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Attitudes Towards STEAM, Critical Thinking Disposition and Decision-Making Skills: Mediation and Gender Moderation

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Abstract

The relationship between highly desired 21st century skills, such as students' attitudes toward STEAM, critical thinking dispositions, and decision-making abilities, and the role of gender on these associations was investigated in this study. The data was collected from 4th grade students in the 2022-2023 academic year using the typical case sampling method. "STEAM Attitude Scale", "Critical Thinking Disposition Scale" and "Decision-Making Skill Scale" were utilized. The mediation model was estimated using the whole sample, followed by multigroup analyses that employed gender as the moderation variable. The results indicated that primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills were at a high level. The mediation analysis revealed that attitudes towards STEAM had direct effect on decision-making skills, and critical thinking disposition was found to be partially mediating this association. Multigroup analyses provided evidence for the significant moderating role of gender pertaining to the specified associations in the model. The findings provide insights into the importance of developing positive attitudes towards STEAM disciplines regarding their evidential effect on critical thinking disposition and informed decision-making skills in primary schools and the necessity of attending to the role of gender in future educational interventions.

Keywords: Critical thinking disposition, Decision-making skill, STEAM, Primary school, Gender

Introduction

Changes in individual and societal needs, along with rapid global changes in science, technology, innovations, and teaching approaches, have undoubtedly affected the adaptive skills expected from the individual. Many countries have incorporated these skills into their curriculum, such as producing knowledge and using it in daily life, thinking critically, being decisive entrepreneurs, working collaboratively to solve problems, and having communication skills (e.g., Ministry of National Education [MoNE], 2018; National Research Council, 2014). Although there is no consensus on 21st century skills that globally inspire curricula, these vital skills for schooling can be listed as self-efficacy, career and life skills, cooperation and collaborative thinking, critical thinking, creative thinking, and problem solving (Beers, 2001; Lamb et al., 2017). Additionally, the widespread use of social media, along with rampant misinformation (Kyza et al., 2020), and the availability of online educational resources require students to gain and apply higher-order decision-making skills to effectively access and critically select useful, reliable, and trustworthy information. Therefore, critical thinking and decision-making skills are among the most prominent skills that an individual should have in the 21st century (Binkley et al., 2012). Promoting STEAM education—which is an interdisciplinary approach consisting of science, technology, engineering, art, and mathematics disciplines—can help individuals attain these skills and provide opportunities for learning via real-life applications (Ge et al., 2015). This interdisciplinary and integrated type of education is considered to be significantly contributing to the pivotal skills of individuals such as critical thinking, decision-making, creativity, communication, and cooperation (Kardeş, 2020). The skills targeted by science programs, the goals of STEAM education, and 21st century skills overlap. Therefore, in this study, the relationships between attitudes towards STEAM and 21st century skills—specifically, critical thinking disposition and decision-making skills—were investigated.

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Attitudes towards STEAM

By adding the art discipline, STEAM education is created to understand and promote the relationship between the science, technology, engineering, and mathematics (STEM) disciplines (Jin et al., 2012). This approach to education contributes positively to students' cognitive development, as well as their psychological and emotional development, critical and creative thinking, problem-solving skills (Gürliyenkaya-Baş, 2020) and creativity (Aguilera & Ortiz-Revilla, 2021). Due to its utilitarian and instrumental values that promote economic growth and productivity, STEM education is incorporated into scientific, mathematical, and technical disciplines throughout the world (Takeuchi et al. 2020). A course of action for a successful STEM education is to ensure that students gain a positive attitude towards these skills at an early age because it is difficult to change student attitudes that are developed at an early age in the absence of impactful perception-altering situations or regulations (Nacaroğlu & Kızkapan, 2021). Children's participation in integrated STEM activities during their childhood enables them to develop higher order thinking on topics that are beyond the scope of a single subject (Aguilera & Ortiz-Revilla, 2021), and through well-planned STEM education, students can gain a positive attitudes towards STEM-related fields (Tseng et al., 2013).

Critical Thinking Disposition

Critical thinking is defined as a "nonlinear and recursive" process of making purposeful, evaluative, and situated judgments in order to form beliefs and perform actions (Facione et al., 1995). Students need to have critical thinking skills not only to be able to define and overcome the problems encountered in daily life (Nugraheni et al., 2022) but also to prepare them for the competition in the business world (Duffy et al., 2022). The critical thinking process is mainly explained by its cognitive and dispositional dimensions (Facione, et al., 1995). The cognitive skills consist of analyzing, explaining, and interpreting aspects of problems, thinking about the multidimensionality of a problem, evaluating the accuracy and precision of information, and drawing conclusions (American Philosophical Association [APA], 1990; Facione et al., 2000). The dispositional dimension of thinking critically can be defined as seeking alternatives and reasons for a certain situation, having a tendency to use scientific methods in the decision-making process, self-questioning, and being open to new ideas (Facione, 2000). According to Wan and Cheng (2019), critical thinking disposition is a prerequisite for critical thinking because critical thinking disposition expresses the emotional dimension of thinking. In other words, individuals who excel in the cognitive aspect of critical thinking may not necessarily apply them effectively to relevant contexts due to a low level of critical thinking disposition. They defined this unbalanced status as ‘pre-critical’. Therefore, both cognitive skills and dispositional dimensions should be taken into account to gain a comprehensive understanding of a person’s critical thinking. Studies have shown positive associations between a higher critical thinking disposition and problem-solving skills (Tümkaya et al., 2009) and cognitive flexibility and mathematics achievement (Güner & Gokce, 2021). Furthermore, the degree of critical thinking disposition has been found to be influenced by self-efficacy (Aydın Gürler, 2022), gamified STEM practices (Asigigan & Samur, 2021), the classroom learning environment, and the family environment (Wan, 2022).

Decision-Making Skills

Decision-making is defined as making a choice among many alternatives for the purposes of “accountability, selection, placement, evaluation, diagnosis, and improvement” (Griffin et al., 2012, p.19). During the decision-making process, individuals intend to choose the most probable outcome, that meets their needs among multiple options with differing levels of importance (Byrnes, 2002). This skill is integrated into Turkey’s current science curriculum as ‘life skills’. Low level of decision-making skills was found to be associated with low academic achievement (Papachristou et al., 2022), low cognitive ability (Demaree et al., 2010; Flouri et al., 2019), including problem solving skills (Yurtseven et al., 2021), and a higher likelihood of maladaptive behaviors including bullying and ADHD (Bubier & Drabick, 2008; Flouri & Papachristou, 2019). Although equipping individuals with better decision-making skills is among the most general goals of education (Clemen & Gregory, 2000), there exists very limited research related to primary school students as the majority of studies are conducted on adults. Some of the activities that improve students' decision-making skills are participation in brainstorming sessions, effective teamwork with their peers, and being active in the problem-solving process (Clemen & Gregory, 2000). STEM applications also include similar activities. During STEM activities, students develop different solutions for real-world problems, decide on the most appropriate solution, test and evaluate their decisions, and make necessary improvements for their evaluation (Ercan, 2014).

