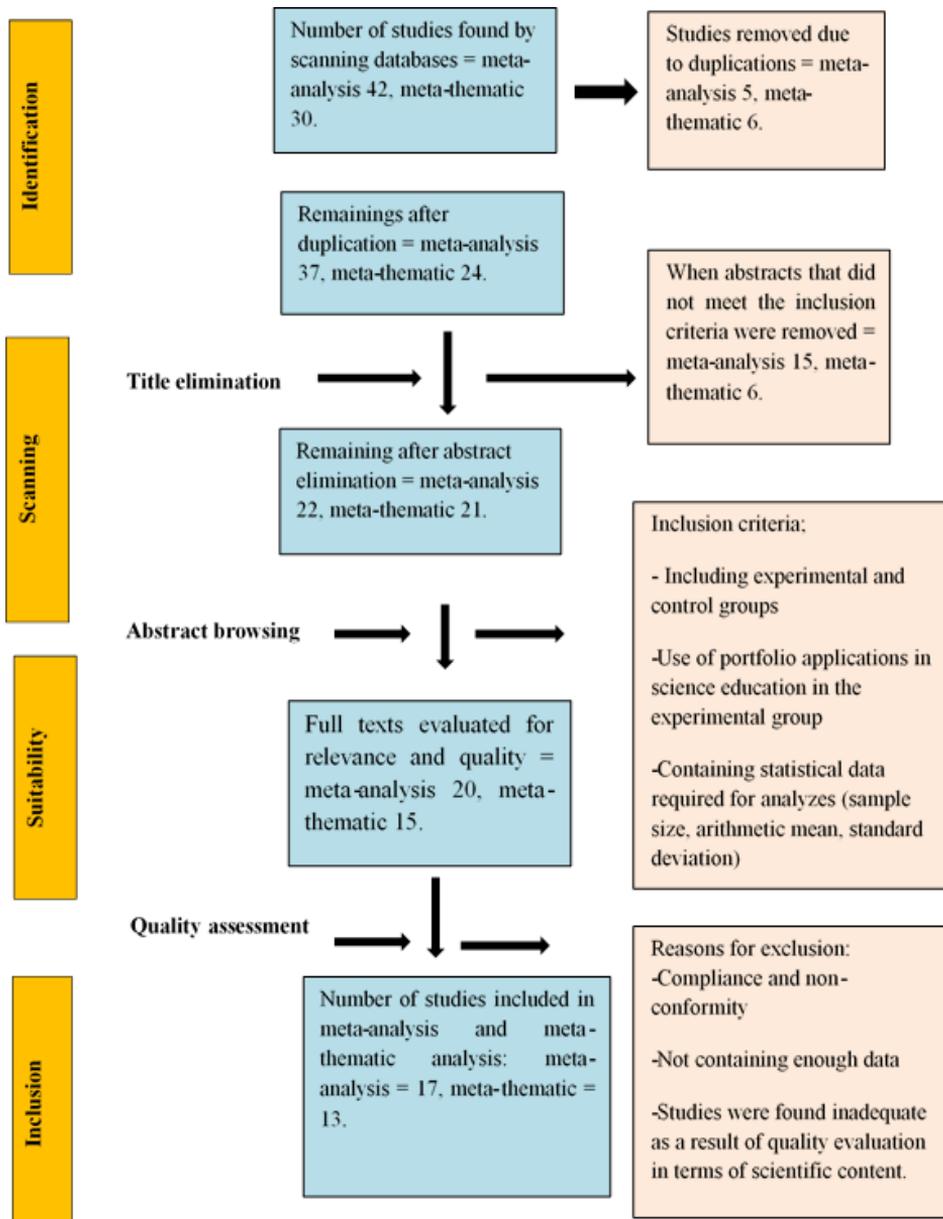


Figure 1. The Process of Studies Included in the Analysis.

chosen based on a variety of study criteria, including suitability, sufficient data content and scientific quality, as shown in **Figure 1**, using meta-analysis and meta-thematic analysis. At this stage, it is necessary to evaluate the quality of the studies and check their compliance with the level of scientific competence in order to achieve quality study results and make

original and unique contributions to the field. In this regard, emphasis was placed on presenting the studies in an unbiased, systematic, and organized manner, as well as ensuring their relevance and originality. As a consequence of extensive reviews, studies appropriate for meta-analysis and meta-thematic analysis were included in the analytical process.

