
International Journal of Science Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tsed20

# Predictors of science identity in primary school: epistemological beliefs, competency beliefs, and science learning experiences

Menşure Alkış Küçükaydın, Çiğdem Akkanat Avşar, Elçin Ayaz & Elif Sayıcı

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION
https://doi.org/10.1080/09500693.2024.2361172



# Predictors of science identity in primary school: epistemological beliefs, competency beliefs, and science learning experiences

Menşure Alkış Küçükaydın [a], Çiğdem Akkanat Avşar [b], Elçin Ayaz [c] and Elif Sayıcı [a]

[a]Necmettin Erbakan University, Konya, Turkey; [b]Ministry of National Education, Ankara, Turkey; [c]Faculty of Ziya Gökalp Education, Dicle University, Diyarbakır, Turkey

**ABSTRACT**
Science identity helps explain the attitude students have towards science, assessing how and why they choose to engage with it both inside and outside of school. Over time, each student develops an identity as a scientist based upon perceptions held by themselves and others. Students' science identity may vary depending on their gender, educational opportunities, and epistemological beliefs. For this reason, the study investigated the predictors of primary school students' science identity. A total of 775 primary school students aged 9–12 from the Turkish sample participated in the research. Structural equation modelling was used to examine the predictors of science identity. Findings showed that science identity is related to epistemological beliefs, science competence, and optional science learning experiences. Accordingly, the models used to explain science identity can be expanded with belief, competence, and experience variables. The current study has contributed to the understanding of the science identity in primary school students and has provided insights into the science identity of children in Turkey as an Eastern society.

**ARTICLE HISTORY**
Received 25 October 2023
Accepted 24 May 2024

**KEYWORDS**
Epistemological beliefs; competency beliefs; science learning experiences; science identity

## Introduction

Students take on various academic identities such as writer, scientist, mathematician, painter, etc. in line with their interests and abilities throughout their education (Kim, 2018). Identity development is generally related to how one is defined both by oneself and other people (Gee, 2000). In other words, it involves understanding an individual's level of interest, self-assessment of their competence, and the extent to which they feel recognised for it (Scutt et al., 2013). In other words, it involves understanding an individual's level of interest, self-assessment of their own competence, and the extent to which they feel recognised in relation to it. A conceptual framework for understanding science identity was developed by Carlone and Johnson (2007) based on Gee's (2000) theory. This framework includes the elements of recognition, competence, and performance. According to this, the first element is to identify oneself as 'a scientist' and be

**CONTACT** Menşure Alkış Küçükaydın mensurealkis@hotmail.com

looked upon 'like a scientist' by other people, such as family, peers, and teachers. The second element refers to having access to scientific content and being able to utilise various practices. And the final element involves social performance in the culture of science and the public sphere. Understanding science identity is key for comprehending students' persistence in science (Trujillo & Tanner, 2014).

The science identity that a person has is not fixed and can change over time as different variables come into play (Brickhouse et al., 2000). Carlone (2022) refers to this as a 'process of becoming, rather than a final-form achievement' (p.11). Science identity can then be realised and implemented (Archer et al., 2022, p. 25). It also has a close relationship with learning (Nasir & Hand, 2008). The complexity and richness of science identity can be increased through learning activities and other processes that offer support (Avraamidou, 2019). In this case, it is possible to talk about students having a strong science identity (Carlone, 2022). In Chapman and Feldman's (2017, p. 477) study with high school students, it was observed that students' performances in the science laboratory made them feel competent as if they were scientists, and this was explained by a 'strong science identity'. For this reason, it seems pertinent to discuss the continuity and development of science identity.

Accordingly, science identity can be developed with the support of both the student's own beliefs and external factors such as teachers, peers, or family members (Chen & Wei, 2022). However, aside from these factors that are effective for the individual, there may be other factors that influence the development of science identity. Understanding the variables affecting science identity can inform educators in their development of the most appropriate teaching strategies (Vincent-Ruz & Schunn, 2018).

It has been reported that epistemological beliefs, which express an individual's beliefs regarding knowledge and how they acquire it (Lee & Chan, 2018), are a variable related to an individual's identity development (Krettenauer, 2005). It has been reported that students with complex and high-level epistemological beliefs construct knowledge more adequately, develop deep learning strategies, and have a strong motivational system (Hosbein & Barbera, 2020). All these skills enable individuals to evaluate themselves as competent in accessing knowledge, thereby contributing to the construction of a science identity (Guo et al., 2022a). For this reason, Guo et al. (2022b) stated that if science identity is to be developed, the students' epistemological beliefs should be emphasised first. However, epistemological beliefs are also related to an individual's competence beliefs (Dorph et al., 2016). Competence beliefs in science refer to the extent to which individuals believe that they are good at science tasks (Vincent-Ruz & Schunn, 2017). McBride et al. (2020) reported that domain-specific competence beliefs affect identity development by shaping an individual's level of self-confidence. Therefore, competence beliefs are worth examining as an effective variable in accessing knowledge and science identity development (Starr et al., 2020).

In addition to epistemological beliefs and competence beliefs, it has been reported that students' science experiences also have an impact on science identity (Liu & Schunn, 2018). Students who have intensive experiences in science show more interest in science than their peers, and their science skills begin to improve (Dawson, 2014). This leads students to have positive attitudes and feel closer to science (Dabney et al., 2012). At the end of the day, students may begin to feel like scientists (Vincent-Ruz & Schunn, 2018). Therefore, it seems that there are some components that affect science identity. In addition, the literature has pointed to gender differences in science identity (Seyranian et al., 2018) and provided evidence that science performance may vary depending on the school campus (Alhadabi, 2021). Attempting to investigate further, this study aimed to examine the predictors of science identity of primary school students. The following research questions were generated to give specific direction to the research:

(1) What is the relationship between science identity, epistemological beliefs, competency beliefs, and science learning experiences of primary school students?
(2) How do epistemological beliefs, competency beliefs, science learning experiences, and demographic variables (gender and rural/urban) predict science identity?

## The importance of the study

Children with a positive science identity are on their way to becoming individuals who question science, seek accurate information, and solve problems throughout their lives. Throughout their educational lives, some students may approach science with feelings of curiosity, interest, desire, and perseverance. Such ongoing dedication contributes to students feeling that they themselves are scientists and supports the development of this perception by other people around them (Barton & Tan, 2010), something which can occur at any age. Although examining the science identity of middle school or high school students may seem more prudent, as this is a more academically advanced population, it is actually quite important to address primary school, considering it is a critical period of cognitive development.

Sagan (1996) did state that every child is born a scientist and their curiosity regarding science is extinguished due to the influence of social and educational systems. Moreover, if curiosity and interest in science are not developed by age 14, it can be difficult to re-engage (Lindahl, 2007). This seems to create a strong basis for investigating science identity formation in primary school. Understanding the variables related to science identity in this period may create an opportunity for those who shape educational systems, especially teachers, to think about the ideal paths that should be followed. Furthermore, understanding the components that affect science identity at the primary school level can add breadth to the literature in terms of designing science environments and expanding the theoretical frameworks used in science identity development.

Unlike the previous literature, this study focuses on the science identity of primary school students, which may be seminal for studies at this level. In addition, the study offers a first-time look into the education of Turkish children when it comes to science identity, as they have a different cultural structure than European society. In Turkish society, families generally expect their children to choose certain professions (Turan & Kayıkçı, 2019). Professions related to science are socially respected (Altan et al., 2019), so it may be possible to learn about the interaction of children's interest in science and their desire to pursue this interest with family and social expectations. Again, Turkish culture has a deep-rooted history and traditional values (Alkış Küçükaydın et al., 2023). Studying the blend between science identity and traditional values can generate some much-needed insights. Additionally, the overview of the Turkish education system in the development of science identity should be considered as one of the important contributions of the study.