The Constructs of Interest and the Role of Gender

The literature encourages the use of STEAM education for the purpose of attaining 21st century skills and dispositions, including critical thinking, problem solving, and decision-making. The art dimension of STEAM education supports the development of cognitive skills such as decision making, thinking, problem solving, collaboration, and communication skills (Taylor, 2016). Critical thinking and meta-cognitive skills develop especially during the applications of STEAM education (Mangold & Robinson, 2013). Some studies conducted with students and teacher candidates suggest that STEM education contributes positively to students' critical thinking and problem-solving skills (Elliot et al., 2001). According to teachers, the STEM approach yields multidimensional thinking and improves students' decision-making skills (Bakırcı & Kutlu, 2018).
STEM education is aimed at training individuals who design and implement products according to problem situations. In addition, STEAM activities aim to support decision-making skills by raising individuals who can reach the most accurate solution for problems (Bybee, 2010; Jonassen, 2011). Critical thinking is an antecedent skill to decision-making, and some literature demonstrates the effectiveness of particular teaching practices—that enhance critical thinking skills—in the decision-making process of individuals (Schraagen & van de Ven, 2008; van den Bosch & Helsdingen, 2002). Critical thinking offers important benefits to individuals by helping them make better decisions both in their private and professional lives (Daft, 2010). Finally, pertaining to gender, numerous studies have found differing degrees of attitude or tendency towards STEM/STEAM (e.g., Karakuş & Bircan, 2022; Knezek et al., 2011; Vervecken et al., 2013); critical thinking disposition (e.g., Emir, 2012; Rudd et al., 2000; Shubina & Kulakli, 2019); and decision-making skills (e.g., Tekin & Ulas, 2016). Therefore, we sought to examine the role of gender with respect to the constructs and their associations.

Significance of the Study

A wide variety of studies on attitudes towards STEAM, critical thinking, and decision-making skills are examined. However, no study has been found that concurrently examines STEAM attitudes, critical thinking and decision-making skills. Many studies in the literature show that activities and initiatives related to STEM education in the early years of education affect students' perceptions and dispositions towards the STEM field (Bagiati et al., 2010; Bybee & Fuchs, 2006). Therefore, raising awareness among students about STEM at an early age is necessary to both develop positive attitudes towards STEM and have them pursue a STEM-oriented profession (Wyss et al., 2012). STEAM education plays a central role in helping students acquire 21st century competencies such as creativity, critical thinking, and decision-making (Liao, 2016; Sousa & Pilecki, 2013). By developing students' attitudes towards STEAM, students' critical thinking disposition and decision-making skills can be positively affected. The aforementioned literature provides strong evidence that these three concepts are related to each other (see Section 1.4.). Given that many studies in the literature emphasize the importance of STEM/STEAM education in the primary school (Becker & Park, 2011; Murphy & Mancini-Samuelson, 2012), the following reasons warrant the conduct of this study: the scarcity of studies on primary school students in relation to our constructs; the importance of developing students' attitudes towards STEM/STEAM at a young age and its influence on subsequent attitudes; and the degree to which these attitudes are associated with 21st century skills including attitudes towards STEAM and decision-making skills. Therefore, the aim of this study is to examine the relationships between primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills. Based on the formerly established bi-relations, we propose the conceptual model in Figure 1. Moreover, Kocak et al. (2021) reported that critical thinking mediated the relationship between 21st century skills and problem-solving skills. Based on the literature and the conceptual model in Figure 1, critical thinking dispositions display a possible mediating role in the relationship between attitudes towards STEAM and decision-making skills. Finally, examining the moderating role of gender on these relationships will contribute to theory about the generalizability of the associations.

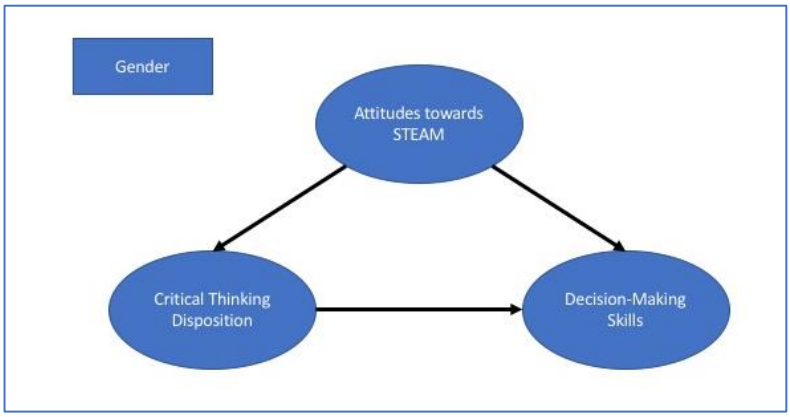

Figure 1. The conceptual model

In this regard, the following research problems are proposed:

1. What are the levels of primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills?
2. What are the direct and indirect relationships between primary school students' attitudes towards STEAM, their critical thinking dispositions and their decision-making skills? (Pertaining to indirect relationships, we seek the mediating role of critical thinking disposition on the relationship between attitudes towards STEAM and decision-making skills.)
3. Do the direct and indirect relationships between primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills differ according to gender? In other words, does gender moderate the relationships?

Method

Research Design

In this study, we collected cross-sectional quantitative data to analyze direct and indirect relationships between fourth-grade students attitudes towards STEAM, critical thinking disposition, and decision-making skills using structural equation modeling (SEM), which refers to a family of statistical techniques to examine directions and strengths of relationships between multiple variables (Kline, 2011). Additionally, we analyzed the mediating role of critical thinking disposition by using the SEM model and the moderating role of gender after multigroup analyses (Ryu & Cheong, 2017).

Participants

In this study, we sought a normative sample—pertaining to student socioeconomic status and achievement levels—that has a higher probability of representing the overall student population of Turkey. We employed convenience sampling method by considering our selection criteria and selected five primary schools from a district of a city that is located in the Southeast Anatolia Region within 2022-2023 academic year. We obtained ethical approvals and subsequently collected data from 650 fourth-grade students (53.1% female and 46.9% male).

Measures

Attitudes toward STEAM, critical thinking, and decision-making skills were latent factors in the model. The items that predicted these factors had categorical response scales. We quantified the items such that higher values represented more favorable responses for the underlying factor. Gender is measured by a binary item (coded 0 for male and 1 for female).

Students' attitudes toward STEAM were measured by the *STEAM Attitude Scale for Elementary School Students* (Gürliyenkaya-Baş, 2020). This scale consists of 20 five-point Likert-type items—each subdomain was measured by four items—such as "I am curious about how machines work" and "I like solving mathematics problems." The responses range from 1 "absolutely disagree" to 5 "absolutely agree." Negatively worded items such as "I find science lessons unnecessary" were reverse coded. Cronbach's alpha coefficients for items ranged from 0.80 to 0.83. Additionally, reliability coefficients for sub-domains, due to the low number of items, ranged from 'satisfactory' to 'high' (Taber, 2018): Cronbach's alpha coefficient was 0.74 for science, 0.59 for technology,

0.69 for engineering, 0.62 for art, and 0.64 for mathematics. However, the reliability of the whole scale was very good (α=0.82).