Data Analysis

The meta-analysis data were analyzed using MetaWin and the CMA 2.0 programs. The g value obtained was interpreted using Thalheimer and Cook's (2002, p.4-9) level classification. Thalheimer and Cook (2002, p. 3–9) defined the impact level as: $-0.15 \leq \text{Cohen's } d < 0.15$ at a minor level; $0.15 \leq \text{Cohen's } d < 0.40$ at a small level; $0.40 \leq \text{Cohen's } d < 0.75$ at a moderate level; and $0.75 \leq \text{Cohen's } d < 1.10$ at a large level; $1.10 \leq \text{Cohen's } d < 1.45$ were classified as very large level, and $1.45 \leq \text{Cohen's } d$ as excellent level. The effect size is important in meta-analysis since it helps determine the effect value of the independent variable on the dependent variable.

Meta-Thematic Analysis Process

In the second dimension of the research, it was aimed at obtaining rich data by combining the findings of qualitative research and performing meta-thematic analysis. Meta-thematic analysis takes place based on document analysis. In meta-thematic, coding created with specific criteria is summarized into specific categories, with the goal of generating holistic results by revealing specific themes (Büyükoztürk et al., 2018 p.259-260). As a result, the research conducted attempted to acquire comprehensive data about the study through meta-thematic and meta-analysis.

Data Collection and Analysis

Document analysis was used in this research to acquire data on the effectiveness of portfolio use in science education. Document review is defined as the process of reading, reviewing, querying, analyzing, and methodically carrying out the documents collected through a literature review of the primary and secondary sources that comprise the study's data set. Document review allows you to make sense of the data you've gathered, assess it, and synthesize it (Özkan, 2021 p.2). The contents of the studies that met the qualitative requirements were reviewed in the research, and their common points were discovered. When selecting common points, structural and semantic similarities in the data were taken into account. These common points were classified and reinterpreted. The meta-thematic analysis includes

13 studies. These studies were analyzed using the Mawqda-11 qualitative data analysis program.

Coding

The papers included in the research were examined in the meta-thematic analysis dimension, and themes were produced with the requisite coding. Coding is the process of categorizing information. The researcher selects his or her own categories in published papers and theses by focusing on his or her own study subject (Büyüköztürk et al., 2018, p.261-262). The codes obtained in this research were analysed with the Maxqda-11 program. As a result of the analysis, the coding was grouped into five themes. Models were created by grouping portfolios under five themes: “The effect of portfolios on academic achievement”, “The effect of portfolios on the classroom environment”, “The effect of portfolios on 21st-century skills”, “Negative aspects of the portfolio” and “The recommendations for the portfolio”. The research theses were coded by writing the thesis number and page number side by side (example: 123456, p.32).

Reliability in the Meta-Thematic Analysis Process

It is a well-known truth that capturing objects in qualitative research is challenging. Therefore, qualitative researchers use a range of strategies to increase the “credibility” of their findings (Merriam, 2013, p.205). One of these is triangulation, which is the comparison of the findings of two or more data gathering methods or two or more data sources (Başkale, 2016). In this research, two of the authors worked together from the beginning to the end of the research and exchanged ideas during the data collection, analysis, interpretation, and reporting processes.

Expert review is another view. It contributes to credibility when an expert who is knowledgeable about the subject of the research and methodology reviews the article and gives recommendations (Merriam, 2013, p.210). Throughout the analysis, coding, and interpretation of the study, a second expert researcher provided constant opinions, and required arrangements were made within the framework of these opinions.

Results

The findings of the quantitative (meta-analysis) and qualitative (meta-thematic) analyses are reported under subheadings in this section of the research. First, the interpretation of meta-analysis data from studies on portfolio use in science education is addressed in this context. Following that,

Table 1. Meta-Analysis Findings.

Models	95% Confidence Interval			Heterogeneity			
	N	G	Lower	Upper	Q	P	I
SEM	17	1.086	0.957	1.214	389.971	0.000	95.897
REM	17	1.692	1.041	2.343			

