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Taylor & Francis Group

Research in Science & Technological Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/crst20

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To cite this article: Menşure Alkış Küçükaydın, Seher Esen, Hakan Çite & Sümeyra Gürbüzer (21 Nov 2023): Science Identity of Turkish Students: Adaptation of the Science Identity Questionnaire and Analysis in Terms of Demographic Variables, Research in Science & Technological Education, DOI: 10.1080/02635143.2023.2285296

To link to this article: https://doi.org/10.1080/02635143.2023.2285296

Published online: 21 Nov 2023.

RESEARCH IN SCIENCE & TECHNOLOGICAL EDUCATION
https://doi.org/10.1080/02635143.2023.2285296

Science Identity of Turkish Students: Adaptation of the Science Identity Questionnaire and Analysis in Terms of Demographic Variables

Menşure Alkış Küçükaydın[a], Seher Esen[b], Hakan Çite[a] and Sümeyra Gürbüzer[a]

[a]Faculty of Education, Necmettin Erbakan University Eregli, Konya, Turkey; [b]Faculty of Education, Selçuk University, Konya, Turkey

ABSTRACT

Background: Science identity has an important place in revealing the effects of learning experiences. Furthermore, science identity can help to understand future career intentions related to science; therefore, it needs to be understood and assessed.

Purpose: The aim of this study was to adapt the Student Science Identity Questionnaire into Turkish and examine its validity and reliability.

Sample: In the study, data were collected from 755 high school students in the Central Anatolian Region of Turkey.

Design and Methods: In the first part of the study, a scale adaptation was performed. In the second part, differences between groups were analyzed using parametric tests.

Results: Confirmatory factor analysis confirmed the structure of the instrument consisting of 24 items and four factors and showed that the model had excellent fit values. Cronbach's alpha values of the factors that make up the instrument were between .83 and .90, composite reliability values ranged between .92 and .93, factor loads and average variance extracted values were found to be above .50. In addition, the square root of the average variance extracted values and the correlation values between the factors were examined and the validity of the measurement model was ensured.

Conclusion: The findings show that the Student Science Identity Questionnaire is a valid and reliable instrument in the Turkish sample. In addition, students' science identity varies according to gender and socioeconomic status.

KEYWORDS
High school students; reliability; science identity; validity

Introduction

As the impact of science and technology on the social sphere continues to expand, new occupational groups related to science have begun to emerge. In order to educate individuals in these new occupational groups, first of all, science interest should be increased. However, studies conducted in recent years have shown that attitude and interest in regard to science sees a significant downshift (Riegle-Crumb, Moore, and

CONTACT Menşure Alkış Küçükaydın mensurealkis@hotmail.com Faculty of Education, Necmettin Erbakan University Eregli, Konya, Turkey

Ramos-Wada 2011) as children enter high school (Marginson et al. 2013). For this reason, many researchers emphasize that learning experiences should be especially tailored toward younger children who have yet to determine a career trajectory (DeJarnette 2012; Makransky, Petersen, and Klingenberg 2020; Thisgaard and Makransky 2017). According to Carlone and Johnson (2007), science identity has an important place in revealing the effects of learning experiences.

Science identity is not only a good lens for exploring participation in science, it is also intertwined with different dimensions. An individual's interest in science, perception of science learning competence, and science class performance are other basic elements that make up the science identity (Wulff et al. 2018). As a matter of fact, studies on science identity have started to garner attention especially in recent years. In addition, science identity has been associated with academic achievement (Merolla and Serpe 2013), epistemological belief and reflective thinking (Guo et al. 2022), and motivation for learning science (Williams et al. 2018) is supposedly connected to this. It has also been reported that science identity plays an important role in choosing a career in a science-related field (Hazari et al. 2010; Merolla and Serpe 2013). This indicates that studies on science identity should continue and be examined through different variables.