## Theoretical background

Although the theoretical framework of the expression of science identity cannot be fully drawn, the three main components of Gee's (2000) identity theory are noteworthy: (a) competence to understand scientific knowledge, (b) performance for the recognition of scientific practices in the public sphere and scientific culture, and (c) being seen as a scientist by other people. According to this theory, if students are motivated to understand the natural world, demonstrate strong performance in this regard, and establish themselves as scientists in their environment, science identity construction begins to take place (Carlone & Johnson, 2007). Hazari et al. (2010) later added the component of enjoyment in doing scientific tasks to this long-accepted model. This was reflected in the structure of instruments measuring science identity and models measuring competence/performance, recognition, and interest components were tested. In this context, Chen and Wei (2022) developed a science identity scale for middle and high school students in a Chinese sample. Wang and Hazari (2018), on the other hand, developed a scale to determine the development of the physics identity of high school students in the USA sample.

Testing has taken place on different constructs such as situational interest, verbal persuasion, vicarious experiences, and mastery experiences have been tested, all which help measure science identity of undergraduate students. These structures have also been examined in the USA sample (Hosbein & Barbera, 2020). In studies conducted at the primary school level, science identity was associated with epistemological beliefs and thinking skills (Guo et al., 2022b), competency beliefs, values (Vincent-Ruz & Schunn, 2018), and science experiences (Liu & Schunn, 2018). These primary school level studies were conducted in Asian countries and the USA. The present study, on the other hand, tested the science identity of primary school students in a Turkish sample as an Eastern society. Based on this, a framework consisting of these variables examined in the literature was drawn for the science identity model in primary school.

### *Science identity*

In the related literature, language of commitment has been used to express science identity (Carlone & Johnson, 2007), such as 'attitudes' (Aschbacher et al., 2010), 'perceptions' (Hazari et al., 2013) and the match between 'school science' and 'real science' (Archer et al., 2010). However, Hosbein and Barbera (2020) examined science identity in terms of interest, recognition, competence, and performance. According to them, it is a social phenomenon that includes the ability to think about and understand science, characterising oneself as a person who loves science, competence in understanding scientific content, and having the belief that one can perform science-related tasks. In the development of this phenomenon, students need social support and interaction (Aschbacher et al., 2010). The support to be provided to students can be realised through the learning environment and peer interaction (Kim, 2018; Olitsky, 2007), but it also needs internal dynamics such as self-efficacy and motivation (Williams et al., 2018). Children who develop a science identity participate more in science activities in the classroom and thus generate more scientific ideas (Kim, 2018). Therefore, more strategies to develop students' science identity are needed (Vincent-Ruz & Schunn, 2021). However, before determining these strategies, it is necessary to define the basic components that constitute science identity. In this context, epistemological beliefs, competency beliefs and science learning experiences were discussed.

### *Epistemological beliefs*

Epistemological beliefs are defined as beliefs about knowledge or knowing (Schommer, 1994), and they act as a window into students' understanding of learning and thinking processes (Settlage & Southerland, 2019). In essence, epistemological beliefs can be used to understand the development of science identity (Krettenauer, 2005), considering that students gain experience about the work of scientists through various activities in science classrooms (Zhai et al., 2014). The reasoning processes that students employ in these science activities and the attitudes they exhibit throughout the process are guided by their epistemological beliefs (Verdín, 2021).

Epistemological beliefs are closely related to an individual's perceptions of competence in the subject area (Mason et al., 2013). Therefore, they are one of the factors that should be considered in the science learning process (Guo et al., 2022b; Karakolidis et al., 2019). Students' knowledge and deepening understanding of the subject matter can contribute to the positive progress of their epistemological beliefs. In contrast, negative epistemological beliefs may hurt perceptions of efficacy and hinder the development of science identity (Wang & Hazari, 2018). Guo et al. (2022a) determined that epistemological beliefs have a holistic effect on science identity. Accordingly, positive epistemological beliefs enable students to actively participate in learning and teaching processes and help the development of science identity (Lonka et al., 2021).

The relationship between science identity and epistemological beliefs shapes the way individuals and scientific communities think about science (Guo et al., 2022a). An individual's science identity is based on their epistemological beliefs, and these beliefs influence the individual's knowledge acquisition and evaluation processes (Krettenauer, 2005). At the same time, science identity determines how individuals interact within the scientific community, how they evaluate scientific knowledge, and how they relate to science (Alhadabi, 2021; Aschbacher et al., 2010). Epistemological beliefs form the basic intellectual infrastructure that shapes this identity (Guo et al., 2022b). Therefore, epistemological beliefs were evaluated first in this study.

### *Competency beliefs*

Competence beliefs are a fundamental construct in social cognitive theory and include judgments about one's abilities to achieve a certain type of performance (Bandura, 1986). Competence beliefs in science refer to the extent to which an individual believes that they understand science subjects and can perform science tasks (Dorph et al., 2016). In many educational studies, efficacy beliefs have been considered a predictor of interest in science or identity development (Alhadabi, 2021; Sandrone, 2022; White et al., 2019). In a study conducted with more than 1,800 undergraduate students, it was reported that a sufficient level of competence belief contributed to the development of science identity (Williams & George-Jackson, 2014). In other words, when students assessed themselves of being more competent in science, their science identity becomes more pronounced (Williams et al., 2018). This is because science competence beliefs can affect decisions to participate in science-related activities, performance in related tasks, perseverance throughout the process (White et al., 2019).

Competency beliefs were another important component of this study. This is because the relationship between competency beliefs and science identity helps us understand students' science-related experiences and how they feel in this field (Vincent-Ruz & Schunn, 2018). Competency beliefs can shape a student's science identity (Chemers et al., 2011). When those beliefs are strong, the student will be more adept at viewing him or herself as an individual who interacts with science and takes on such an identity (White et al., 2019). The relationship between competency beliefs and science identity is important for understanding and positively influencing students' science-related experiences (Dorph et al., 2016; Nhien, 2022). High competency beliefs can create a strong science identity (Sandrone, 2022).

### *Science learning experiences*

Apart from formal learning environments, students can also learn science in museums, zoos, or summer camps (National Research Council, 2015). Related research has shown that informal science learning experiences contribute to the development of science identity (Joy et al., 2021). An individual can have an informal science learning experiences at school or at home (Liu & Schunn, 2018). Students' informal science learning experiences result in stimulating interaction with professionals in scientific fields, such as doctors, museum curators, and others (Callanan et al., 2020; Mulvey et al., 2020). This contributes to the acquisition of science skills and provides students with opportunities for practice (Burns et al., 2023). According to Goff et al. (2019), the experiences of students increase their interest in science and contribute to the formation of a sense of competence in science.

When one begins learning experientially about science, the individual's scientific thinking skills start to take shape (Burns et al., 2023; Callanan et al., 2020). Experiential learning includes processes such as observation, hypothesising, designing experiments, and evaluating the results (Alkış Küçükaydın et al, 2023). Such experiences increase individuals' familiarity with scientific thinking and methods (Lave & Wenger, 1991; Nasir & Hand, 2008). In essence, science learning experiences shape individuals' relationships with science and help them form a science identity (Carlone & Johnson, 2007). Achievements, coping with challenges, exploring, and curiosity contribute to individuals seeing themselves as scientists who interact with science (Dabney et al., 2012). Science learning experiences encourage individuals to participate in scientific processes (Goff et al., 2019). Taking part in these processes reinforces the sense of being part of the scientific community. Therefore, science learning experiences were included in the study as a component of science identity.

## Present study

Studies on science identity have shown that it is related to students' engagement in science learning (Barton & Tan, 2010). Vincent-Ruz and Schunn (2021) found a close relationship between science identity and science learning experiences. In addition, science identity affects science-related career intentions (Chemers et al., 2011). Therefore, science identity appears to be related to many science-related components. Therefore, it is important to identify the components of science identity.

To date, science identity studies have mostly been conducted intensively at the high school (Aschbacher et al., 2010; Brickhouse et al., 2000; Chen & Wei, 2022; Hazari et al., 2013), and sometimes undergraduate level (Hosbein & Barbera, 2020; McBride et al., 2020). However, these are periods when individuals experience complexities in their physical, emotional, and social development (Master et al., 2012) and when interest in science decreases (Barmby et al., 2008). The findings of studies conducted during these developmental periods will be different from the findings of studies conducted with children. Moreover, the number of studies on children's science identity is quite limited. To date, studies conducted with children are generally aimed at understanding the effect of science field trips (Dabney et al., 2012; Shaby & Vedder-Weiss, 2020) and classroom-based programmes on science identity (Kim, 2018; Starr et al., 2020; Williams et al., 2018). Although these studies are valuable, a limited number of studies have been conducted to understand the components of science identity in primary school (Guo et al., 2022b; Kim, 2018). Therefore, in this study, the variables related to primary school students' science identity were examined and a model was proposed. Hypotheses were tested based on previous literature.