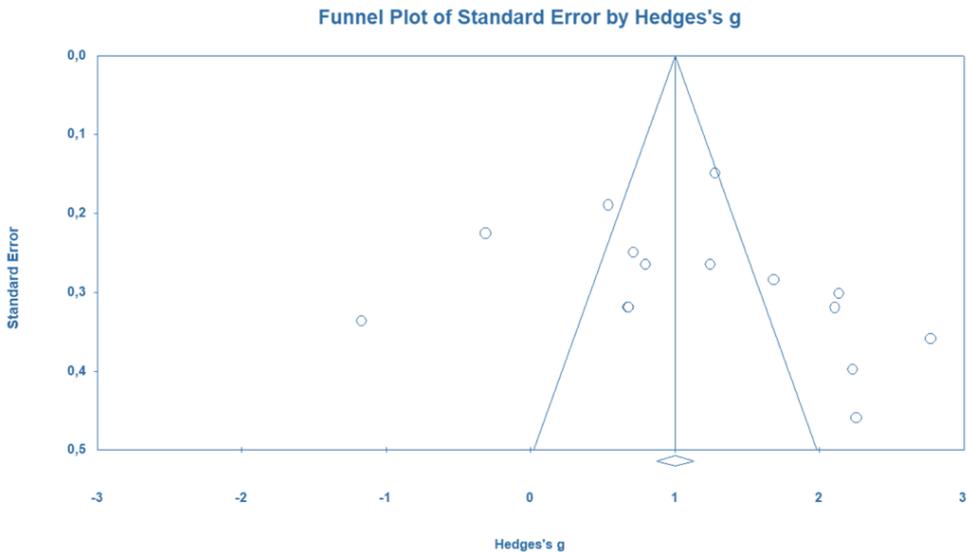


Figure 2. Funnel Plot Chart.

the findings and comments derived from the meta-thematic analysis of the study undertaken on the subject are included.

Meta-Analysis Results

Table 1 summarizes the findings, including meta-analysis data. The effect level according to REM was calculated as 1.692 [1.041; 2.343], and this effect level was assessed as 1.45 Cohen’s d according to Thalheimer and Cook’s (2002, p.3-9) classification in Table 1. This value obtained is at an excellent level, and it has been determined that the use of portfolios in science education has a positive effect on the academic achievement of students.

The graph in **Figure 2** is a summary of the meta-analysis data generated with the MetaWin and CMA data analysis programs, and it includes a funnel plot illustrating publication bias in addition to being

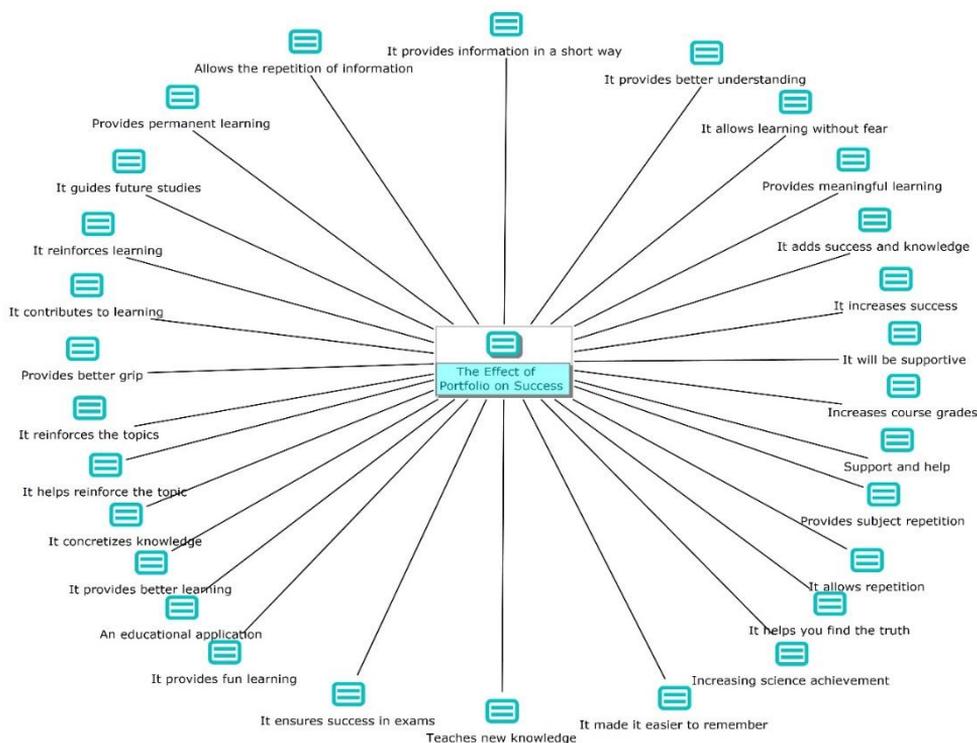


Figure 3. The Effect of Portfolios on Academic Achievement.

analyzed in a visual dimension (Cooper, et al., 2009, p428). Data gathered using the Meta Win and CMA analysis programs sometimes reveal scattering (Borenstein, et al., 2009). On the other hand, a funnel plot chart is given to show whether there is a publication bias. The 995 value obtained as a result of the calculations in the research indicates the error protection number used to reduce or eliminate the bias that occurs in the meta-analysis [Fail Safe (FSN)] (Rosendhal, 1979, p.638).