Science identity focuses on what students want to do and can do while studying science (Brickhouse, Lowery, and Schultz 2000). Students with positive science identity have inquiry skills in science and approach science learning with a willingness and enthusiasm to learn (Kim 2018). Students with positive science identity learn science with curiosity and willingness, which contributes to creating new scientific ideas (Barton and Tan 2010). According to Vincent-Ruz and Schunn (2018), students with positive science identity are also more likely to participate in in-school and out-of-school science learning activities; this situation indicates that students' science identity should be better understood and that appropriate teaching strategies should be developed accordingly. Therefore, there is a need for valid and reliable instruments to determine the level of science identity. In previous studies, the general identity profiles of individuals were revealed, identification studies as a scientist have been carried out (Chemers et al. 2011). Identification instruments specific to certain fields of science have also been employed (Wulff et al. 2018). However, the tools for determining the science identity of students are specific and there is no Turkish instrument available. Therefore, this study has aimed to adapt the science identity scale to the Turkish culture.

Science identity for Turkish students

Chen et al. (2021) explained that science identity is related to the way it is racially or ethnically underrepresented. In this respect, although Turkey has been represented by respected scientists on international platforms in recent years, interest in science has failed to find widespread traction (Üstün et al. 2019). This also varies according to gender. The Turkish Industry and Business Association (2017) report indicated that the placement rate in science fields among the students ranked in the top 1,000 in their respective universities is 81% for boys and 19% for girls. Although science proficiency in Turkey varied significantly between 2006 and 2018, it regularly remained below the OECD averages (OECD 2019). Financial obstacles related to pursuing a science education away from one's hometown, cultural and religious factors, and the inability to finance schools specific to the field of science may hinder students considering such an education (Çınar 2022). With all these challenges, there is a need to understand the o science identity in order to better address the obstacles in its domain, as science identity has not yet been addressed in Turkish literature. The findings may serve as a guide for educators and education policy developers.

Conceptual background

Science identity

Science identity studies have recently attracted the attention of researchers and educators seeking to support the science education of their students (Barton et al. 2013; Rodriguez, Cunningham, and Jordan 2017). The science identity dimension was also pointed out in the preparatory studies for the PISA 2024 strategic vision (OECD 2020). This increasing interest reveals how important science identity is in the formation of a young scientist.

Students' science identity has been an important focal point in the literature. These studies depict science identity as fostering a sense of belonging (Chen et al. 2021), supporting attitudes and skills towards STEM (Guo et al. 2022; Kuchynka et al. 2022), and contributing to the development of positive scientific attitudes (Kim 2018). When these results are considered comprehensively, it can be observed that scientific identity impacts many different areas.However, adolescence is very important in terms of examining science identity (Barmby, Kind, and Jones 2008) because this life and learning stage is a time of significant physical, social, and emotional development and change – and student interest in science decreases during this period (Master, Markman, and Dweck 2012). Moreover, during this period, students start to make career plans (Tai et al. 2006); as a result, it is an important factor in examining science identity.

In the related literature, various frameworks have been developed to examine science identity. Carlone and Johnson (2007) developed a model that includes science content knowledge, recognition of scientific practices in the public sphere and science culture, and recognition of oneself as a scientist by others. Hazari et al. (2010) defined science identity as the feeling of being recognized as a scientist by oneself and others. In addition, interest in science and science competence are the main components of science identity. Childers and Jones (2017), who developed a model for high school students, created the Science Identity Survey to measure science identity. Wulff et al. (2018) also examined students' identities in physics courses. These scales and models are primarily aimed at measuring the effect of a specific intervention program. However, a general science identity scale in the school context is required. The Science Identity Questionnaire (SSIQ), developed by Chen and Wei (2022), serves this purpose. The basic components of the SSIQ are as follows: a) science class performance, b) science learning competence, c) science recognition, and d) science career interest.

Science Class Performance

Performance is a major key to developing a science identity and includes science practices, such as using specific tools or terminology related to science tasks (Rodriguez, Cunningham, and Jordan 2017). In other words, science performance refers to the social performance of science practices (e.g. ways of speaking, interacting, using scientific tools) (Shein, Falk, and Li 2019). The ways individuals' view themselves through a scientific lens affect their science performance (Seyranian et al. 2018). According to Chen and Wei (2022), performance in science classrooms refers to the ability to complete science-related tasks. Accordingly, beliefs about student performance in science classrooms using surveys, assignments, applied research, and science competitions constitute this dimension.

However, the science performance of individuals differs according to ethnicity and gender (Avraamidou 2020; Dawson et al. 2020; Miles and Naumann 2021). This difference also affects the science identity. Salehjee and Watts (2022) suggest that students who tend to see negative factors as opportunities are converting a negative attitude into a positive outlook, which greatly affects their science identity.