In the science identity literature, science identity comparisons of boys and girls students are frequently discussed (Seyranian et al., 2018; Williams & George-Jackson, 2014). A study conducted with 5th-grade middle school students, significant differences were found between the science identity of boys and girls students (Moote et al., 2020). Similarly, Alhadabi (2021) examined the differences between adult women's and men's science identity. However, as far as we know, the relationship between science identity and gender in younger age groups has not yet been determined. Therefore, we first tested the relationship between gender and science identity at the primary school level. The hypothesis formed in this context is as follows:

**H1:** Gender is a significant predictor of science identity.

It is known that children living in rural areas have different priorities from those in urban environments. For example, while children living in rural areas are expected to support their family work (agriculture, animal husbandry, etc.) in addition to their education, children living in cities are directed solely towards academic achievement (Basun & Erden, 2020). This explains why there are such significant differences in learning. In Alhadabi's (2021) study comparing the science identity of students in the urban centre and rural areas, it was seen that the settlement in which they lived had a significant effect on their science identity. We also assumed that students living in rural areas have a lower level of science identity than students living in the city centre. The hypothesis tested in the study was written as follows:

**H2:** Location of residence (rural/urban) is a significant predictor of science identity.

A select few studies have noted that students' epistemological beliefs were found to impact science identity (Guo et al., 2022a; 2022b). This would indicate that there is a relationship between science identity and epistemological beliefs from a young age. The following hypothesis was formed to test this:

> **H3:** Primary school students' epistemological beliefs are a significant predictor of science identity.

In a study conducted with 6th-grade students, garden-based activities were found to be instrumental in supporting students' engagement and learning in science and in encouraging long-term interest in science professions (Williams et al., 2018). In another study conducted with 6th and 8th-grade students, it was found that extracurricular activities related to science were effective in fostering students' attitudes towards science, and thus contributed to the development of science identity (Liu & Schunn, 2018). In their study with undergraduate students, Goff et al. (2019) found that informal activities in science education were associated with the development of science identity. Informal science learning experiences may be an important predictor of science identity. The hypothesis formed to examine this further was generated thusly:

> **H4:** Informal science learning experiences are a significant predictor of science identity.

In Nhien's (2022) study conducted with senior high school and first-year university students, it was reported that there was a significant relationship between science identity and science competence. Again, Robinson et al. (2019) testified that there was a relationship between science identity and science competence and that science identity develops positively as science competence increases. Science identity is positively affected as science competence increases (Sandrone, 2022). Assuming that this relationship is also valid for younger age groups, the final hypothesis of the study is as follows:

> **H5:** Science-specific efficacy beliefs are a significant predictor of science identity.

## Method

The goal of this study was to reveal the variables related to primary school students' science identity. The survey method was adopted to help achieve this (Karasar, 2011). A model proposal was tested to determine the predictors of students' science identity. The tested model is presented in Figure 1.

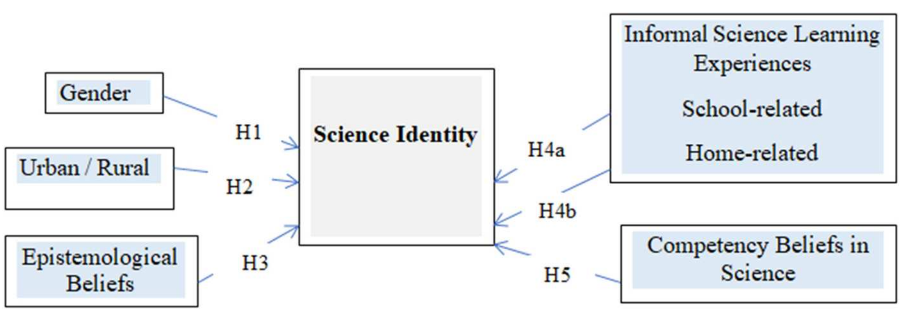



**Figure 1.** Default Model.

## Participants

A total of 775 primary school students between the ages of 9–12 ($M = 9.60$, $SD = .65$) participated in the study. As for the gender ratio, 399 (51.5%) of the students were girls and 376 (48.5%) were boys. The participating students lived in the Central Anatolia and Southeastern Anatolia regions of Turkey. Of the 775 students, 476 (61.4%) lived in the city centre and 299 (38.6%) were located in rural areas. All the students were studying in public schools.

## Instruments

The science identity, epistemological beliefs, competency beliefs, and science learning experiences scales used in this study were incorporated based on evidence from previous studies. The content and structure of the questionnaires used in previous studies provided valuable guidance for us in designing a questionnaire that was appropriate for the main questions and hypotheses of our study.

Guo et al. (2022b) conducted a similar study with primary school students whereby then provided evidence for the questionnaires they used, and this helped us identify a questionnaire design appropriate to our own research questions. Again, Dorph et al. (2016), in their study with middle school students, provided solid evidence for the competency beliefs scale. Liu and Schunn (2018) categorised science learning experiences as both formal and informal experiences, as in the hypotheses of our study. This combined with the fact that the measurements obtained strongly reflected the behaviours in the relevant population guided us in the fabrication of our questionnaire. The use of questionnaires in the literature also helped us to create a language and structure appropriate to the participant profile and target group of our study. In addition to the validity and reliability evidence in the questionnaires, the present study also provides some evidence.

### *Personal information form*

This was prepared by researchers to obtain demographic details from the students. It specifically sought information on gender, age, and residence (urban/rural).

### *Science identity scale*

The science identity scale developed by Vincent-Ruz and Schunn (2018) was used in the study. The scale asks how children perceive themselves as a scientists and how others (e.g. parents, teachers, peers) perceive them as scientists. The scale has 4 questions and is scored on a 4-point Likert scale (4 = YES!, 3 = yes, 2 = no, 1 = NO!). The higher the score obtained from the scale, the higher the level of science identity. The scale was adapted into Turkish within the scope of this study.

### *Epistemological beliefs questionnaire*

Developed by Conley et al. (2004), this questionnaire was utilised to help determine students' epistemological beliefs. The scale consists of the source (5 items), certainty

(9 items), development (6 items), and justification (6 items) sub-dimensions. The source dimension examines the belief in the source of scientific knowledge; certainty pursues the belief in the accuracy and certainty of scientific knowledge; development attempts to uncover the belief in the development and change of scientific knowledge over time; and justification asks questions that evaluate beliefs on whether knowledge is scientific or not. The 5-point Likert-type scale (1 = strongly disagree; 5 = strongly agree) has a total of 26 questions, and the items in the source and certainty dimensions are reverse coded. The total score obtained from the scale is calculated and higher scores are interpreted as complex epistemological beliefs. The scale was previously adapted into Turkish by Özkan (2008), and validity and reliability studies were conducted. For this study, Cronbach's alpha coefficients of the dimensions of the scale were .72 for source, .80 for certainty, .82 for development, and .73 for justification.

### *Competency beliefs in science scale*

The competency beliefs in science scale developed by Dorph et al. (2016) were used to assess students' beliefs regarding their competency in science. The scale includes 9 items (e.g. I think I am pretty good at: Coming up with questions about science), and is scored on a 4-point Likert scale (4 = YES!, 3 = yes, 2 = no, 1 = NO!). A high score denotes firm beliefs in personal science competency. The scale was adapted to Turkish in this study.

### *Science learning experiences scale*

The optional science learning experiences scale developed by Liu and Schunn (2018) was used to assess optional science learning experiences. The scale addressed optional science experiences conducted in the context of home and school. School-related science experiences included 5 items (e.g. I talked to a science teacher about good science books or websites), while home-related science experiences included 6 items (e.g. Outside of class, I watched TV programmes about science topics). The scale is scored on a 4-point Likert scale (range: never, once, a few times, many times). Scores obtained from the dimensions of the scale are evaluated separately. An average score of 2.5 and above means a high level of science experience. The scale was adapted into Turkish within the scope of this study.