According to the study that revealed the number of FSNs, the influence of bias can be minimized by incorporating 995 additional papers in the scope of the meta-analysis. However, when the number of 995 obtained by calculating the number of studies included in the meta-analysis is evaluated, it is interpreted that the FSN value for the current study is a high value that cannot be achieved, and that the analysis is quite reliable, given that there is no publication bias (Cheung & Slavin, 2011, p.288).

Findings Regarding Meta-Thematic Analysis

Data from meta-thematic analysis are given in this section of the research. For the data, many codes and themes are provided. The investigation

resulted in five themes for the use of portfolios in science education: *The effect of portfolios on academic achievement, the effect of portfolios on the classroom environment, the effect of portfolios on 21st-century skills, Negative aspects of using portfolios and Recommendations for using portfolios*. Models were created for these themes and codes. The models are presented, and they are backed up by quotes from the sources from which the codes are taken.

Figure 3 shows the codes associated with the theme of the effect of portfolios on academic achievement in scientific education. Under the theme of the impact of a portfolio on academic success, it provides such codes as *permanent learning, contributes to learning, provides better comprehension, provides mental visualization, reinforces subjects, provides the opportunity to apply what we have learned, is useful in understanding and interpreting information, ensures subject reinforcement, concretizes knowledge, provides better learning, and provides meaningful learning*, among others. In page 121 of the source code 442974, it says “*I think the portfolio is effective in reinforcing what we have learned; I think it is more permanent when we do it by applying it and adding things ourselves; I think it increases our creativity and skills.*” On page 192 of the source code for 373632, it states: “*First of all, I think it is useful; because our homework is not forgotten; we look at each other’s with ease; I also find the process good*”. On page 119 of the source code 313929, it states: “*Yes, it is necessary; because it prevents him from forgetting the information he has learned; yes, children’s education level improves faster*”. On page 96 of the source code 199552, it says: “*it had an impact on the exams; it had an impact on questions at school; with his influence, we entered many competitions, we organized competitions, we conducted experiments, we held a competition about static electricity, and thanks to this study, we learned the impact of electricity and technology on human life.*” The usage of a portfolio, as demonstrated by the phrases, reinforces learning, ensures permanent learning, prevents material from being lost, raises the level of education, and ensures exam achievement. Other detailed codes regarding the effect of portfolios on academic achievement can be seen in the model in **Figure 3**.

Figure 4 shows the codes under the theme of the impact of portfolios on the classroom environment. Some of the codes belonging to this theme are listed as follows: *It makes them enjoy the course; it has peer evaluation; it provides an exchange of ideas; it provides feedback; it provides feedback opportunities; it makes them love the science course; it enables them to be active in the lessons; and it enables the exchange of ideas*. On page 121 of the source code 442974, it states: “*Portfolio evaluations are a suitable method to receive feedback; they enable students to review their portfolios themselves, see their shortcomings, mistakes, or areas where they did very well, and chart their own path in their next work*”. On page 118 of the