Science Learning Competence

Science learning competence is defined as acquiring scientific knowledge and understanding the concepts of science (McAlister, Lilly, and Chiu 2022; Shein, Falk, and Li 2019). Having science learning competence, which has a central place in developing a science identity, is considered important for students in terms of critical thinking, reasoning, language development, and new learning (Raudenbush 2009). In order to be successful in science, it is necessary to believe that in addition to cognitive ability, one must possess a capability to succeed in science. In this dimension, in which the competence of the individual in science is measured, the student's expectation for learning science is also revealed (Beghetto 2007). For these reasons, the competency within one's science identity is intertwined with the other three dimensions.

Science Recognition

According to Chen and Wei (2022), being recognized as a scientist by oneself and others (such as family, teachers, or peers) is an important dimension of science identity. A person's science identity can change due to influences from variables such as the activities they participate in, science, and parental capital (Brickhouse, Lowery, and Schultz 2000). Therefore, science identity is related to internal and external factors (Roberts and Hughes 2022; Vincent-Ruz and Schunn 2018).

Internal recognition is expressed as a person's recognition of their as belonging to science, and external recognition is expressed as how the person is viewed by others in relation to science. Scientific recognition is important for students participating in scientific activities (Cwik and Singh 2022; McAlister, Lilly, and Chiu 2022). According to Hazari et al. (2010), one of the most striking aspects of a person's science identity is science recognition. McAlister et al. (2022) stated that the greatest effect on identity development is science recognition, followed by science career interest.

Science Career Interest

The individual's curiosity and enjoyment of science is what comprises overall science interest. People with a positive science identity state that they are interested in and enjoy science (Shein, Falk, and Li 2019). Science career interest begins in early childhood and can be encouraged by parents and teachers (Pattison and Dierking 2019). Accordingly sstudents interested in science begin to pursue science-related careers over time (Christensen, Knezek, and Tyler-Wood 2015). This occurs because interactions and experiences with peers and professionals in science environments contribute to individuals' identities (Kim and Sinatra 2018). Consequently, students who like science and develop career intentions toward science tend to take a scientist as an inspirational example (Esen, Türyılmaz, and Alkış Küçükaydın 2022; AlkışKüçükaydın and Esen 2023). Students who intend to have a career in science show interest in the activities that scientists effectuate and can perform the activities of these scientists (Kim 2018). Therefore, this dynamic contributes to the development of science identity. Interest, which is one of the basic emotions and affects permanence in science, is a dimension that has an impact on participation in science and most certainly helps to build the science identity (Hazari et al. 2010).

Present study

Science identity is believed to have a significant impact on the career choices that students make regarding their futures (Stets et al. 2017). By identifying students' science identity, it is possible to focus on the development of the identity process (Stryker and Burke 2000), and thus reveal their science-related career intentions (Merolla and Serpe 2013). When evaluated from a practical perspective, determining one's science identity during the high school years (Tai et al. 2006), which is the most critical period for assessing career trajectory, can be guided in terms of academic achievements. Therefore, it is possible to determine a student's science identity by using valid and reliable measurement tools. In this respect, SSIQ (Chen and Wei 2022), which includes the general science learning context, seems sufficient. Though it has yet to be adapted into different languages in the existing literature, SSIQ has been developed for students in mainland China. Unlike other science identity instruments (Childers and Jones 2017; Wulff et al. 2018), SSIQ is presented from the general science learning context to students at school.

Previous studies on science identity have investigated the relationship between science identity and science achievement (White, DeCuir-Gunby, and Kim 2019), science engagement (Burke and Navas Iannini 2021), and science self-efficacy (Williams and George-Jackson 2014). Until now, the majority of science identity studies have been conducted in the United States (Merolla and Serpe 2013), Western Canada (Kim 2018), Denmark (Krogh and Andersen 2013), Germany (Wulff et al. 2018) and China (Guo et al. 2022). However, no study has been conducted on scientific identity in Turkey, an eastern society. Existing studies in the literature provide information about science identity under the influence of European and some Asian cultures. In the Turkish sample – Turkey has a collective social structure – the view of science and, thus, the reflections of science identity may differ. Therefore, a cross-cultural adaptation of an instrument developed in a different culture, such as Turkey's, may provide insight in terms of data collection and result comparisons between diverse populations. Moreover, the cross-cultural adaptation process of the SSIQ is important in reducing the risk of introducing bias into the study by using it in a different language, environment, and time. In addition to the topics of science career interest and identity have started to attract attention in Turkey in recent years. However, there has been no valid and reliable instrument to measure students' science identity. Therefore, the primary aim of the study was to adapt the SSIQ to Turkish.