We measured critical thinking skills using the *Critical Thinking Disposition Scale* that was developed by Ulucinar and Akar (2021). This scale's items were graded on a four-point Likert scale (from 1 "never" to 4 "always"). This 18-item scale contains four subscales: skepticism, curiosity, open-mindedness and objectivity/bias. It included items such as "I try to understand the reason for someone's behavior before judging it" to measure skepticism, "I don't believe everything I see or hear. I doubt if it is true" to measure curiosity, and "I pay attention to whether there is an implicit meaning in what someone says" to measure open-mindedness. Negatively worded items that measure the objectivity or bias of students—such as "I think the ideas of my loved ones are correct"—were reverse coded. The reliability of this scale was good (α=0.81). Cronbach's alpha coefficients of items ranged from 0.79 to 0.81.

Finally, we used '*Decision Making Skills Scale for Primary School Students*' (Sever & Ersoy, 2019) to measure students' decision-making skills. Items of this 15-item Likert-type scale had four response categories ranging from 1 "never" to 4 "always" and included items such as "I examine the content of the subject for which I make a decision." The scale of this construct demonstrated very good reliability (α=0.84). Cronbach's alpha coefficients for items ranged from 0.83 to 0.84.

Data Management and Analysis

We applied Anderson and Gerbing's (1988) two-step procedure for SEM analyses. First, we performed confirmatory factor analysis (CFA) to verify the unidimensionality of the factor structures of our latent variables. In the second stage, we fit the data to estimate our hypothesized SEM model. We performed two SEM analyses: the first was performed on the whole sample, and the second was performed by grouping the gender variable. Prior to data analyses, we conducted data diagnostics to check for normality, outliers, and missing data. Some of our categorical variables were slightly skewed. Thus, we used a robust maximum likelihood (MLR) estimator that is robust to the non-normality of the observed variables (Muthen-Muthen, 1998-2017). Mplus has a default procedure to handle missing data via the implementation of the full information maximum likelihood estimator (FIML). Finally, outliers can distort the estimation of fit indices and population parameters (Leys et al., 2018). The literature provides mixed recommendations about the removal of outliers. We adopted Verardi and Dehon's (2010) procedure in Stata to detect multivariate outliers using the 'minimum covariance determinant estimator' which is a more robust variant of the basic Mahalanobis distance. Stata returned 17 possible multivariate outliers. We only removed three cases that were logically unacceptable (i.e., the students who provided extreme responses to both negatively worded items and other items of the same construct). Moreover, both MLR and bootstrapping procedures in Mplus improve standard errors when outliers are present (Muthen-Muthen, 1998-2017). Therefore, to obtain robust estimates and to ascertain ecological validity, the other items were kept in the data.

For evaluating the model fit, Kline (2011) suggests RMSEA to be less than 0.10, CFI and TLI greater than 0.90, and SRMR less than 0.08. We performed CFA on three scales: in line with Gürliyenkaya-Baş (2020), the scale measuring STEAM attitudes consisted of five level-1 factors that are loaded on the main factor (i.e., attitudes towards STEAM), and the other items were defined to measure the corresponding factor without a hierarchical factor structure. In cross-sectional studies, items that measure the same construct are considered to correlate due to the overlapping of the item content (Byrne, 2012), so we allowed residual variances of some items of the same construct to correlate due to the method effect. Our CFA model fits the data well. The analysis produced the following fit indices: $\chi^2 = 1241.285, df = 932\ and\ p < 0.05; RMSEA = 0.023, CI = [0.019, 0.026]; CFI = 0.947; TLI = 0.943; and\ SRMR = 0.042$. All items had sufficient loadings on factors. We used the same measurement model for mediation analyses. We performed the bootstrapping method, which does not rely on distributional assumptions (Ryu & Cheong, 2017), with 1000 replications to estimate bias-corrected standard errors and confidence intervals of indirect effects (Preacher & Hayes, 2008). The mediation analyses were conducted using Mplus 8 software.

Results

Missing Data

Following the removal of multivariate outliers, the results of statistical analyses were obtained from the remaining data, which contained 647 cases. We examined the data for the missing values and their pattern. Each variable had less than 4% of missing values, which is very little concern in a relatively large sample (Kline, 2011), and the

majority of the missing values were generated due to students' mistakes (specifically, providing multiple answers for the same item). There was no systematic pattern of missing data. Therefore, the Mplus FIML procedure and bias-corrected bootstrap standard errors and confidence intervals were utilized to account for the missing values (Muthen-Muthen, 1998-2017).

Descriptive Statistics

Using Mplus, we obtained correlations and standard deviations of latent variables for the whole sample and the multigroup sample. Descriptive statistics and the results of mediation analyses are reported separately for each cohort. We obtained the descriptive statistics depicted in Table 1 to answer our first research question.

Table 1. Descriptive statistics[1,2]: Estimated means, standard deviations, and correlations of latent factors

	All Sample				Female				Male			
	Mean[3] (SD)	Steam	CT	DM	Mean[3] (SD)	Steam	CT	DM	Mean[3] (SD)	Steam	CT	DM
Steam	3.797 (0.666)	1			3.804 (0.625)	1			3.788 (0.709)	1		
CT	2.838 (0.554)	0.608	1		2.858 (0.544)	0.635	1		2.815 (0.565)	0.587	1	
DM	3.005 (0.556)	0.597	0.798	1	3.044 (0.543)	0.669	0.807	1	2.959 (0.567)	0.524	0.800	1

[1] Abbreviations: Steam = Attitudes towards STEAM; CT = Critical thinking disposition; DM = Decision-making skills
[2] All correlations were significant
[3] Mplus does not produce means if the data is cross-sectional. For comparison, average values of factors, ignoring missing cases, were estimated by their composite values in Stata

Our first research problem sought to determine the level of primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills. Students' attitudes towards STEAM values are of the 5-point Likert-type, and the values of the other two scales are of the 4-point Likert type. The range of these values was divided into five categories, and each category was labeled from 1 (very low) to 5 (very high). Students, on average, had a high level of attitudes towards STEAM ($M = 3.797, SD = 0.666$), critical thinking disposition ($M = 2.838, SD = 0.554$) and decision-making skills ($M = 3.005, SD = 0.556$). In comparison with male students, female students had slightly higher mean scores on all factors. In the correlation matrices, the highest correlation was seen between critical thinking disposition and decision-making skills in all three cohorts. The bi-correlations among factors were higher for female students.

Mediation Analyses

To answer the second research problem, we specified our models based on our conceptual model. To answer our third research problem, we performed multigroup analyses to test whether structural paths are equivalent with respect to male and female students.