## Procedure

Before the instruments were applied, permission was obtained from the Dicle University Social and Human Sciences Ethics Committee. Then, the personal information form and scales were prepared as a paper-and-pencil test. Ethics committee permission was sent to school principals prior to implementation. The principals delivered the relevant items to teachers and parents and had them fill out the consent forms. The forms were collected by the researchers and information was transferred to the Excel programme. Then the analysis process started. Data collection took place at the beginning of the 2023–2024 academic year.

## Validity and reliability studies of instruments

The science identity scale, competency beliefs in science scale, and science learning experiences scale were adapted into Turkish within the scope of this study.

According to the confirmatory factor analysis conducted for the *science identity scale*, the factor loadings of the items in the scale ranged between .664 and .723. The fit index values of the scale are as follows: $\chi 2$ /d*f* = 4.86, RMSEA = .07 [90% CI; .04/ .12], AGFI = .97, NFI = .99, GFI = .98, CFI = .99, TLI = .96. This shows that the scale has acceptable fit values (Kline, 2011). Cronbach's alpha and McDonald's omega reliability coefficients of the scale are .85. In addition, the average variance extracted (AVE) value is .50 and the composite reliability (CR) value is .81.

According to the confirmatory factor analysis for *competency beliefs in the science scale*, the factor loadings of the items in the scale ranged between .538 and .667. The fit index values of the scale are as follows: $\chi 2$ /d*f* = 3.21, RMSEA = .05 [90% CI; .04/ .06], AGFI = .91, NFI = .94, GFI = .98, CFI = .99, TLI = .96. In this case, the scale has acceptable fit values. Cronbach's alpha and McDonald's omega reliability coefficients for the school-related science experiences dimension of the scale were .79, and Cronbach's alpha and McDonald's omega reliability coefficients for the home-related science experiences dimension were .70. The AVE value for the school-related science experiences dimension is .52 and the CR value is .82, while the AVE value for the home-related science experiences dimension is .51 and the CR value is .81.

According to the confirmatory factor analysis of the *science learning experiences scale*, the factor loadings of the items in the scale ranged between .509 and .720. The fit index values of the scale are as follows; $\chi 2$ /d*f* = 3.62, RMSEA = .05 [90% CI; .04/ .07], AGFI = .94, NFI = .94, GFI = .97, CFI = .95, TLI = .93. In this case, the scale has acceptable goodness of fit. The Cronbach's alpha value calculated for the scale is .80 and McDonald's omega value is .81. In addition, the AVE value is .50 and the CR value is .88.

The factor loading and validity and reliability evidence of the items that make up the scales are presented in Appendix A.

## Data analysis

In the data analysis section, missing and extreme values were first checked. In the preliminary analysis, the normality distribution of the data was examined with skewness and kurtosis values. Then, descriptive analyses were conducted using SPSS 26 programme. The multivariate kurtosis critical ratio of the data was observed to be below 10 (Kline, 2011). Based on this, model analysis was performed in AMOS 25 programme.

The structural equation model was used to test the predictors of scientific identity. Model fit was tested with $\chi 2$ /d*f* (<5), RMSEA (<.08), AGFI, NFI, GFI, CFI, and TLI (>.90) values (Kline, 2011).

## Results

Descriptive analyses were conducted to answer the first research question of the study and the results are summarised in Table 1. While evaluating the scores obtained from the 4-point Likert-type scales, 2.50 were accepted as the cut-off score. Accordingly,

**Table 1.** Descriptive Statistical Analysis Results.

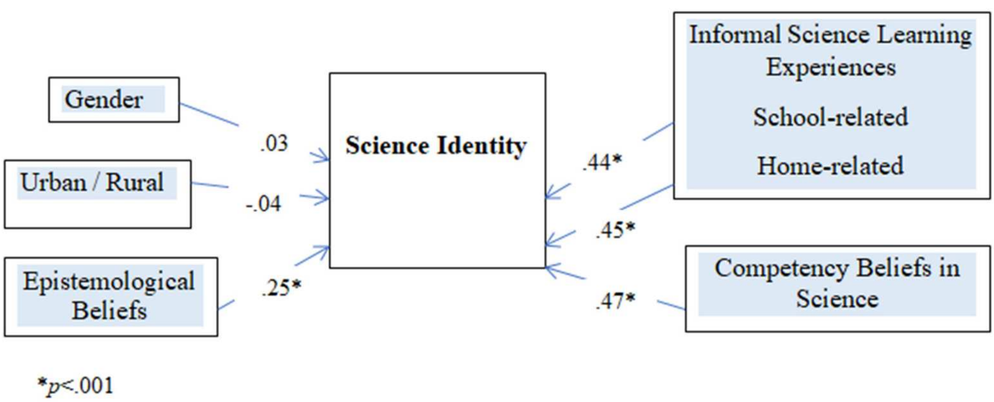
| Variables | Min | Max | *M* | *M/k** | *SD* | Skewness *(SE = .08)* | Kurtosis *(SE = .17)* |
|---|---|---|---|---|---|---|---|
| Science Identity | 4.00 | 16.00 | 9.09 | 2.27 | 2.96 | .32 | −.22 |
| Epistemological Beliefs | 26.00 | 129.00 | 92.82 | 3.57 | 12.36 | .50 | 1.39 |
| Competency Beliefs in Science | 9.00 | 36.00 | 25.97 | 2.88 | 5.13 | −.34 | 1.28 |
| Science Learning Experiences | 11.00 | 44.00 | 24.24 | 2.20 | 7.35 | .28 | −.58 |
| *School-related science experiences* | 5.00 | 20.00 | 9.84 | 1.96 | 4.08 | .65 | −.53 |
| *Home-related science experiences* | 6.00 | 24.00 | 14.42 | 2.40 | 4.75 | .01 | −.66 |

**k = items of number.*

students' science identity (*M/k* = 2.27, *SD* = 2.96), school-related science experiences (*M/*k = 1.96, *SD* = 4.08), and home-related science experiences (*M/k* = 2.40, *SD* = 4.75) were below the cut-off point. This means that these competencies are low. However, students' science efficacy was better (*M/k* = 2.88, SD = 5.13) and their epistemological beliefs were above average (*M/k* = 3.57, *SD* = 12.36).

To answer the second research question of the study, the model including the variables was tested (Figure 2). The fit index values of the model obtained are as follows: $\chi 2$ /*df* = 3.05, RMSEA = .05 [90% CI; .04/ .05], AGFI = .92, NFI = .92, GFI = .95, CFI = .96, TLI = .95. According to the model, there were significant relationships between science identity and epistemological beliefs ($r = .25$, $p < .001$), school-related science experiences ($r = .44$, $p < .001$), home-related science experiences ($r = .45$, $p < .001$), and science competencies ($r = .47$, $p < .001$). The highest correlation coefficient was between science identity and science competence ($r = .47$). This was followed by home-related science experiences ($r = .45$) and school-related science experiences ($r = .44$). In this case, the predictors of science identity were science efficacy, home-related science experiences, and school-related science experiences in order of relative importance.