The related literature has reported that science identity is affected by several demographic variables. Hazari et al. (2013) conducted a study with 7,505 students and reported that females perceived themselves as weaker in science than males. Williams and George-Jackson (2014) study, conducted with 1,808 undergraduate students, obtained similar results. Another study conducted with 5th-grade students concluded that the science identity of male students was significantly higher than that of their female counterparts. Finally, Alhadabi (2023) reported that female's science identity levels were lower. Based on this data, we expect a significant differentiation in science identity according to gender in Turkish high school students. The hypothesis tested in this context is as follows:

H1: Science identity shows a significant difference according to gender.

The study also tested whether the construct of science identity differs in terms of socioeconomic level. The previous literature has reported that socioeconomically disadvantaged groups face structural and cultural barriers, such as financial pressure, discrimination, and unfair treatment, which can negatively affect scientific identity (Gnilka and Novakovic 2017; Mau and Li 2018; Schuster and Martiny 2017). Salvadó et al. (2021) reported that students who were excluded for socioeconomic reasons and lived under difficult conditions had lower levels of science identity than their peers. Therefore, the second hypothesis tested in the study is the following:

H2: Science identity significantly differs according to students' socioeconomic status.

The research shows that an interest in science is related to age and, therefore, decreases with an increase in grade level (Brickhouse, Lowery, and Schultz 2000). Hazari et al. (2013) reported that as young females' age, they begin to recede into the background, especially in fields such as physics and engineering. In addition, perceived personal and external factors change with an increase in grade level, which impacts perceptions of science identity (Vincent-Ruz and Schunn 2018). Based on this reality, the third hypothesis tested in the study is as follows:

H3: Science identity differs according to grade level.

Finally, the literature reported that science identity is related to the parents' education level, characterized as family capital (Sáinz and Müller 2018). Parents with a high level of education are aware of science and generally guide their children in this direction (Šimunović and Babarović 2021). In addition, according to Schnabel et al. (2002), parents direct their children to science according to their level of competence, regardless of academic achievement. Therefore, assuming that science identity is related to the parents' level of education, the fourth hypothesis, listed below, was tested:

H4: Science identity differs according to the parents' level of education.

Table 1. Demographic variables of the students participating in the study.

Variables	*n*	%
Gender		
Female	428	56.7
Male	327	43.3
Age	*M* = 16.03	*SD* = 1.29
Grade		
Preparatory grade	93	12.3
Grade 1	170	22.5
Grade 2	277	36.7
Grade 3	135	17.9
Grade 4	80	10.6
Socioeconomic status		
Low	95	12.6
Middle	600	79.5
High	60	7.9
Mother's education level		
Primary school and low	299	39.6
Middle school	140	18.5
High school	182	24.1
Undergraduate and high	134	17.7
Father's education level		
Primary school and low	171	22.6
Middle school	160	21.2
High school	211	27.9
Undergraduate and high	213	28.2

Study 1: Adaptation of the Science Identity in Science Learning Scale

Method

Participants

The participants of this study consist of 755 high school students from the Central Anatolian Region of Turkey studying during the 2021–2022 academic year. Demographic information of the students is presented in Table 1.

According to Table 1, 428 (57%) of the students were female and 327 (43%) were male. The students were between the ages of 14–21 and the average age was 16.03 (*SD* = 1.29). In Turkey, high schoolers study for five years, and the first year is referred to as the preparatory class. Based on this understanding, 93 (12.3%) of the students participating in the study were in the preparatory class, 107 (22.5%) were in the first grade, 277 (36.7%) were in the second grade, 135 (17.9%) were in the third grade, and 80 (10.6%) were in the fourth grade. All of the students take basic science courses during the first two years, and the intensity of the optional science courses changes in the following years. Of the students participating in the study, 95 (12.6%) expressed themselves as having low socio-economic status, 600 (79.5%) moderate, and 60 (7.9%) high status. Most of the mothers (39.6%) of the students participating in the study had a primary school or lower education level. On the other hand, fathers of 211 (27.9%) of the students have a high school education level, and fathers of 213 (28.2%) have a bachelor's degree or higher education level.