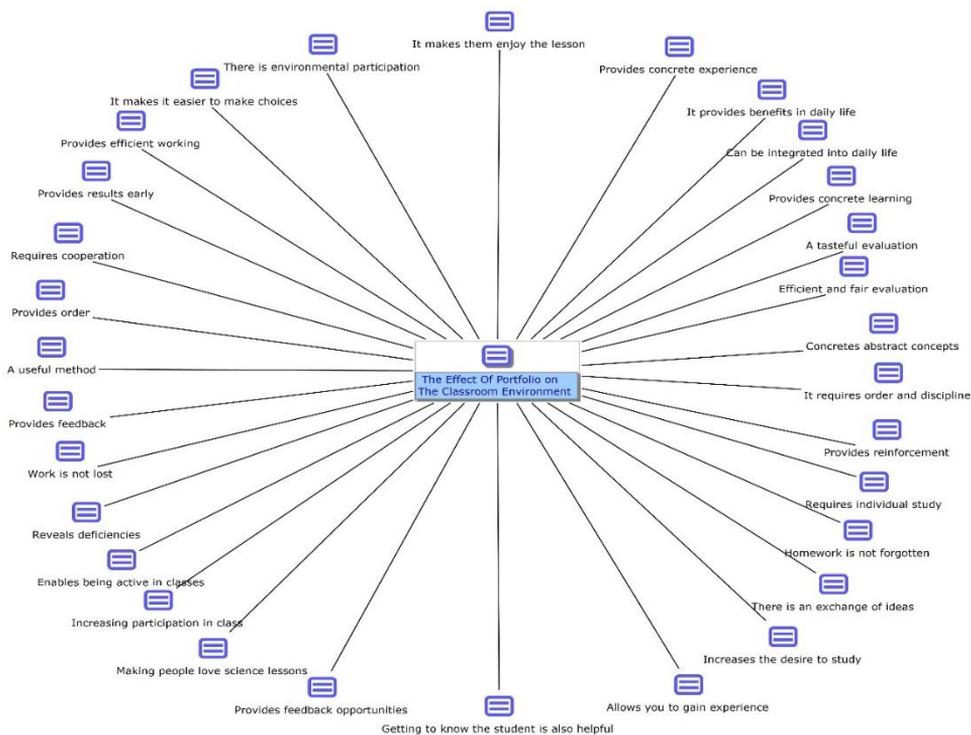


Figure 4. The Effect of Portfolio on the Classroom Environment.

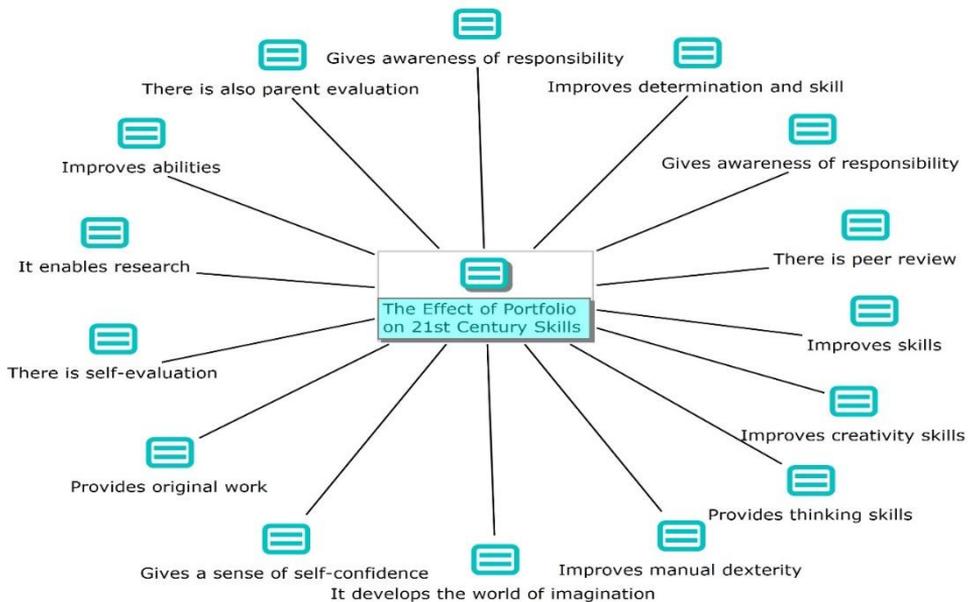


Figure 5. The Effect of Portfolios on 21st-Century Skills.