Variance-covariance values of the variables are provided in Table 2, which shows that the variable with the highest variance value was science identity (var = 8.78),




| Test for Exact Fit | | |
|---|---|---|
| $\chi^2$ | *df* | *p* |
| 3575 | 1169 | < .001 |

**Figure 2.** Correlation coefficient for model.

**Table 2.** Covariance Matrix.

| Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1.Gender | .25 | | | | | | |
| 2.Rural/urban | −.01 | .23 | | | | | |
| 3.Science identity | .05 | −.05 | 8.78 | | | | |
| 4.Epistemological beliefs | .40 | .37 | 9.24 | 7.75 | | | |
| 5.School-related science experiences | .23 | .03 | 5.38 | 6.06 | 6.69 | | |
| 6. Home-related science experiences | .08 | −.01 | 6.33 | 3.98 | 1.24 | 2.61 | |
| 7. Competency beliefs in science | .01 | −.04 | 7.19 | 5.88 | 1.01 | 3.82 | 1.33 |

**Table 3.** Acceptance/Rejection.

| Hypothesis | Relation | β | t | Accept/ Reject |
|---|---|---|---|---|
| H1 | Gender is a significant predictor of science identity. | −.00 | −.03 | Reject |
| H2 | Location of residence (rural/urban) is a significant predictor of science identity. | −.04 | −1.51 | Reject |
| H3 | Primary school students' epistemological beliefs are a significant predictor of science identity. | .10 | 3.31 | Accept |
| H4a | Informal science learning experiences (school-related science experiences) are a significant predictor of science identity. | .22 | 6.87 | Accept |
| H4b | Informal science learning experiences (home-related science experiences) are a significant predictor of science identity. | .18 | 5.57 | Accept |
| H5 | Science-specific efficacy beliefs are a significant predictor of science identity. | .29 | 8.96 | Accept |

while the variable with the lowest variance value was rural/urban (var = .23). When the covariance value between variables was analyzed, the highest value was between science identity and epistemological beliefs (cov = 9.24). The lowest covariance value is between gender and rural/urban (cov = -.01) and rural/urban and home-related science experiences (cov = -.01).

The acceptance and rejection of the hypotheses tested in the study are presented in Table 3. Accordingly, hypotheses H1 ($\beta = -.00$, $t = -.03$, $p > .05$) and H2 ($\beta = -.04$, $t = -1.51$, $p > .05$) were rejected. Hypotheses H3 ($\beta = .10$, $t = 3.31$, $p < .05$), H4a ($\beta = .227$, $t = 6.87$, $p < .05$), H4b ($\beta = .18$, $t = 5.57$, $p < .05$), and H5 ($\beta = .29$, $t = 8.96$, $p < .05$) were accepted.

## Discussion

In the study, some variables hypothesised to predict primary school students' science identity were tested. Ultimately, the H1 and H2 hypotheses were rejected. Science identity does not show a significant difference according to students' gender and place of residence. According to previous literature on science identity, there are differences in the science identities of girls' and boys'. Consequently, boys have a stronger science identity structure. This data runs contrary to the findings of our research. However, it is worth remembering that the results obtained in previous literature were obtained from older age groups (Alhadabi, 2021; Moote et al., 2020; Seyranian et al., 2018; Williams & George-Jackson, 2014). Science literature reports that students' interest in science is high in younger age groups, but there is a general decline especially after the age of 14–17 (Hanushek et al., 2019). However, our descriptive analysis showed that students' science identity scores were low. Various reasons may factor into these results.

In his theory of identity formation, Gee (2000) emphasised the importance of being seen as a scientist by other people. Therefore, the identity-blocking foreclosures of parents, teachers, or friends (Alhadabi, 2021) may have had an impact on the formation of children's science identities. For example, the parents' lack of interest in science and their imposing goals related to other fields may have hindered the full formation of the child's science identity. Additionally, the type of school may have played an active role in the weakness of science identity. Braun et al. (2006) stated that there is a performance difference in science between private and public schools, which is reflected in students' science identity. Accordingly to this, the performance differences arising from school resources may influence science identity. For our study, data was collected only from students in public schools. Therefore, it does not seem possible to make such a comparison at the moment. In that case, within the scope of our study, we are focusing on other variables that may affect students' science identity. It was observed that there was no significant difference between students' residential area (urban/rural) and science identity scores. However, the literature reported that the school area is related to science identity. In Arnold et al.'s (2005) study, it was emphasised that rural students had lower levels of science competence and science identity than urban students. In Alhadabi's (2021) study, when all predictors were held constant, students in urban schools had higher science identity scores than rural students. It should be noted that these findings were obtained from older age groups, even though there may also be other reasons for this phenomenon. Archer et al. (2010) reported that although 10-to-11-year-old children found science lessons fun and interesting, they did not adopt science as an identity domain. Carlone et al. (2014) mentioned that cultural narratives about what is considered scientific in school science are influential in shaping students' science identities. Therefore, the reason for this finding may be that in Turkish culture, regardless of rural or urban areas, science is portrayed as a cold, cheesy, and asocial human endeavour. The teacher's approach and the structure of the lesson may also effect this perception (Titrek & Cobern, 2011).

In the study, informal science learning experiences, epistemological beliefs, and science competence were found to be significant predictors of science identity. Activities at home (e.g. Reading science-related books, watching science-related TV programmes, dealing with insects) or at school (e.g. Chatting with the teacher about science, participating in optional science clubs) can help the student feel like a scientist. This is because individuals who have informal science learning experiences are in groups with high rates of internalisation of science and interest in this subject (Liu & Schunn, 2018). This can be used to explain how informal science learning experiences can be used to keep science identity high without losing interest in science over time.

Science identity includes the individual's acceptance of themselves as a scientist as well as their confidence in their performance to become a scientist (Chen & Wei, 2022). In this context, students choose specific goals and participate in activities to achieve them. In this pursuit, students use a cognitive structure to define themselves as scientists (Guo et al., 2022a). Research has shown that beliefs are effective on these cognitive structures (Verdín, 2021; Wang & Hazari, 2018). In the current study, epistemological beliefs were found to be an effective variable in the development of science identity. Bromme et al. (2009) stated that epistemological beliefs are a cognitive system that activates the internal dynamics of the individual. This makes it possible to note how an internal recognition on the impact of epistemological beliefs contributes to a student's self-perception as a scientist. However, both the scarcity of empirical studies on the relationship between science identity and epistemological beliefs and the lack of supportive findings at the primary school level are serious gaps in the literature. In addition, previous studies have drawn attention to the perception of efficacy, which is thought to have an impact on science identity (Sandrone, 2022; Williams & George-Jackson, 2014). Therefore, the relationship between science identity and science learning efficacies was also tested in this study.

Our results showed that science-specific efficacy beliefs are related to science identity. Students who consider themselves competent in science and think that they can conduct research in this field are likely to perceive themselves as legitimate scientists. This point to the necessity of practices that nurture self-efficacy if students' science identity level is to be increased. If self-efficacy is low across the board, intervention in primary school years would be vital. The relevant literature emphasises the unreflective role of practices that increase self-efficacy (White et al., 2019). In conclusion, students' perception of themselves as competent in science is a determinant variable in the development of science-related identity.

## Limitations and implications

The study has some limitations. Firstly, only the effects of gender and residential area on science identity were examined as far as demographics were concerned, and data was collected only from public schools. In addition, teacher, and classroom variables, which were previously reported to influence science identity (Kim, 2018), were not included in the model. The effect of these variables can be tested in future studies.

In addition, the study examined the relationship between epistemological beliefs, competency beliefs, science learning competencies, and the variables of gender and place of residence with science identity. Therefore, 5 hypotheses were tested in this context. However, there may also be social (e.g. ethnicity, social class difference), cultural (e.g. the value given to science, language), gender and inclusiveness, and familial factors related to science identity. Other variables such as educational curriculum, teacher attitudes, and the way the media portrays science should also be taken into account. In fact, all these variables should be taken into consideration in future research. Although the study focused on the variables affecting primary school students' science identity, it was based entirely on self-report scales. Although this revealed the effect of social desirability, it did not take into account parent, teacher, and classroom/school variables. In future studies, the proposed model could be extended to obtain strengthening evidence through observation forms or opinions from parents, peers, and teachers.

The 4-point Likert-type scales and the approach to setting cut-off scores may lead to measurement limitations. More precise measures and strategies for determining cut-off scores should be considered in future research. Using more precise measurements and revising strategies for determining cut-off scores may be useful to better understand students' science identity and its relationships with other variables. Finally, data collection was limited to only two of the seven regions of Turkey. In addition, the number of samples taken from urban and rural areas was not equal. Consequently, the findings cannot be generalised to the whole country. We recommend enlarging the sample in research to come.

## Conclusion

According to Gee's theory (2000), identity is explained as 'being the kind of person one tries to realize'. However, a person cannot claim an identity on their own, and identity formation requires external support (Carlone & Johnson, 2007). In other words, for an individual to form an identity, they should be visible in the eyes of others (Carlone et al., 2014). And for an individual to form a science identity, they are expected to use a language of science with norms, interact, express competence, and perform (Chen & Wei, 2022). However, the development of science identity may vary at different ages. The current study focuses on the primary school years, which is the period when science identity first begins to form.