Translation of the instrument and procedure

There are many methods adopted in the measurement tool adaptation process. However, none of these methods offer a 'gold standard' (Epstein, Santo, and Guillemin 2015). For this reason, it is necessary to adopt an appropriate methodology in scale adaptation and it is important to form an expert group. For this study, first Bing Wei (second author of SSIQ) was contacted for approval and consulted in order for the researchers to better understand his instrument. Then, the instrument items were translated into Turkish by experts from the fields of science education, measurement and evaluation, and language education, in addition to the authors of this study. Later translations were brought together by the researchers and the most appropriate Turkish expressions were determined for each item. The created Turkish form, together with the original form of the questionnaire, was presented to a doctoral specialist working in the field of science education. The expert was asked to evaluate the equivalence of the two forms. The expert approved the linguistic equivalence provided between the original form and the Turkish form and deemed the translation appropriate.

The final form was submitted to the second author's university for ethical approval. After the approval, an online form was generated to include the survey items and demographic material in a way that would not jeopardize anonymity. The form was then sent to the students through the school principals. The principals first distributed online parent consent forms to the parents, and afterwards the link of the online form was sent to the students of the parents who had given permission. An annotation section was presented to the students so that they would be able to report that the study was completely voluntarily. The students were informed that the completed form was for scientific research purposes only. Filling out the form took an average of 20–25 minutes, and the data collection process continued during the spring semester of the 2021–2022 academic year.

Measures

Demographic questionnaire

In the study, an online questionnaire was used to obtain information regarding the students' age, gender, grade level, socioeconomic status, and the educational level of their parents.

Student science identity questionnaire

SSIQ was developed by Chen and Wei (2022) for grades 10–12 (senior high school) students (aged 16–18) in mainland China. The instrument consists of science class performance (six items), science learning competence (six items), science recognition (four items) and science career interest (eight items). The items in the instrument are scored with 5-point Likert-type ('strongly disagree' to 'strongly agree'). High scores on the scale indicate high science identity; low scores indicate low-level science identity. The factor loads of the items that make up the instrument vary between .54 and .87, and the Cronbach's alpha values of the factors vary between .83 and .95. Sample items in the instrument include 'I think I did well in science classes' (Science class performance scale), 'I think I am good at science' (Science learning competence scale), 'I think myself as a science person' (Science recognition scale), 'I will learn more about science knowledge through a variety of sources' (Science career interest scale).

Data analysis

After the data were collected, the data set was examined in terms of extreme values. Z-scores were evaluated to determine the extreme values and it was determined that there was no data outside the ± 3 range. Then, the normality distribution of the data was evaluated. Upon review, it appeared that the skewness values of the instrument items varied between −1.234 and .182, and the kurtosis values between −1.080 and .545. According to Tabachnick and Fidell (2013), the fact that the skewness and kurtosis coefficients are within ± 1.5 limit values indicates that the data do not show a significant deviation from the normal distribution. Confirmatory factor analysis (CFA) was used to test the factorial model of the questionnaire. Maximum likelihood method was used in CFA. The values adopted to evaluate model-data fit in CFA were as follows; $\chi^2/df < 3$; RMSEA and S-RMR < .10; AGFI, GFI, NFI, IFI, CFI, and TLI > .90 (Kelloway 2015; Schermelleh-Engel, Moosbrugger, and Müller 2003). The construct validity of the instrument was evaluated in terms of convergence and discriminant validity techniques, and its reliability in terms of Cronbach's alpha and composite reliability (CR) values. Fornell and Larcker's (1981) criteria were taken into account for construct validity. Accordingly, it was adopted that the factor loads and the average variance extracted (AVE) value should be .50 and above. For reliability, Cronbach's alpha and (CR) values of .70 and above were taken into account (Gefen, Straub, and Boudreau 2000).