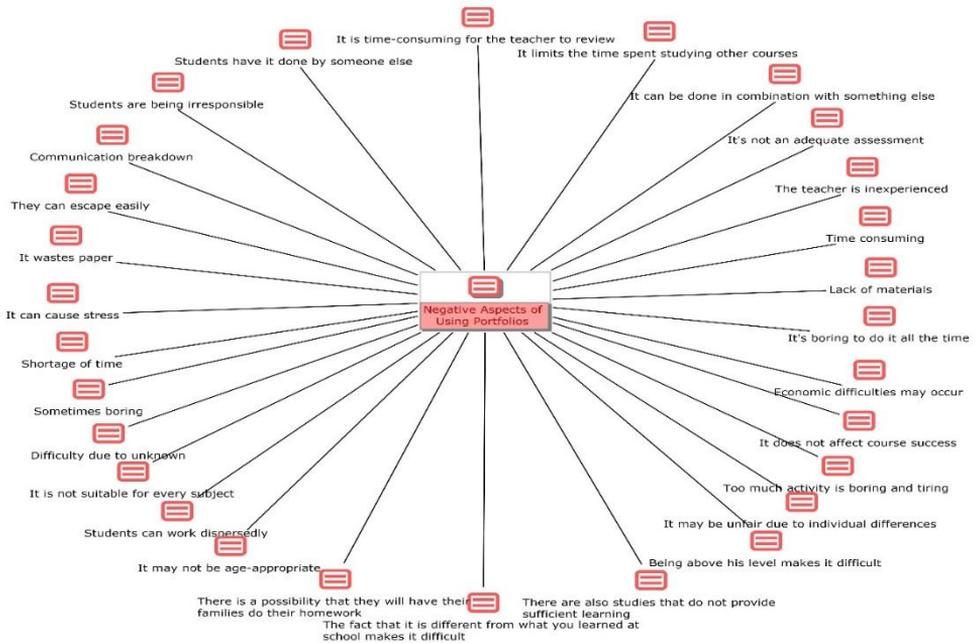


Figure 6. Negative Aspects of Using Portfolios.

source code 313929, it says “I think it is necessary because having the skills together in a file is useful for me to learn what the student does annually and what stages he/she has gone through.” On page 96 of the 199552 source code, it states “We can prepare the file at home and come and explain the topic in science class; its biggest contribution is that it helps people who do not like science to love it; we saw this in our class: if even a disorganized person like our friend named T. keeps a file, everyone else keeps a file.” As seen in the sample expressions, using a portfolio gives feedback, helps them understand their flaws, guides future studies, and can be said to make kids enjoy science lectures. **Figure 4** shows further codes from this theme in greater depth.

Figure 5 shows the codes related to the theme of the impact of portfolio use in science education on 21st-century skills. Some codes related to the theme of the effect of portfolio use on 21st-century skills are: “It enables research; develops creativity skills; gives awareness of responsibility; develops manual dexterity; develops the world of imagination; develops determination and skill; there is self-evaluation; develops talents; provides thinking skills; self-esteem; it gives a sense of trust and awareness of responsibility.” In the source code 313929, page 118, it says, “I believe that our students develop their talents and thinking power better in this way, and yes, I think it is necessary; the student becomes responsible.” In the

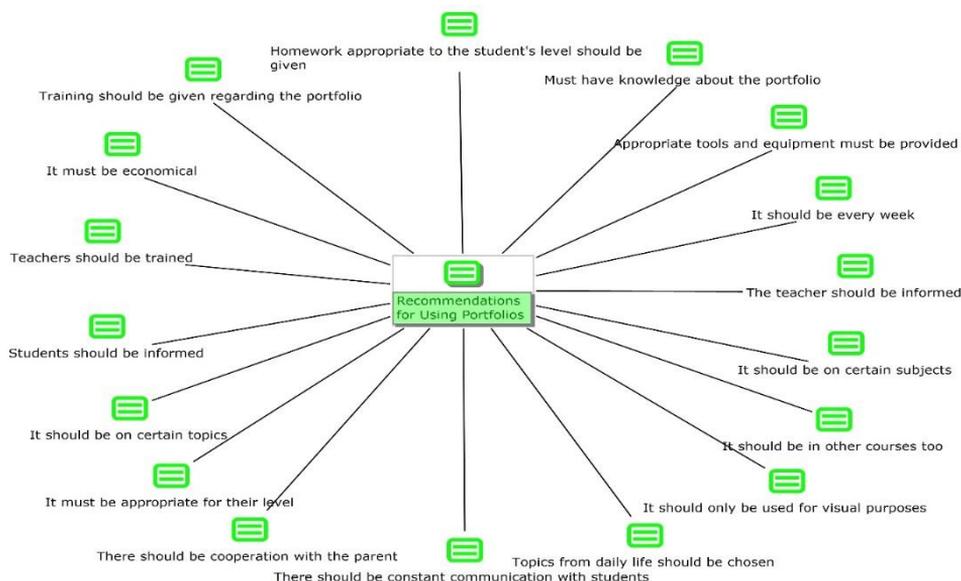


Figure 7. Recommendations for Using Portfolios.

source code 373632, page 200, it says, *“It is nice to evaluate and be evaluated; I can prepare myself accordingly.”* In the source code for 442974, page 121 states, *“I think the portfolio file is effective in reinforcing what we have learned; I think it is more permanent when we do it by applying it and adding something ourselves; I think it increases our creativity and skills.”* The sample expressions show that using a portfolio improves responsibility, develops creativity, increases abilities, and gives chances for self and peer evaluation. **Figure 5** depicts further codes from this theme in greater detail.