In our hypothesized model, student attitudes towards STEAM predicted student decision-making skills and critical thinking disposition, and critical thinking disposition predicted student decision-making skills. We hypothesized that critical thinking disposition is a mediator in the relationship between attitudes towards STEAM and student decision-making. The data fit our model well. $\chi^2 = 1241.285, df = 932\ and\ p < 0.05; RMSEA = 0.023, CI = [0.019, 0.026];\ CFI = 0.947; TLI = 0.943; and\ SRMR = 0.042$. The proportion of variance explained on dependent variables (i.e., R-square) was 0.369 for critical thinking disposition and 0.657 for decision-making skills. R-squared values for subdomains of attitudes towards STEAM were 0.466 for science, 0.725 for technology, 0.813 for engineering, 0.773 for art, and 0.507 for mathematics. The results indicated that all specified paths were significant (see Figure 2 and Table 2).

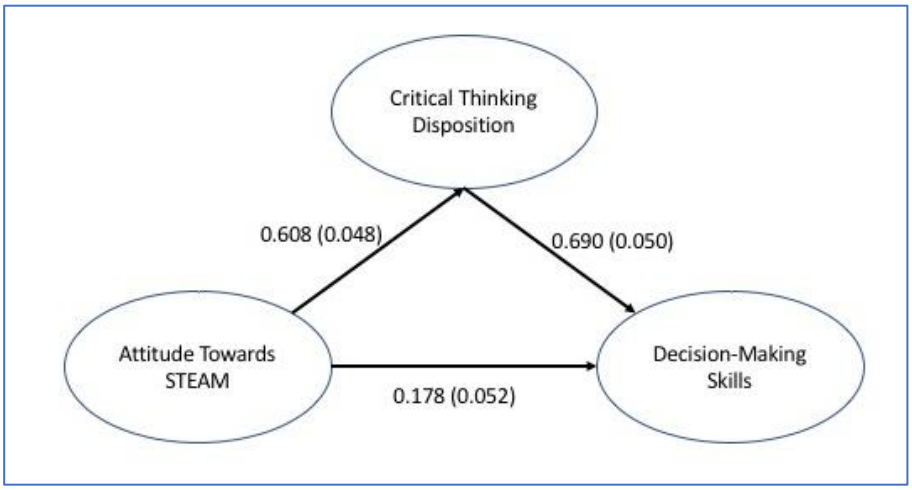

Figure 2. Standardized structural path coefficients

Figure 2 shows that student attitudes towards STEAM significantly predicted student critical thinking disposition ($\beta = 0.608$). Similarly, critical thinking disposition significantly predicted student decision-making skills ($\beta = 0.690$) in this relationship. The smallest effect size was found on the path from attitudes towards STEAM to decision-making skills ($\beta = 0.178$).

Gender Differences: Moderated Mediation

To evaluate the moderating effect of gender on the model, we employed a multigroup analysis (Ryu & Cheong, 2017). We compared an unconstrained model that freely estimated path coefficients to a constrained model that forced corresponding path coefficients to be equal across male and female samples. Unconstrained multigroup SEM model fit indices were acceptable: $\chi^2 = 2405.121, df = 1948 \; and \; p < 0.05; RMSEA = 0.027 \; [0.023, 0.030]; \; CFI = 0.924; TLI = 0.923; SRMR = 0.057$. Constrained multigroup SEM model fit indices were also acceptable: $\chi^2 = 2463.606, df = 1953 \; and \; p < 0.05; RMSEA = 0.028 \; [0.025, 0.032]; \; CFI = 0.915; TLI = 0.914; SRMR = 0.064$. These two models are nested; therefore, we performed a scaled chi-square difference test for the moderation role of gender: $\Delta\chi^2 = 58.49, \Delta df = 5, p < 0.001$. This result indicates that the structural associations differ with respect to gender. In other words, gender moderates the direct and indirect effect sizes. For this reason, we report standardized path coefficients for each cohort separately. Table 2 shows that the standardized path coefficients from attitudes towards STEAM to both critical thinking disposition and decision-making skills were larger for girls. For boys, although the path coefficient from critical thinking disposition to decision-making skills was larger than that of female students, the path from attitudes towards STEAM to decision-making skills was nonsignificant.

Table 2. Standardized path coefficients

	All Sample	Unconstrained Multigroup Model	
Outcome variables		Female	Male
Attitudes towards STEAM → Critical thinking Disposition	0.608* (0.048)	0.654* (0.057)	0.588* (0.074)
Critical Thinking Disposition → Decision-Making	0.690* (0.050)	0.632* (0.069)	0.740* (0.075)
Attitudes towards STEAM → Decision-Making	0.178* (0.052)	0.266* (0.072)	0.096 (0.078)

Upon obtaining acceptable model fit indices and significant relationships between factors, we report indirect effects of critical thinking disposition on the relationship between 4th grade students' attitude towards STEAM and their decision-making skills following the procedures that are suggested by MacKinnon (2008). For testing the mediation effect with bias-corrected standard errors, we performed the bootstrapping method in Mplus. Additionally, instead of using the Sobel method for testing the significance of the indirect relationship, Mplus employs the default delta parameterization method—from which the Sobel method is derived (MacKinnon, 2008)—by default (Muthen-Muthen, 1998-2017).

Table 3. Standardized bootstrap values and their 95% confidence intervals for the direct and indirect effects

Paths	All Sample	Female	Male
Direct effect $Steam \rightarrow DM$	0.178** (0.053) CI = [0.079, 0.228]	0.266*** (0.075) CI = [0.125, 0.407]	0.096 (0.082) CI = [-0.069, 0.262]
Indirect effect $Steam \rightarrow CT \rightarrow DM$	0.419***(0.045) CI = [0.343, 0.521]	0.414*** (0.060) CI = [0.309, 0.545]	0.435*** (0.076) CI = [0.300, 0.589]
Total effect	0.597*** (0.042) CI = [0.514, 0.679]	0.680*** (0.049) CI = [0.567, 0.765]	0.531*** (0.065) CI = [0.390, 0.652]

Note: Standardized values; standard deviations are given in parenthesis; (*** p < 0.001; ** p <0 .01; * p<0.05)
Abbreviations: Steam = Attitudes toward STEAM; CT = Critical thinking disposition; DM = Decision-making skills

Table 3 shows that the critical thinking disposition partially mediated the association between student attitudes towards STEAM and their decision-making skills in the all sample and the female-only sample. Their significant indirect effects were $\beta = 0.419$ for all students in the sample and $\beta = 0.414$ for female students. For the male-only sample, attitudes towards STEAM had a significant indirect effect on student decision-making skills via student critical thinking disposition ($\beta = 0.435$) and it was larger than that of the female-only sample. The total effect for all samples was ($\beta = 0.597$). Female students had a larger total effect ($\beta = 0.680$) than male students ($\beta = 0.531$).