Results

CFA was applied to the data obtained within the scope of the study. In the first analysis, in which no changes were made, weak fit values were found for the four-factor model (χ^2 (246) = 1779.420, ($p < .01$), $\chi^2/df = 7.233$, RMSEA = .09, S-RMR = .05, AGFI = .77, NFI = .85, IFI = .87, GFI = .81, CFI = .86, TLI = .85). Therefore, the error terms between items #1 ('I think I did well in science classes') and #2 ('I am able to get a good grade in science subjects'), #4 ('I am proficient in using tools and operating apparatus in experiments') and #5 ('I like to attend classes that are related to science') in the science class performance factor and #4 and #5 in the science career interest factor were combined. Thus, the model fit values obtained in the final analysis were as follows: $\chi^2/df = 2.696$, RMSEA = .07, S-RMR =.05, AGFI = .90, NFI = .91, IFI = .92, GFI = .92, CFI = .92, TLI = .91. It has been determined that these values are in excellent fit level (Kline 2011) and the model is presented in Figure 1.

The factor loads for the four-factor model ranged from .614 to .880, and it was found to be significant at the $p < .01$ level according to the t-values. The construct validity of the instrument was examined through the convergent validity and discriminant validity techniques, and Cronbach's alpha and CR values were taken into account for reliability. These values are presented in Table 2.

According to Table 2, Cronbach's alpha values for the sub-dimensions of the science identity scale vary between .83 and .90, and CR values between .92 and .93. These values show that the criteria considered (Gefen, Straub, and Boudreau 2000) had been met. Additionally, factor loads and AVE values were discussed in order to examine the

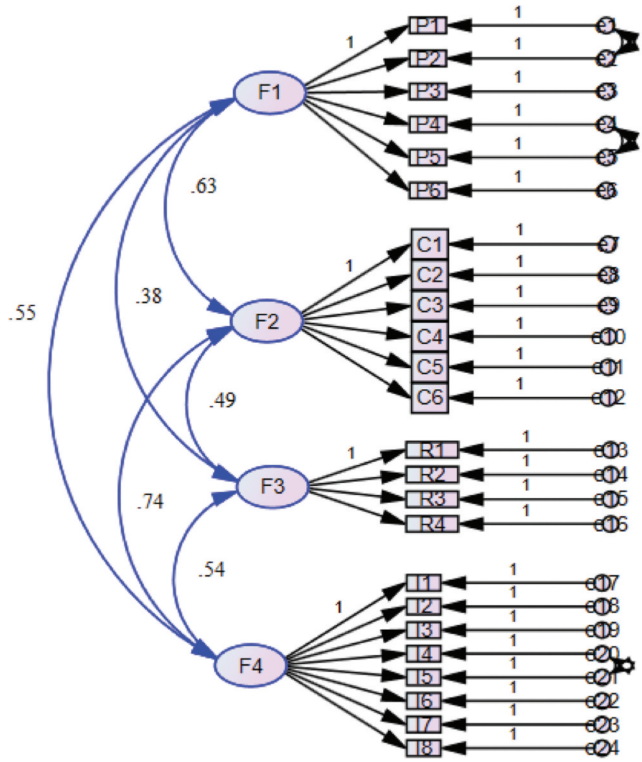

Figure 1. CFA results for the modified model.

convergence and discriminant validity of the questionnaire. It was noted that the factor loads and AVE values of the sub-dimensions of the questionnaire were above .50. Furthermore, the square root of the AVE values (shown in bold in Table 2) and the correlation values between dimensions were examined and it was determined that the measurement model was valid (Fornell and Larcker 1981).

Discussions

In this study, SSIQ, developed by Chen and Wei (2022), was adapted to Turkish and the four-factor structure in the instrument was tested with CFA. It was determined that the tested model had excellent fit values. Even though the error terms were matched between some of the items belonging to the first and fourth factors of the questionnaire, the nature of the instrument was not corrupted and no item was deleted. The values obtained as a result of convergence and discriminant validity analyses met the criteria recommended in the literature. It was determined that there was a medium ($r = .459$; $r = .499$; $r = .560$, $p < .01$) and high ($r = .703$; $r = .706$; $r = .707$, $p < .01$) level of correlation between the factors, and all of these correlations were found to be positive.

Cronbach's alpha and CR values for reliability were found to be above .70. The values obtained from both the validity and reliability analyzes are quite close to the values stated in the original instrument. All these results show that the theoretical framework underlying SSIQ is also valid for the Turkish context. SSIQ is observably

Table 2. Factor loading, convergent and discriminant validity, and reliability.