Figure 6 shows the codes related to the theme of negative aspects of using portfolios in science education. Codes that deal with the negative aspects of employing portfolios were as follows: *“Time-consuming; lack of materials; students being irresponsible; time-consuming for the teacher to review; lack of communication; students working in a disorganized manner; waste of paper; may not be age-appropriate; may cause stress; they can take it easy; economic difficulties may occur; and being above his level makes it difficult.”* In the source code, page 121, it says *“I think portfolio evaluation is a really good exercise for some courses and applications; but I have come to the conclusion that there is a problem with doing this at very frequent intervals; I don’t think it’s right to have it at the end of every subject; because not every subject may be suitable for portfolio evaluation work.”* The source coded 313929, p.133, states, *“Sometimes, when homework is given at a level that the student cannot do, the burden falls on us.”* On page

86 of the source coded 330160, it says, “*Students acting lazy; not taking responsibility; the teacher does not care about this issue with the students.*” As seen in the sample expressions, it can be said that the use of a portfolio may not be suitable for every subject, it may not be suitable for the student’s level, and it has negative aspects such as the student not taking responsibility. **Figure 6** shows further codes from this theme in greater depth.

Figure 7 shows the codes related to the theme of suggestions for the use of portfolios in science education. Codes for recommendations for using portfolios are as follows: “*One should have information about the portfolio; training should be given about the portfolio; students should be informed; teachers should be trained; teachers should be informed; homework appropriate to the student’s level should be given; appropriate tools and equipment should be provided; it should be on certain subjects; cooperation with the parents should be done; and there should be constant communication with students.*” In the source coding 373632, p.202, it says “*In mathematics class... because I am not good at mathematics.*” I was successful in both social work and science. I also want to be successful in maths.” On page 80 of the source code for 330160, it states: “*First of all, we need to have very good knowledge about the portfolio; education for this is not provided at a sufficient level at the university; it is used in schools as much as we know, but in order to apply this effectively at school, we must first know what it is; collaborating with parents on issues by drawing students’ attention and being in constant communication with students in this process.*” On page 127 of the source code for 442974, it states “*The process was very good; but I think that if it were done not every week, but in the weeks when certain subjects are covered, the student would not get bored of doing it all the time and more creative things would come out.*” Suggestions for using the portfolio are seen in the sample statements, such as: it should be used in other courses; one should have knowledge about the portfolio; and one should be familiar with certain subjects. **Figure 7** depicts further codes from this theme in greater detail.

Conclusion and Discussion

This study was conducted based on the mixed-meta method and is research that deals with the analysis of quantitative (meta-analysis) and qualitative (meta-thematic) data within the scope of document analysis. In the first part of the document analysis method in which the study was carried out, quantitative data were examined and presented with meta-analysis, and in the second part, qualitative data were examined and presented with meta-thematic analysis. The mixed-meta study enabled an attempt to comprehend the large picture, that is, a meaningful picture, of the issue. First, a meta-analysis of portfolio studies was performed in this study. Following that, the

literature was used to examine and interpret the meta-thematic data collected under the themes of the effect of portfolios on academic achievement, classroom environment, 21st-century skills, negative effects of using portfolios, and recommendations for using portfolios. In this context, the meta-analysis comprised 17 papers, while the meta-thematic analysis included 13 researches.

When we examined the meta-analysis data, it was concluded that portfolio, which is one of the contemporary evaluation techniques in science education, has a positive effect on the learners ($g = 1.005$), considering the studies on academic achievement in learning. Based on this, it has been revealed that the evaluation technique applied to the experimental group was portfolio, which had a positive effect on academic success in science education when compared to the traditional evaluation technique applied to the control group. According to Thalheimer and Cook (2002, p.4-9)'s impact level classification, the impact value ($g = 1.005$) exhibits a positive and significant trend. When the findings of the meta-thematic analysis, which comprise the second part of this study, were investigated and evaluated, relevant codes and themes were developed by scanning the portfolio research, which is one of the evaluation approaches in scientific education. The analysis was modelled in accordance with these codes and topics. When the modelling is analysed in this context, it is discovered that the portfolio is an effective evaluation technique for learners' academic achievement. When we look at the literature, there are many studies (Turan & Sakız, 2014; Birgin, 2008; Okan, 2005; Bedir et al., 2009; Saylan et al., 2019) that show portfolios have a positive effect on the academic success of learners. It was discovered that the findings of this research support the literature and that the portfolio improves students' academic progress. When we examine the meta-thematic data, we see that codes like reinforce learning, provide permanent learning, provide better learning, boost success, and provide meaningful learning support the meta-analysis findings and relevant research or literature. This is because the portfolio encourages students to be creative and critical thinkers while also supporting their future learning with more qualified studies (Betty, 2012). These impacts are readily seen in the codes acquired from this research.