Discussion

In this study, primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills were examined in connection with their descriptive statistics, structural relationships, and varying degrees of paths in relation to gender. Pertaining to the first research question, we found that primary school students' attitudes towards STEAM, their critical thinking dispositions, and their decision-making skills are at a high level. In similar contexts, primary and secondary school students' attitudes towards STEM were found to range from 'good' to 'high' level (Karakuş & Bircan, 2022; Nacaroğlu and Kızkapan, 2021). The higher attitudes of students towards STEAM at an early age may enable them to willingly participate in activities related to the STEAM discipline in the future. Ersoy and Başer (2012) found that the middle school students' critical thinking dispositions were at a low level, and they related this result to the decreased application of student-centered teaching in secondary school. In line with our findings, Korkmaz and Yeşil (2009) found that students' critical thinking dispositions were at their highest level at the primary school level and decreased through high school. He attributed these findings to the practices that promote rote learning, the lack of research-inquiry-oriented activities, and the deprivation of the students of opportunities to use and develop their critical thinking skills. In contrast to our result pertaining to high-level decision-making skills in primary school, Yurtseven et al. (2021) and Baysal et al. (2021) found their level to be moderate. In the literature, children's overestimations of their abilities and competencies abound. As children grow older, ratings of their competencies and certain abilities gradually decrease as the accuracy of their self-perception increases (Eccles et al., 1993). The literature and our results suggest that as students transition to higher levels of education, their mentioned attitudes, tendencies, and skills likely decrease more. Worldwide demand for cultivating students with these 21st century skills implies the presence of undesired levels of these constructs at the primary school level in other contexts, and this problem calls for more research.

Related to the second research question, the results showed that all identified paths were positively associated and significant. An increase in students' attitudes towards STEAM is associated with higher critical thinking dispositions and decision-making skills. Moreover, as students' critical thinking dispositions increase, their decision-making skills also increase. In various experimental studies, STEM applications influenced students' problem solving and critical thinking skills (Çetin, 2020) and contributed positively to students' attitudes towards STEM and their critical thinking dispositions (Açışlı Çelik, 2022). According to Roberts (2012), when STEM education is properly included in the curriculum, it allows students to think and work creatively, critically, and in teams. Providing students with positive attitudes towards STEAM from an early age contributes to their critical thinking dispositions. Based on the similarity of the decision-making process and the engineering design process, engineering design-based science education is found to be important in the development of students' decision-making skills (Denson, 2011; Jonassen, 2011). Therefore, important contributions can be made to decision-making skills by providing students with positive attitudes towards STEAM starting at an early age and giving importance to group work in STEAM applications. In addition to its direct effect on decision-making, STEAM

attitudes have also been found to have an indirect effect through critical thinking disposition (i.e., partial mediation). In other words, as students' positive attitudes towards STEAM increase, their decision-making skills also increase, partly due to the increase in their critical thinking disposition. Experimental studies have reported that teaching based on critical thinking is effective in the decision-making process (Schraagen & van de Ven, 2008; van den Bosch & Helsdingen, 2002; van Dongen et al., 2005).

For the third research question, we sought the moderating role of gender on the specified associations. According to the multi-group analysis, the findings should be interpreted separately for boys and girls. The direct effect of STEAM attitudes on critical thinking disposition is significant for girls and boys, and it is higher for girls. Therefore, in comparison with boys, as female students' positive attitudes towards STEAM increase, their critical thinking dispositions benefit more than those of male students. The majority of the studies have reported that male students are more interested in STEM-related careers than female students (Azgın & Şenler, 2019; Karakuş & Bircan, 2022; Knezek et al., 2011). Some occupational groups such as engineering, are seen as male occupations in society (Vervecken et al., 2013). However, our findings provide satisfactory evidence that female students gain positive attitudes towards STEM and STEM-related professions, and thus, gender inequality might be mitigated.

Surprisingly, the direct effect of attitudes toward STEAM on decision-making skills was significant for girls but not for boys. In other words, female students' positive attitudes towards STEAM are associated with higher-level decision-making skills, but this association is not significant for male students. Bacanlı and Sürücü (2006) stated that male students are more reckless than female students and that male students tend to avoid taking responsibility in the decision-making process compared to female students. Also, girls use the independent decision-making style at a higher level than boys (Tekin & Ulas, 2016). There is a need for qualitative and experimental studies to explain factors that might explain the moderating role of gender in this finding. According to Weller et al. (2014), children with poor decision-making skills should be helped to develop their skills since inadequacy in decision-making skills at an early age might cause behavioral problems such as risky decision-making in the later stages of life. Young children have difficulty distinguishing between necessary and unnecessary information and eliminating the inappropriate options that they use in the decision-making process due to paying attention to irrelevant stimuli (Howse et al., 2003). Since young children may have difficulty making decisions, improving their attitudes towards STEAM and their critical thinking skills may help them narrow down their options for making decisions.

The results revealed that the indirect effect of STEAM attitudes on decision-making skills through critical thinking disposition was significant for both girls and boys and was higher for boys. While attitudes towards STEAM do not have a direct effect on male's decision-making skills, they might channel this effect through critical thinking disposition. Therefore, to develop male students' decision-making skills by having them develop attitudes towards STEAM, their critical thinking dispositions need to be improved together. Effective use of decision-making skills is directly related to critical and creative thinking skills. While creative thinking skills are effective in creating more than one solution proposal in individuals' decision-making processes, critical thinking skills are effective in choosing the right solution from the proposed suggestions for the solution (Baysal, 2009). The direct effect of critical thinking disposition on decision-making skills was significant for females and males, and it was found to be higher for males. In other words, as the critical thinking dispositions of male students increase, their decision-making skills increase more than that of female students. Literature depicts mixed results about the significant effect of gender on critical thinking skills, including nonsignificant differences (Bagheri & Ghanizadeh, 2016; Sezer et al., 2022; Yıldırım & Şensoy, 2017), significant differences that are mostly in favor of females (Rudd et al., 2000; Shubina & Kulakli, 2019), and significant differences that are mostly in favor of males (Emir, 2012; Kartal, 2012). In our study, while the attitudes towards STEAM did not have a direct effect on male students' decision-making skills, the indirect effect through critical thinking disposition was found to be higher. Overall, there are two implications of these gender-moderated mediations: i) female students' decision-making skills can be improved by developing either or both attitudes towards STEAM and critical thinking disposition, and ii) male students' decision-making skills can be improved by developing their critical thinking disposition.

Conclusion

There is an international effort to equip students with 21st-century skills. In this study, the mediating role of critical thinking disposition on the relationship between fourth-grade students' attitudes towards STEAM and decision-making skills was found. Additionally, gender moderated these associations. These findings should guide future actions of policymakers, researchers, and practitioners in terms of: i) the importance of developing students' attitudes towards STEAM and critical thinking dispositions starting from the primary school years; ii) the insignificant association between attitudes towards STEAM and decision-making skills in boys; and iii) in efforts

to improve students' decision-making skills through STEM and STEAM related interventions, the necessity of placing greater emphasis on improving students' critical thinking dispositions, specifically in boys.

Limitations and Recommendations

Due to the limitations of this study, including the cross-sectional nature of the data and the possibility of self-report bias, evidence obtained from randomized-controlled studies testing these associations will contribute to theory. Specifically, experimental or quasi-experimental designs can be conducted to causally investigate the degree to which enhancing attitudes toward STEAM through various teaching practices improves students' decision-making skills both directly and indirectly. In our study, attitudes toward STEAM did not have a direct association with decision-making skills for male students, and they had a higher indirect association through critical thinking disposition. Qualitative studies can provide insights into the mechanism of the moderating role of gender in these associations. Moreover, STEM education has a positive effect on critical thinking and problem-solving skills (Asisigan & Samur, 2021). Its effect on other 21st century skills such as high-level thinking skills including creativity, analytical thinking, collaboration and reasoning can be examined. Together with the aforementioned recommendations, early interventions can help researchers and policymakers take a lower-cost proactive approach before individuals are near to finalizing their personal characteristics, which are less prone to change as they age.