Related literature has suggested that science identity is connected to epistemological beliefs that deal with what science is and how knowledge is acquired (Guo et al., 2022a; 2022b). Accordingly, it is valuable to examine the science identity development of children who seek ways to access knowledge. Again, science identity is related to an individual's belief in competence in science (Kim, 2018). It is a fact that children who are interested in science in formal or informal settings are intertwined with science (Hazari et al., 2010). In addition, the development of science identity in male and female students was examined according to the variables of place of residence.

Accordingly, informal science learning experiences, epistemological beliefs, and science efficacy beliefs were found to be significant predictors of science identity. The findings can be used as a model suggestion for science identity at the primary school level. However, as many educators would agree, the study did not include variables that have the potential to affect science identity such as parental influence, teacher approach, and peer support. Therefore, the proposed model can be developed and tested with primary school students from different cultures.

The study was conducted with primary school students in a Turkish sample and addressed some predictors of science identity. Unlike the studies in the literature, which generally focus on middle and high school students (Alkış Küçükaydın et al., 2023; Dorph et al., 2016), research on this age group is vital to better understanding how a science identity is formed. In the study, structural equation modelling was used to examine the relationships among the factors affecting science identity. Based on the data obtained from the Turkish sample, the findings of the study provide a basis for understanding and generalising the influences on Turkish primary school students' science identity. This is a valuable contribution to the international literature in understanding the role of cultural and educational systems. Finally, the model tested in the study provides theoretical contributions to explain the components of science identity in primary school.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

This study is supported within the scope of TUBITAK 1002 project number 123K683.

## Ethics approval

This study was approved by the ethics committee of the Dicle University (02.08.2023/−539904).

## Consent to participate

Informed consent was obtained from all individual participants included in the study.

## Data availability statement

The data that support the findings of this study are available from the corresponding author upon request.

## ORCID

*Menşure Alkış Küçükaydın* http://orcid.org/0000-0003-4410-1279
*Çiğdem Akkanat Avşar* http://orcid.org/0000-0002-6797-6740
*Elçin Ayaz* http://orcid.org/0000-0003-2488-6777
*Elif Sayıcı* http://orcid.org/0000-0003-3414-7150

## References

Alhadabi, A. (2021). Science interest, utility, self-efficacy, identity, and science achievement among high school students: An application of SEM tree. *Frontiers in Psychology*, *12*, 634120. https://doi.org/10.3389/fpsyg.2021.634120

Alkış Küçükaydın, M., Esen, S., Çite, H., & Gürbüzer, S. (2023). Science identity of Turkish students adaptation of the science identity questionnaire and analysis in terms of demographic variables. *Research in Science & Technological Education*, https://doi.org/10.1080/02635143.2023.2285296

Altan, E. B., Üçüncüoğlu, İ, & Zileli, E. (2019). Yatılı bölge ortaokulu öğrencilerinin STEM alanlarına yönelik kariyer farkındalığının araştırılması (Investigation of career awareness of STEM fields of the regional boarding secondary schools students). *Kastamonu Journal of Education*, *27*(2), 785–797.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old school children's constructions of science through the lens of identity. *Science Education*, *94*(4), 617–639. https://doi.org/10.1002/sce.20399

Archer, L., Godec, S., & Moote, J. (2022). "My love for it just wasn't enough to get me through": A longitudinal case study of factors supporting and denying black British working-class young women's science identities and trajectories. In H. T. Holmegaard & L. Archer (Eds.), *Science identities: Theory, method and research* (pp. 23–45). Springer.

Arnold, M. L., Newman, J. H., Gaddy, B. B., & Dean, C. B. (2005). A look at the condition of rural education research: Setting a direction for future research. *Journal of Research in Rural Education*, *20*(6), 1–25.

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, *47*(5), 564–582. https://doi.org/10.1002/tea.20353

Avraamidou, L. (2019). Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectionality lens. *Cultural Studies of Science Education*, *15*(2), 323–345. https://doi.org/10.1007/s11422-019-09954-7

Bandura, A. (1986). *Social foundations of thoughts and action: A social cognitive theory*. Prentice Hall Inc.

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education*, *30*(8), 1075–1093. https://doi.org/10.1080/09500690701344966

Barton, A. C., & Tan, E. (2010). We be burn in'! Agency, identity, and science learning. *The Journal of the Learning Sciences*, *19*(2), 187–229. https://doi.org/10.1080/10508400903530044

Basun, B., & Erden, Ş. (2020). Analysis of social problem solving skills of preschool children living in urban and rural areas. *Journal of National Education*, *49*(227), 271–288.

Braun, H., Jenkins, F., & Grigg, W. (2006). Comparing private schools and public schools using hierarchical linear modeling. NCES 2006-461. U.S. Government Printing Office, U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*(5), 441–458. https://doi.org/10.1002/(SICI)1098-2736(200005)37:5<441::AID-TEA4>3.0.CO;2-3

Bromme, R., Pieschl, S., & Stahl, E. (2009). Epistemological beliefs are standards for adaptive learning: A functional theory about epistemological beliefs and metacognition. *Metacognition and Learning*, *5*(1), 7–26. https://doi.org/10.1007/s11409-009-9053-5

Burns, E. C., Martin, A. J., Kennett, R., Pearson, J., & Munro-Smith, V. (2023). High school students' out-of-school science participation: A latent class analysis and unique associations with science aspirations and achievement. *Journal of Research in Science Teaching*, *60*(3), 451–483. https://doi.org/10.1002/tea.21806

Callanan, M. A., Legare, C. H., Sobel, D. M., Jaeger, G. J., Letourneau, S., McHugh, S. R., Willard, A., Brinkman, A., Finiasz, Z., Rubio, E., & Barnett, A. (2020). Exploration, explanation, and parent–child interaction in museums. *Monographs of the Society for Research in Child Development*, *85*(1), 7–137. https://doi.org/10.1111/mono.12412

Carlone, H. B. (2022). Understanding and contextualizing the field of science identity research. In H. T. Holmegaard, & L. Archer (Eds.), *Science identities: Theory, method and research* (pp. 3–20). Springer.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching*, *51*(7), 836–869. https://doi.org/10.1002/tea.21150

Chapman, A., & Feldman, A. (2017). Cultivation of science identity through authentic science in an urban high school classroom. *Cultural Studies of Science Education*, *12*(2), 469–491. https://doi.org/10.1007/s11422-015-9723-3

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, *67*(3), 469–491. https://doi.org/10.1111/j.1540-4560.2011.01710.x

Chen, S., & Wei, B. (2022). Development and validation of an instrument to measure high school students' science identity in science learning. *Research in Science Education*, *52*(1), 111–126. https://doi.org/10.1007/s11165-020-09932-y

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, *29*(2), 186–204. https://doi.org/10.1016/j.cedpsych.2004.01.004

Dabney, K. B., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education Part B*, *2*(1), 63–79.

Dawson, E. (2014). Equity in informal science education: Developing an access and equity framework for science museums and science centers. *Studies in Science Education*, *50*(2), 209–247. https://doi.org/10.1080/03057267.2014.957558

Dorph, R., Cannady, M. A., & Schunn, C. D. (2016). How science learning activation enables success for youth in science learning experiences. *The Electronic Journal for Research in Science & Mathematics Education*, *20*(8), 49–85.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, *25*(1), 99–125. https://doi.org/10.3102/0091732X025001099

Goff, E. E., Mulvey, K. L., Irvin, M. J., & Hartstone-Rose, A. (2019). The effects of prior informal science and math experiences on undergraduate STEM identity. *Research Science and Technological Education*, *38*(3), 1–17.