Ayaydın and Yıldız-Ayaydın (2016) conducted a secondary school study in which they investigated students' and parents' opinions on building a product (selection) portfolio in the social studies course. And they came to the conclusion that, based on the students' perceptions, the portfolio delivers meaningful learning, ensures permanent learning, reinforces what they have learned, and promotes success. Güven and Aydodu (2008) conducted a semi-experimental application of the portfolio evaluation technique on the sixth grade science and technology course's "systems in our body" unit. The portfolio approach was used to teach the course in the experimental group,

while the traditional technique was used in the control group. According to the application results, the students' capacity to express themselves, confidence, responsibility, and cooperation abilities in the experimental group were more effective than in the control group. Portfolio evaluation methodologies are utilized to measure 21st century abilities (group work, communication, and leadership), according to a study conducted by Soland, Hamilton et al., (2013). Yalçın (2018) conducted a study with the goal of defining 21st-century talents and the methods used to measure them. For these purposes, the portfolio technique was examined, and according to this study, it was concluded that the portfolio technique developed the 21st-century skills of the students. Some of the codes in the data collected by meta-thematic analysis in this current research support these studies of relevant literature, such as enhancing creativity skills, improving thinking abilities, delivering original work, and gaining responsibility skills.

Ülker et al., (2021) conducted a study on science teacher candidates in which they were asked about the usability of the e-portfolio system, its positive and negative elements, and the application process. Accordingly, it was concluded that it has negative aspects such as being exhausting, making it difficult to access the internet, and not being face-to-face. The research conducted by Öncü (2009) mentions both the positive and negative elements of portfolios. Accordingly, it is found that the bulk of the works in the portfolio were done by the student herself, that the portfolio was economically costly, and that it was difficult to store spatially. Some of the codes in the data gathered from this current research support these literature-related findings, such as the potential of having their relatives do their homework, the fact that it is different from what they learned in school, and the lack of communication. Avan and Şahin (2020) conducted research on teachers' views on the usage of peer coaching and portfolio strategies in classroom supervision. In accordance with these viewpoints, it has been determined that portfolio methods can be used to address issues that teachers have in the classroom, that they can be utilized as a professional control and development tool, and that the employment of democratic approaches such as portfolios can be encouraged. Similar findings were achieved in this current research and related studies in the literature, implying that portfolio training should be provided, teachers should be taught, and they should be incorporated in other courses as well.

In conclusion, meta-analysis is utilized to design similar research in addition to doing a thorough literature review. In this way, it is possible to integrate various study data and synthesize them in an objective manner (Göçmen, 2013). Meta-thematic analysis is based on document analysis. Codings developed with certain criteria are summarized in specific categories, with the goal of achieving comprehensive findings by disclosing specific themes (Büyüktürk et al., 2018, p.259-260). As a result, the current

research was undertaken with the goal of acquiring holistic data about the subject through meta-thematic and meta-analysis. The mixed meta method allows the studies to present their broad aspects in a meaningful totality (Batdı, et al., 2021). Based on this, it is recommended that different assessment and evaluation methods and techniques, which have an important place in education, be carried out with the mixed-meta method. Only papers about the effect of portfolios, which is one of the assessment methodologies in scientific education in Turkey, were included in the review for this study. Therefore, it is recommended that the review contain various issues based on studies and sources completed in other countries. It is possible to establish which components of the portfolio have been investigated and analyzed from various perspectives by comparing studies and sources in Turkey and other countries. Furthermore, because the portfolio is a particularly effective evaluation approach, it is advised that both students and teachers receive training on how to use it more effectively. However, the teaching environment should be designed accordingly, without ignoring the limitations of the portfolio.

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Received: February 10, 2024

Revised: March 14, 2024

Accepted: March 25, 2024