Author (s) Contribution Rate

All authors contributed equally to the article.

Conflicts of Interest

There is no conflict of interest.

Ethical Approval

Ethical permission (8.3.2022 - E-87841438-604.01.01-218299) was obtained from Gaziantep University Social and Humanities Sciences Ethics Committee for this research.

References

Açışlı Çelik, S. (2022). STEM etkinliklerinin ortaokul 6. sınıf öğrencilerinin problem çözme becerilerine, eleştirel düşünmelerine ve STEM'e yönelik tutumlarına etkisinin araştırılması [An investigation on the effect of STEM practices on sixth-grade students' problem solving skills, critical thinking, and attitudes toward STEM]. *Pamukkale University Faculty of Education, 56,* 287-313. https://doi.org/10.9779/pauefd.1054678

Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences, 11*, 331. https://doi.org/10.3390/ educsci11070331

American Philosophical Association (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction ("The Delphi Report"). ERIC Document Reproduction, No. ED 315423. https://www.qcc.cuny.edu/socialsciences/ppecorino/CT-Expert-Report.pdf

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411-423. https://doi.org/10.1037/0033-2909.103.3.411

Asigigan, S. İ., & Samur, Y. (2021). The effect of gamified STEM practices on students' intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills. *International Journal of Education in Mathematics, Science and Technology, 9*(2), 332-352. https://doi.org/10.46328/ijemst.1157

Aydın Gürler, S. (2022). State of prediction of the critical thinking dispositions of primary school teacher candidates through their self-efficacy for STEM practices. *Participatory Educational Research (PER), 9*(3), 61-81. http://dx.doi.org/10.17275/per.22.54.9.3

Azgın, A. O., & Şenler, B. (2019). İlkokulda Stem: Öğrencilerin kariyer ilgileri ve tutumları [STEM in primary school: Students' career interest and attitudes]. *Journal of Computer and Education Research, 7*(13), 213-232. https://doi.org/10.18009/jcer.538352

Bacanlı, F., & Sürücü, M. (2006). İlköğretim 8. sınıf öğrencilerinin sınav kaygıları ve karar verme stilleri arasındaki ilişkilerin incelenmesi [An examination of the relationship between test anxiety and decision making styles of elementary school 8th grades students]. *Educational Administration: Theory and Practice, 12*(1), 7-35.

Bagheri, F., & Ghanizadeh, A. (2016). Critical thinking and gender differences in academic self-regulation in higher education. *Journal of Applied Linguistics and Language Research*, *3*(3), 133-145.

Bagiati, A., Yoon, S.Y., Evangelou, D., & Ngambe-ki, I. (2010). Engineering curricula in early education: Describing the landscape of open resources. *Early Childhood Research & Practice*, *12*(2), 1-22.

Bakırcı, H., & Kutlu, E. (2018). Fen bilimleri öğretmenlerinin FeTeMM yaklaşımı hakkındaki görüşlerinin belirlenmesi [Determination of science teachers' views on STEM approach]. *Turkish Journal of Computer and Mathematics Education*, *9*(2), 367-389. https://doi.org/10.16949/turkbilmat.417939

Baysal, Z. N. (2009). An application of the decision-making model for democracy education: a sample of a third grade social sciences lesson. *Educational Sciences: Theory & Practice*, *9*(1), 75-84.

Baysal, Z. N., Demirbaş-Nemli, B., Özçelik, S., & Güneypınar, Ş. (2021). An examination of the decision-making skill perceptions of third grade and fourth grade students in primary school. *Bartın University Journal of Faculty of Education*, *10*(1), 85-96. https://doi.org/10.1016/buefad.590947

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering and mathematics (STEM) subjects on students' learning: A preliminary meta analysis. *Journal of STEM Education*, *5*(6), 23-37.

Beers, S. Z. (2011). *21st century skills: Preparing students for their future*. https://cosee.umaine.edu/files/coseeos/21st_century_skills.pdf .

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.) *Assessment and Teaching of 21st century skills* (pp. 17-66). Springer. https://doi.org/10.1007/978-94-007-2324-5_2

Bubier, J. L., & Drabick, D. A. (2008). Affective decision-making and externalizing behaviors: The role of autonomic activity. *Journal of Abnormal Child Psychology*, *36*(6), 941-953. https://doi.org/10.1007/s10802-008-9225-9

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, *70*(1), 30-35.

Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and technology education. *Journal of Research in Science Teaching*, *43*(4), 349-352. https://doi.org/10.1002/tea.20147

Byrne, B. M. (2012). *Structural equation modeling with Mplus: Basic concepts, applications, and programming.* Routledge.

Byrnes, J. P. (2002). The development of decision making. *Journal of Adolescent Health*, *31*, 208-215. https://doi.org/10.1016/S1054-139X(02)00503-7

Clemen, R. T., & Gregory, R. (2000). Preparing adult students to be better decision makers. In I. Gal (Ed.), *Adult numeracy development: Theory, research, practice* (pp. 73–86). Hampton Press.

Çetin, A. (2020). Examining project-based STEM training in a primary school. *International Online Journal of Education and Teaching (IOJET)*, *7*(3). 811- 825. https://iojet.org/index.php/IOJET/article/view/761

Daft, R. L. (2010). *Organization theory and design* (Tenth edition). Cengage Learning.

Demaree H. A., Burns K. J., & DeDonno M. A. (2010). Intelligence, but not emotional intelligence, predicts Iowa Gambling Task performance. *Intelligence, 38*(2), 249–254. https://doi.org/10.1016/j.intell.2009.12.004

Denson, C. (2011). Building a framework for engineering design experiences in STEM: a synthesis. *National Center for Engineering and Technology Education*. https://files.eric.ed.gov/fulltext/ED537389.pdf

Duffy, L. N., Stone, G. A., Townsend, J., & Cathey, J. (2022). Rethinking curriculum internationalization: Virtual exchange as a means to attaining global competencies, developing critical thinking, and experiencing transformative learning. *SCHOLE: A Journal of Leisure Studies and Recreation Education*, *37*(1-2), 11-25. https://doi.org/10.1080/1937156X.2020.1760749

Eccles, J., Wigfield, A., Harold, R.D., & Blumenfeld, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64*(3), 830–47. https://doi.org/10.1111/j.1467-8624.1993.tb02946.x

Elliott, B., Oty, K., McArthur, J. & Clark, B. (2001). The effect of an interdisciplinary algebra/science course on students' problem solving skills, critical thinking skills and attitudes towards mathematics. *International Journal of Mathematical Education in Science and Technology*, *32*(6), 811–816. https://doi.org/10.1080/00207390110053784

Emir, S. (2012). Eğitim fakültesi öğrencilerinin eleştirel düşünme eğilimleri [Critical thinking dispositions of education faculty students]. *Journal of the Hasan Ali Yucel Faculty of Education*, *17*(1), 34-57.