Guo, X., Hao, X., Deng, W., Ji, X., Xiang, S., & Hu, W. (2022b). The relationship between epistemological beliefs, reflective thinking, and science identity: A structural equation modeling analysis. *International Journal of STEM Education*, *9*(1), 1–17. https://doi.org/10.1186/s40594-021-00318-8

Guo, J., Hu, X., Marsh, H. W., & Pekrun, R. (2022a). Relations of epistemic beliefs with motivation, achievement, and aspirations in science: Generalizability across 72 societies. *Journal of Educational Psychology*, *114*(4), 734–751. https://doi.org/10.1037/edu0000660

Hanushek, E. A., Piopiunik, M., & Wiederhold, S. (2019). The value of smarter teachers: International evidence on teacher cognitive skills and student performance. *Journal of Human Resources*, *54*(4), 857–899. https://doi.org/10.3368/jhr.54.4.0317.8619R1

Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The science identity of college students: Exploring the intersection of gender, race, and ethnicity. *Journal of College Science Teaching*, *42*(5), 82–91.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978–1003. https://doi.org/10.1002/tea.20363

Hosbein, K. N., & Barbera, J. (2020). Development and evaluation of novel science and chemistry identity measures. *Chemistry Education Research and Practice*, *21*(3), 852–877. https://doi.org/10.1039/C9RP00223E

Joy, A., Law, F., McGuire, L., Mathews, C., Hartstone-Rose, A., Winterbottom, M., Rutland, A., Fields, G. E., & Mulvey, K. L. (2021). Understanding parents' roles in children's learning and engagement in informal science learning sites. *Frontiers in Psychology*, *12*, 635839. https://doi.org/10.3389/fpsyg.2021.635839

Karakolidis, A., Pitsia, V., & Emvalotis, A. (2019). The case of high motivation and low achievement in science: What is the role of students' epistemic beliefs? *International Journal of Science Education*, *41*(11), 1457–1474. https://doi.org/10.1080/09500693.2019.1612121

Karasar, N. (2011). *Scientific research methods*. Nobel Publishing.

Kim, M. (2018). Understanding children's science identity through classroom interactions. *International Journal of Science Education*, *40*(1), 24–45. https://doi.org/10.1080/09500693.2017.1395925

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

Krettenauer, T. (2005). The role of epistemic cognition in adolescent identity formation: Further evidence. *Journal of Youth and Adolescence*, *34*(3), 185–198. https://doi.org/10.1007/s10964-005-4300-9

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Lee, W. W. S., & Chan, C. K. K. (2018). Relationships among epistemic beliefs, perception of learning environment, study approaches and academic performance: A longitudinal exploration with 3P model. *The Asia-Pacific Education Researcher*, *27*(4), 267–276. https://doi.org/10.1007/s40299-018-0384-3

Lindahl, B. (2007). *A longitudinal study of students' attitudes towards science and choice of career*. Paper presented at the 80th NARST International Conference, New Orleans, LA.

Liu, A. S., & Schunn, C. D. (2018). The effects of school-related and home-related optional science experiences on science attitudes and knowledge. *Journal of Educational Psychology*, *110*(6), 798–810. https://doi.org/10.1037/edu0000251

Lonka, K., Ketonen, E., & Vermunt, J. D. (2021). University students' epistemic profiles, conceptions of learning, and academic performance. *Higher Education*, *81*(4), 775–793. https://doi.org/10.1007/s10734-020-00575-6

Mason, L., Boscolo, P., Tornatora, M. C., & Ronconi, L. (2013). Besides knowledge: A cross-sectional study on the relations between epistemic beliefs, achievement goals, self-beliefs, and achievement in science. *Instructional Science*, *41*(1), 49–79. https://doi.org/10.1007/s11251-012-9210-0

Master, A., Markman, E. M., & Dweck, C. S. (2012). Thinking in categories or along a continuum: Consequences for children's social judgments. *Child Development*, *83*(4), 1145–1163. https://doi.org/10.1111/j.1467-8624.2012.01774.x

McBride, E., Oswald, W. W., Beck, L. A., & Vashlishan Murray, A. (2020). "I'm just not that great at science": Science self-efficacy in arts and communication students. *Journal of Research in Science Teaching*, *57*(4), 597–622. https://doi.org/10.1002/tea.21603

Moote, J., Archer, L., DeWitt, J., & MacLeod, E. (2020). Science capital or STEM capital? Exploring relationships between science capital and technology, engineering, and math aspirations and attitudes among young people aged 17/18. *Journal of Research in Science Teaching*, *57*(8), 1228–1249. https://doi.org/10.1002/tea.21628

Mulvey, K. L., McGuire, L., Hoffman, A. J., Goff, E., Rutland, A., Winterbottom, M., Balkwill, F., Irvin, M. J., Fields, G. E., Burns, K., & Drews, M. (2020). Interest and learning in informal science learning sites: Differences in experiences with different types of educators. *PLoS One*, *15*(7), e0236279. https://doi.org/10.1371/journal.pone.0236279

Nasir, N. I. S., & Hand, V. (2008). From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *The Journal of the Learning Sciences*, *17*(2), 143–179. https://doi.org/10.1080/10508400801986108

National Research Council. (2015). *Identifying and supporting productive STEM programs in out-of-school settings*. The National Academies Press.

Nhien, C. (2022). *Dismantling the Asian monolith: Examining Southeast Asian students' science self-efficacy and science identity* [Doctoral dissertation]. University of California, Los Angeles.

Olitsky, S. (2007). Facilitating identity formation, group membership, and learning in science classrooms: What can be learned from out-of-field teaching in an urban school? *Science Education*, *91*(2), 201–221. https://doi.org/10.1002/sce.20182

Özkan, Ş. (2008). *Modeling elementary students' science achievement: The interrelationships among epistemological beliefs, learning approaches, and self-regulated learning strategies* [Unpublished doctoral dissertation]. Middle East Technical University, Turkey.

Robinson, K. A., Perez, T., Carmel, J. H., & Linnenbrink-Garcia, L. (2019). Science identity development trajectories in a gateway college chemistry course: Predictors and relations to achievement and STEM pursuit. *Contemporary Educational Psychology*, *56*, 180–192. https://doi.org/10.1016/j.cedpsych.2019.01.004

Sagan, C. (1996). An interview with Carl Sagan. *Psychology Today*. https://www.psychologytoday.com/articles/199601/carl-sagan.

Sandrone, S. (2022). Science identity and its "identity crisis": On science identity and strategies to foster self-efficacy and sense of belonging in STEM. *Frontiers in Education*, *7*, 871869. https://doi.org/10.3389/feduc.2022.871869

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, *6*(4), 293–319. https://doi.org/10.1007/BF02213418

Scutt, H. I., Gilmartin, S. K., Sheppard, S., & Brunhaver, S. R. (2013, June). Informed practices for inclusive science, technology, engineering, and math (STEM) classrooms: Strategies for educators to close the gender gap. In *2013 ASEE Annual Conference & Exposition* (pp. 23–1042).