Item number	Factor loading	Cronbach's alpha	CR	AVE	Science class performance	Science learning competence	Science recognition	Science career interest
Science class performance								
P1	.624	.83	.93	.508	**.712**			
P2	.698							
P3	.777							
P4	.728							
P5	.689							
P6	.750							
Science learning competence								
C1	.695	.89	.93	.511	.706*	**.714**		
C2	.750							
C3	.735							
C4	.657							
C5	.722							
C6	.725							
Science recognition								
R1	.697	.90	.92	.584	.459*	.499*	**.764**	
R2	.784							
R3	.799							
R4	.774							
Science career interest								
I1	.651	.89	.92	.503	.707*	.703*	.560*	**.709**
I2	.850							
I3	.614							
I4	.880							
I5	.726							
I6	.676							
I7	.633							
I8	.635							

$^{*}p< .01$.

comparable to other instruments meant to assess one's science identity as they are often made up of similar structures. For example, the science identity survey developed by Childers and Jones (2017) focused on students' knowledge, competence, and interests related to science. Similarly, Wulff et al. (2018) discussed science identity in the context of recognition, competence, interest, and engagement. However, these instruments, which were previously developed on the subject of science identity, were mostly used in line with an intervention program. SSIQ, on the other hand, attempts to uncover the more general structure of science identity. Although the approach adopted in these various instruments is different, it is possible to say that based on similar structure and questioning, it appears that the SSIQ has robust psychometric properties.

Study 2: Investigation of Science Identity in Science Learning Scale in Terms of Demographic Variables

Method

This study sought to uncover the science identities of the participants through assessing their demographic characteristics. Therefore, the procedures performed in the first study are also valid here.

Data analysis

In the study, one-way multivariate analysis of variance (MANOVA) was used to test the science identity scores of students according to their demographic characteristics. The data were tested to see whether or not they met the MANOVA assumptions. First, the assumption of univariate and multivariate normal distribution was tested. The skewness-kurtosis coefficients for univariate normality were evaluated in Study 1. In terms of multivariate normality, each of the dependent variables was examined to determine whether they were normally distributed at each level of the independent variables. It was later determined that the skewness and kurtosis coefficients of gender (.271 and −1.432), socioeconomic statue (−.197 and 1.250), mother's (.317 and −1.372) and father's education level (−.176 and −1.355) were within the limits of ± 1.5, and the dependent variables did not show a significant deviation from the normal distribution (Tabachnick and Fidell 2013).

In the second step, the relationship between the dependent variables was examined with the scatter diagram and it was determined to be linear. In the third step, the homogeneity of the variance-covariance matrices of the scores of the dependent variables was examined. Equality of variances in groups of dependent variables was examined with Levene's test. The assumption that the covariance matrices of the dependent variables are equal was tested with the Box's M test. The equality of the covariance matrices of the dependent variables along the independent variables has been provided ($F_{gender} = 1.831$, $p > .05$, $F_{socioeconomic\ statue} = 1.076$, $p > .05$, $F_{mother\ education} = .661$, $p > .05$, $F_{father\ education} = 1.114$, $p > .05$). In the study, Wilks' Lambda (λ) was used depending on whether the assumptions were met. The practical effect sizes of the significant differences found in the analyzes were evaluated by examining the η^2 indices (Huck 2012).

Results

Hypothesis 1

The MANOVA test was utilized upon the science identity scores of the students in order to assess whether or not there was a significant difference originating from their demographic characteristics. According to the results of the analysis, there was a statistically significant difference between the science identities of the male and female students ($\lambda = .963$, $F[4,750] = 7.120$, $p = .00$, partial $\eta^2 = .037$). According to post-hoc analyzes to identify the source of the difference, male students scored higher than female students on the science learning competence ($F[1,753] = 8.150$, $p = .04$, partial $\eta^2 = .011$) and recognition ($F[1,753] = 11.419$, $p = .01$, partial $\eta^2 = .015$) dimensions of the science identity instrument. However, there appeared to be no significant difference in the performance ($F[1,753] = .015$, $p = .90$) and science career interest ($F[1,753] = 6.194$, $p = .19$) dimensions.