Ercan, S. (2014). *Fen eğitiminde mühendislik uygulamalarının kullanımı: Tasarım temelli fen eğitimi* [The usage of engineering practices in science education: Design based science learning] [Doctoral thesis, Marmara University]. National Thesis Center.

Ersoy, E., & Başer, N. (2012). İlköğretim ikinci kademe öğrencilerinin eleştirel düşünme eğilimleri [Second grade primary school students' critical thinking disposition]. *Journal of Research in Education and Teaching*, *1*(3), 106-115.

Facione, P. A. (2000). The disposition toward critical thinking: Its character, measurement, and relationship to critical thinking skill. *Informal Logic, 20*(1), 61-84. https://doi.org/10.22329/il.v20i1.2254

Facione, P. A., Facione, N. C., & Giancarlo, C. A. (2000). The disposition toward critical thinking: Its character, measurement and relationship to critical thinking skill. *Informal Logic, 20*(1), 61-84. https://doi.org/10.22329/il.v20i1.2254

Facione, P. A., Sanchez, C. A., Facione, N. C., & Gainen, J. (1995). The dispositions towards critical thinking. *Journal of General Education, 44*, 1–25.

Flouri, E., Moulton, V., & Ploubidis, G. B. (2019). The role of intelligence in decision-making in early adolescence. *British Journal of Developmental Psychology, 37*(1), 101-111. https://doi.org/10.1111/bjdp.12261

Flouri, E., & Papachristou, E. (2019). Peer problems, bullying involvement, and affective decision-making in adolescence. *British Journal of Developmental Psychology, 37*(4), 466-485. https://doi.org/10.1111/bjdp.12287

Ge, X., Ifenthaler, D., & Spector, J. M. (2015). Moving forward with STEAM education research. In X. Ge, D. Ifenthaler, & J. M. Spector (Eds.), *Emerging Technologies for STEAM Education* (pp. 383-395). Springer International Publishing.

Güner, P., & Gökçe, S. (2021). Linking critical thinking disposition, cognitive flexibility and achievement: Math anxiety's mediating role. *The Journal of Educational Research, 114*(5), 458-473. https://doi.org/10.1080/00220671.2021.1975618

Griffin, P., Care, E., & McGraw, B. (2012). The changing role of education and schools. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 1-16). Springer.

Gürliyenkaya-Baş, G. (2020). *İlkokul öğrencilerinin STEAM tutumlarının belirlenmesi* [Determination of steam attitude of elementary school students] [Master's Thesis, Çanakkale Onsekiz Mart University]. National Thesis Center.

Howse, B. R., Best, L. D., & Stone, R. E. (2003). Children's decision making: the effects of training, reinforcement and memory aids. *Cognitive Development*, 18, 247-268. https://doi.org/10.1016/S0885-2014(03)00023-6

Jin, Y., Chong, L. M., & Cho, H. K. (2012, November 26-29). *Designing a robotics-enhanced learning content for STEAM education*. 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), Daejeon, Korea. https://ieeexplore.ieee.org/abstract/document/6463032?casa_token=64psw91JKswAAAAA:UkjA3jUnmw-rvmAZnzHQPVV4v-Hft4kyNzGBfuY02dJAGUceqIFtxh_HsJf_Hsr_QAxBhfjw

Jonassen, D. H. (2011). *Design problems for secondary students*. National Center for Engineering and Technology Education. Retrieved from https://files.eric.ed.gov/fulltext/ED537388.pdf

Karakuş, B., & Bircan, M. A. (2022). İlkokul dördüncü sınıf öğrencilerinin STEM kariyer ilgileri ve STEM'e yönelik tutumları [Fourth grade of primary school students' STEM career interests and their attitudes to STEM]. *Sivas Cumhuriyet University Educational Sciences Institute Journal, 1*(2), 120-129.

Kardeş, S. (2020). Okul öncesi eğitim programının 21. yüzyıl becerileri ve STEAM eğitimi bağlamında incelenmesi [Analysis of preschool education program in the context of 21st century skills and STEAM education]. *Journal of Theory and Practice in Education, 16*(2), 109-119. https://*doi*.org/*10.17244/eku.703361*

Kartal, T. (2012). İlköğretim fen bilgisi öğretmen adaylarının eleştirel düşünme eğilimlerinin incelenmesi [Exploring of dispositions toward critical thinking in pre-service elementary science teachers]. *Ahi Evran University Journal of Kırşehir Education Faculty, 13*(2), 279-297.

Kline, R. B. (2011). *Principles and practice of structural equation modeling* (3rd ed.). Guilford Press.

Knezek, G., Christensen, R., & Tyler-Wood, T. (2011). Contrasting perceptions of Stem content and careers. *Contemporary Issues in Technology and Teacher Education, 11*(1), 92-117.

Koçak, O., Çoban, M., Aydin, A., & Cakmak, N. (2021). The mediating role of critical thinking and cooperativity in the 21st century skills of higher education students. *Thinking Skills and Creativity*, 42, 100967. https://doi.org/10.1016/j.tsc.2021.100967

Korkmaz, Ö., & Yeşil, R. (2009). Öğretim kademelerine göre öğrencilerin eleştirel düşünme düzeyleri [Students' critical thinking level as to educational degrees]. *Ahi Evran University Journal of Kırşehir Education Faculty, 10*(2), 19-28.

Kyza, E. A., Varda, C., Panos, D., Karageorgiou, M., Komendantova-Amann, N., Coppolino Perfumi, S., Shah, S. I. H., & Hosseini, A. S. (2020). Combating misinformation online: re-imagining social media for policy-making. *Internet Policy Review, 9*(4), 1-24. https://doi.org/10.14763/2020.4.1514

Lamb, S., Maire, Q., & Doecke, E. (2017). *Key skills for the 21st century: An evidence-based review. Future Frontiers Analytical Report*. Melbourne: Victoria University.

Leys, C., Klein, O., Dominicy, Y., & Ley, C. (2018). Detecting multivariate outliers: Use a robust variant of the Mahalanobis distance. *Journal of Experimental Social Psychology, 74*, 150-156. https://doi.org/10.1016/j.jesp.2017.09.011

Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education. *Art Education, 69* (6), 44- 49. http://dx.doi.org/10.1080/00043125.2016.1224873

MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis*. Lawrance Erlbaum.

Mangold, J., & Robinson, S. (2013). *The Engineering design process as a problem solving and learning tool in K-12 classrooms.* Paper presented at the 120th ASEE Annual Conference & Exposition, Atlanta. Retrieved from http://escholarship.org/uc/item/8390918m Accessed December 21, 2022

Ministry of National Education (2018). Turkish *Science curriculum (Elementary and Middle School 3,4,5,6,7. and 8. Grades).* Ankara. Retrieved from http://mufredat.meb.gov.tr/Dosyalar/201812312311937-FEN%20B%C4%B0L%C4%B0MLER%C4%B0%20%C3%96%C4%9ERET%C4%B0M%20PROGRAMI2018.pdf Accessed December 21, 2022

Muthén, L.K., & Muthén, B.O. (1998-2017). *Mplus User's Guide. Eighth Edition.* Muthén & Muthén

Murphy, T. P., & Mancini-Samuelson, G. J. (2012). Graduating STEM component and confident teachers: The creation of a STEM certificate for elementary education majors. *Journal of College Science Teaching, 42*(2), 18- 23.