Settlage, J., & Southerland, S. A. (2019). Epistemic tools for science classrooms: The continual need to accommodate and adapt. *Science Education*, *103*(4), 1112–1119. https://doi.org/10.1002/sce.21510
Seyranian, V., Madva, A., Duong, N., Abramzon, N., Tibbetts, Y., & Harackiewicz, J. M. (2018). The longitudinal effects of STEM identity and gender on flourishing and achievement in college physics. *International Journal of STEM Education*, *5*(1), 1–14. https://doi.org/10.1186/s40594-018-0137-0
Shaby, N., & Vedder-Weiss, D. (2020). Science identity trajectories throughout school visits to a science museum. *Journal of Research in Science Teaching*, *57*(5), 733–764. https://doi.org/10.1002/tea.21608
Starr, C. R., Hunter, L., Dunkin, R., Honig, S., Palomino, R., & Leaper, C. (2020). Engaging in science practices in classrooms predicts increases in undergraduates' STEM motivation, identity, and achievement: A short-term longitudinal study. *Journal of Research in Science Teaching*, *57*(7), 1093–1118. https://doi.org/10.1002/tea.21623
Titrek, O., & Cobern, W. W. (2011). Valuing science: A Turkish–American comparison. *International Journal of Science Education*, *33*(3), 401–421. https://doi.org/10.1080/09500691003628379
Trujillo, G., & Tanner, K. D. (2014). Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity. *CBE—Life Sciences Education*, *13*(1), 6–15.
Turan, Ü, & Kayıkçı, K. (2019). Lise son sinif öğrencilerin meslek seçiminde ailenin rolü (The role of family in selection of occupation for students in high schools). *Electronic Turkish Studies*, *14*(4), 2795–2816.
Verdín, D. (2021). The power of interest: Minoritized women's interest in engineering fosters persistence beliefs beyond belongingness and engineering identity. *International Journal of STEM Education*, *8*(1), 33. https://doi.org/10.1186/s40594-021-00292-1
Vincent-Ruz, P., & Schunn, C. D. (2017). The increasingly important role of science competency beliefs for science learning in girls. *Journal of Research in Science Teaching*, *54*(6), 790–822. https://doi.org/10.1002/tea.21387
Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity and its role as the driver of student choices. *International Journal of STEM Education*, *5*(1), 1–12. https://doi.org/10.1186/s40594-018-0140-5
Vincent-Ruz, P., & Schunn, C. D. (2021). Identity complexes and science identity in early secondary: Mono-topical or in combination with other topical identities. *Research in Science Education*, *51*(S1), 369–390. https://doi.org/10.1007/s11165-019-09882-0
Wang, J., & Hazari, Z. (2018). Promoting high school students' physics identity through explicit and implicit recognition. *Physical Review Physics Education Research*, *14*(2), 1–12. https://doi.org/10.1103/PhysRevPhysEducRes.14.020111
White, A. M., DeCuir-Gunby, J. T., & Kim, S. (2019). A mixed methods exploration of the relationships between the racial identity, science identity, science self-efficacy, and science achievement of African American students at HBCUs. *Contemporary Educational Psychology*, *57*, 54–71. https://doi.org/10.1016/j.cedpsych.2018.11.006
Williams, D. R., Brule, H., Kelley, S. S., & Skinner, E. A. (2018). Science in the Learning Gardens (SciLG): A study of students' motivation, achievement, and science identity in low-income middle schools. *International Journal of STEM Education*, *5*(1), 1–14. https://doi.org/10.1186/s40594-017-0097-9
Williams, M. M., & George-Jackson, C. (2014). Using and doing science: Gender, self-efficacy, and science identity of undergraduate students in STEM. *Journal of Women and Minorities in Science and Engineering*, *20*(2), 99–126. https://doi.org/10.1615/JWomenMinorScienEng.2014004477
Zhai, J., Jocz, J. A., & Tan, A. L. (2014). 'Am I like a scientist?': Primary children's images of doing science in school. *International Journal of Science Education*, *36*(4), 553–576. https://doi.org/10.1080/09500693.2013.791958

# Appendices

## Appendix A. Turkish version of scales

### 1. Bilim Kimliği Ölçeği

| Maddeler | Kesinlikle evet 4 | Evet 3 | Hayır 2 | Kesinlikle hayır 1 |
|---|---|---|---|---|
| 1.Ben bir bilim insanıyım. | | | | |
| 2.Ailem beni bir bilim insanı olarak görür. | | | | |
| 3.Arkadaşlarım beni bir bilim insanı olarak görür. | | | | |
| 4.Öğretmenlerim beni bir bilim insanı olarak görür. | | | | |

### 2. Seçime Dayalı Fen Öğrenme Deneyimleri Ölçeği

| | Her zaman 4 | Haftada birkaç kez 3 | Sadece bir kere 2 | Hiç 1 |
|---|---|---|---|---|
| *Okulla İlgili Deneyimler* | | | | |
| 1.Öğretmenimle güzel fen kitapları ya da web siteleri hakkında konuştum. | | | | |
| 2.Fen dersleri dışında belli bir grupla birlikte fen konusunda çalışmalar yürüttük. | | | | |
| 3.Diğer öğrencilerle birlikte fenle ilgili bir ödev ya da proje yaptık. | | | | |
| 4.Fen dersi için fazladan bir proje yaptım. | | | | |
| 5.Okul çıkışları ya da hafta sonlarında bir fen kulübünde yer aldım. | | | | |
| *Evle İlgili Deneyimler* | | | | |
| 1.Ders dışında taşlar, kelebekler, böcekler veya doğadaki diğer şeyleri topladım | | | | |
| 2.Ders dışında, bilim konularıyla ilgili TV programları izledim. | | | | |
| 3.Ders dışında bilim veya bilim kurgu hakkında kitaplar okudum. | | | | |
| 4.Ders dışında, nasıl çalıştıklarını görmek için eşyaları parçalara ayırdım. | | | | |
| 5.Ders dışında, bilgi aramak için bilim web sitelerine girdim. | | | | |
| 6.Ders dışında evde fen deneyleri yapardım. | | | | |

### 3. Fende Yeterlik İnançları Ölçeği

| Maddeler | Kesinlikle evet 4 | Evet 3 | Hayır 2 | Kesinlikle hayır 1 |
|---|---|---|---|---|
| 1.Fende oldukça iyi olduğumu düşünüyorum. | | | | |
| 2.Fende sorular üretme konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 3.Deneyler tasarlama konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 4.Fikirlerim için deliller bulma konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 5.Fende bir şeylerin neden olduğunu açıklama konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 6.Deneyler yapma konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 7.Fikrimi belirtirken deliller sunma konusunda oldukça iyi olduğumu düşünüyorum. | | | | |
| 8.Fikrime katılmayan kişilere karşı fikirlerimi savunmada oldukça iyi olduğumu düşünüyorum. | | | | |
| 9.İşe yaramayan bir fen etkinliğini nasıl düzelteceğimi bulma konusunda oldukça iyi olduğumu düşünüyorum. | | | | |

## Appendix B. Factor loading, AVE, CR, Cronbach's Alpha, and McDonald's omega values

**Table B1.** Science Identity Scale.

| Item | Factor loading | α | CR | ω | AVE |
|---|---|---|---|---|---|
| I am a science person | .664 | .85 | .81 | .85 | .50 |
| My family thinks of me as a 'science person' | .723 | | | | |
| My friends think of me as a 'science person' | .684 | | | | |
| My teachers / instructors think of me as a 'science person' | .701 | | | | |

**Table B2.** School and Home-Related Items on the Optional Science Experiences Survey.

| Item | Factor loading | α | CR | ω | AVE | √AVE | MSV | ASV | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.School-related | | | | | | | | | | |
| I talked to a science teacher about good science books or websites. | .684 | .79 | .80 | .79 | .52 | .72 | .48 | .39 | – | |
| I was part of a group that got together outside of class time to study for science class. | .644 | | | | | | | | | |
| I did my homework or projects for science class with other students. | .644 | | | | | | | | | |
| I did an extra-credit project for science class. | .640 | | | | | | | | | |
| I was part of a science club after school or on the weekends. | .638 | | | | | | | | | |
| 2.Home-related | | | | | | | | | | |
| Outside of class, I collected rocks, butterflies, bugs, or other things in nature. | .538 | .70 | .81 | .70 | .51 | .71 | .48 | .31 | – | .57 |
| Outside of class, I watched TV programmes about science topics. | .619 | | | | | | | | | |
| Outside of class, I read books about science or science fiction. | .616 | | | | | | | | | |
| Outside of class, I took things apart to see how they work. | .645 | | | | | | | | | |
| Outside of class, I went to science websites to look up information. | .664 | | | | | | | | | |
| Outside of class, I did science experiments at home. | .667 | | | | | | | | | |

**Table B3.** Competency Beliefs in Science

| Item | Factor loading | A | CR | ω | AVE |
|---|---|---|---|---|---|
| I think I am pretty good at: Science | .599 | .80 | .88 | .81 | .50 |
| I think I am pretty good at: Coming up with questions about science | .680 | | | | |
| I think I am pretty good at: Designing experiments | .720 | | | | |
| I think I am pretty good at: Finding evidence for my ideas | .686 | | | | |
| I think I am pretty good at: Figuring out why things happen | .509 | | | | |
| I think I am pretty good at: Doing experiments | .685 | | | | |
| I think I am pretty good at: Giving evidence when I tell my opinion | .612 | | | | |
| I think I am pretty good at: Defending my opinion when others disagree with me | .580 | | | | |
| I think I am pretty good at: Figuring out how to fix a science activity that didn't work. | .602 | | | | |