Nacaroğlu, O. & Kızkapan, O. (2021). Özel yetenekli öğrencilerin STEM tutumları ve 21. yüzyıl becerilerine sahip olma düzeyleri [STEM attitudes and levels of 21st century skills in gifted students]. *Turkish Journal of Social Studies, 25*(2), 425-442.

Nugraheni, L. Suyitno., Waluyo, H. J., & Wardani, N. E. (2022). The influence of wayang beber (The Legend of Wasis Joyokusumo) as a character-based learning media on students' critical thinking ability. *International Journal of Instruction, 15*(3), 267-290. https://doi.org/10.29333/iji.2022.15315a

National Research Council. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research.* National Academies Press.

Papachristou, E., Flouri, E., & Joshi, H. (2022). The role of primary school composition in affective decision-making: a prospective cohort study. *Social Psychiatry and Psychiatric Epidemiology*, 1-12. https://doi.org/10.1007/s00127-022-02252-8

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879-891. https://doi.org/10.3758/BRM.40.3.879

Roberts, A. (2012). A justification for STEM education. *Technology and Engineering Teacher*, 1-5. https://www.iteea.org/File.aspx?id=86478&v=5409fe8e

Rudd, R., Baker, M., & Hoover, T. (2000). Undergraduate agriculture student learning styles and critical thinking abilities: Is there a relationship? *Journal of Agricultural Education, 41*(3), 2-12.

Ryu, E., & Cheong, J. (2017). Comparing indirect effects in different groups in single-group and multi-group structural equation models. *Frontiers in Psychology, 8*:747. https://doi.org/10.3389/fpsyg.2017.00747

Schraagen, J. M., & Van de Ven, J. (2008). Improving decision making in crisis response through critical thinking support. *Journal of Cognitive Engineering and Decision Making, 2*(4), 311-327. https://doi.org/10.1518/155534308X377801

Sever, I., & Ersoy, A. (2019). Development of decision-making skills scale for primary school students: Validity and reliability study. *Çukurova University Faculty of Education Journal, 48*(1), 662-692.

Sezer, E. A., Küçüktepe, S. E., & Yıldız, N. (2022). Ortaokul öğrencilerinin eleştirel düşünme becerisi üzerine bir meta-analiz çalışması [A meta-analysis study on secondary school students' critical thinking skill]. *Pamukkale University Journal of Education, 55*, 252- 293.

Shubina, I., & Kulakli, A. (2019). Critical thinking, creativity and gender differences for knowledge generation in education. *Literacy Information and Computer Education Journal (LICEJ), 10*(1), 3086-3093. https://doi.org/10.20533/licej.2040.2589.2019.0405

Sousa, D.A., & Pilecki, T. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the Arts*. Corwin – SAGE Publications.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Takeuchi, M. A., Sengupta, P., Shanahan, M. C., Adams, J. D., & Hachem, M. (2020). Transdisciplinarity in STEM education: A critical review. *Studies in Science Education, 56*(2), 213-253. https://doi.org/10.1080/03057267.2020.1755802

Taylor, B. (2016). Evaluating the benefit of the maker movement in K-12 STEM education. *Electronic International Journal of Education, Arts, and Science (EIJEAS), 2*, 1-22. https://doi.org/10.5642/steam.20160202.04

Tekin, S., & Ulaş, A. (2016). İlkokul 4. Sınıf öğrencilerinin karar verme becerilerine ilişkin bir araştırma [A study on the decision-making skills of 4th gradde primary school students]. *Qualitative Studies*, *11*(3), 27-38. https://doi.org/10.12739/NWSA.2016.11.4.E0026

Tseng, K. H., Chang, C. C., Lou, Ş. J., & Chen W. P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education*, *23*(1), 87-102. http://dx.doi.org/10.1007/s10798-011-9160-x

Tümkaya S., Aybek, B., & Aldağ, H. (2009). An investigation of university students' critical thinking disposition and perceived problem solving skills. *Egitim Arastirmalari-Eurasian Journal of Educational Research, 36*, 57-74.

Ulucinar, U., & Akar, C. (2021). The critical thinking dispositions scale for elementary school students: A study of scale development. *Third Sector Social Economic Review*, *56*(3), 2031-2047. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.21.09.1673

van den Bosch, K., & Helsdingen, A. S. (2002). Improving Tactical Decision Making through Critical Thinking. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46*(3), 448–452. https://doi.org/10.1177/154193120204600349

van Dongen, K., Schraagen, J. M., Eikelboom, A., & te Brake, G. (2005). Supporting Decision Making by a Critical Thinking Tool. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 49(3), 517–521. https://doi.org/10.1177/154193120504900364

Verardi, V., & Dehon, C. (2010). Multivariate outlier detection in Stata. *The Stata Journal*, *10*(2), 259-266. https://doi.org/10.1177/1536867X1001000206

Vervecken, D., Hannover, B., & Wolter, I. (2013). Changing(s) expectations: how gender fair job descriptions impact children's perceptions and interest regarding traditionally male occupations. *Journal of Vocational Behavior*, 82, 208–220. https://doi.org/10.1016/j.jvb.2013.01.008

Wan, Z. H. (2022). What predicts students' critical thinking disposition? A comparison of the roles of classroom and family environments. *Learning Environments Research*, *25*(2), 565-580. https://doi.org/10.1007/s10984-021-09381-y

Wan, Z. H., & Cheng, M. H. M. (2019). Classroom learning environment, critical thinking and achievement in an interdisciplinary subject: a study of Hong Kong secondary school graduates. *Educational Studies, 45*(3), 285-304. https://doi.org/10.1080/03055698.2018.1446331

Weller, J. A., Moholy, M., Bossard, E., & Levin, I. P. (2014). Preadolescent decision making competence predicts interpersonal strengths and difficulties: a 2-year prospective study. *Journal of Behavioral Decision Making*, *28*(1), 76-88. https://doi.org/10.1002/bdm.1822

Wyss, V.L., Heulskamp, D., & Seibert, C.J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental & Science Education*, *7*(4), 501-522.

Yıldırım, H. İ., & Şensoy, Ö. (2017). Fen bilgisi öğretmen adaylarının eleştirel düşünme eğilimlerinin bazı değişkenlere göre incelenmesi [An investigation of the critical thinking dispositions of pre-service science teachers according to some variables]. *Journal of Gazi University Gazi Education Faculty*, *37*(2), 611-648.

Yurtseven, R., Akkas Baysal, Ö., Emine, Ü., & Ocak, G. (2021). Analysis of the relationship between decision making skills and problem solving skills of primary school students. *International Online Journal of Education and Teaching*, *8*(3), 2117-2130.