Hypothesis 2

The MANOVA test results showed that there was a significant difference in the science identity scores of the students according to their socioeconomic status ($\lambda = .967$, $F[4,749] = 3.182$, $p = .01$, partial $\eta^2 = .017$). According to post-hoc analysis, students who reported having a high socioeconomic status in all sub-dimensions of the science identity instrument scored higher than other students ($F_{science\ learning\ competence}[1,752] = 5.265$, $p = .00$, partial $\eta^2 = .014$; $F_{recognition}[1,752] = 7.215$, $p = .00$, partial $\eta^2 = .019$; $F_{science\ class\ performance}[1,752] = 4.793$, $p = .00$, partial $\eta^2 = .013$; $F_{science\ career\ interest}[1,752] = 5.237$, $p = .00$, partial $\eta^2 = .014$).

Hypothesis 3–4

Science identity scores were tested with MANOVA according to other variables in the study. These scores did not show a statistically significant difference according to the grade level of the students ($\lambda = .979$, $F[4,747] = 1.005$, $p = .44$), mother's education level ($\lambda = .985$, $F[4,748] = .915$, $p = .53$), or father's education level ($\lambda = .981$, $F[4,748] = 1.229$, $p = .25$).

Discussions

Our study investigated science identity through the lens of various demographic variables. Results demonstrated that there was no significant difference in the dimensions of science class performance and science career interest, but the science identity scores of male students were higher than female students in the dimensions of science learning competence and recognition. This finding is supported by previous studies. For example, in the study conducted by Cwik and Singh (2022) within the scope of physics course, it was noted that the science recognition scores of female students perceived by their teachers were lower than that of male students. McAlister et al. (2022) discussed how female doctoral students reported that the academy structure may be inherently disadvantageous for females. A similar finding was obtained from the study conducted by Avraamidou (2020) with an immigrant Muslim woman. In addition to this evidence, it is both interesting and significant that male students only scored high on science learning competence and recognition dimensions of SSIQ.

Hazari et al. (2010) suggested that parents' perceptions and expectations of their children's abilities affect the child's self-perception and expectations. In other words, the masculine structure of Turkish society and the affinity and expectation of male students engaging in science may have fed their external recognition perceptions and competencies. As a matter of fact, no difference was found between male and female students in terms of science class performance and science career interest. Female students perform just as adequately in science and are similarly interested in the subject, but lack of crucial support may have hurt their science learning competence and recognition. Clearly, female students need family and teacher supports just as males do.

It was observed that students with high socioeconomic status got higher scores in all dimensions of SSIQ than students with low socioeconomic status. Individuals' income level, educational achievement, professional prestige, access to resources, and exposure to sociocultural contexts shape emotions, thoughts, behaviors, and experiences (Destin, Rheinschmidt-Same, and Richeson 2017). Therefore, we cannot expect a student who does not have the opportunity to participate in science activities, who cannot attend science courses, or who cannot reach a scientific journal/newspaper, to have a positive level of science identity. This shows that students with low socioeconomic status should be more adequately supported. It may be possible to develop a science identity through offering enriching scientific activities and learning experiences to underprivileged students, and introducing them to scientists who can act as role models.

It was observed that the science identity scores did not differ according to the grade level of the students or the education level of the parents. According to Hazari et al. (2010), the expectations that a family or environment places upon a student may not be a component of the science identity, but may be a determinant. As a matter of fact, in this study, these factors did not appear to have a significant effect on science identity. Previous studies were mainly conducted with samples from Western societies (Krogh and Andersen 2013; Merolla and Serpe 2013; Wulff et al. 2018). The results of this study, conducted within a Turkish environment, can be discussed and evaluated separately.

In this study, in which science identity was examined according to demographic variables, each dimension of science identity was analyzed separately. Although scientific identity seems to consist of four dimensions, as Chen and Wei (2022) stated, each dimension is intertwined. Carlone and Johnson (2007) emphasized that the dimensions of scientific identity are intertwined in their study of scientific identity in a specific race and ethnicity. Accordingly, someone who considers their competent in science will perform more, resulting in their being recognized as a scientist by others. Therefore, unlike this study, in which the dimensions constituting science identity are evaluated separately, science identity can be considered a single construct. As a result, the direct relationship between the characteristics of individuals and scientific identity can be revealed.

In this study, in which the SSIQ was adapted and its relationship with demographic variables investigated, some areas of possible improvement of the SSIQ also emerged. First, science identity studies agree that science identity consists of performance, competence beliefs, recognition, and interest (Carlone and Johnson 2007; Hazari et al. 2010). In addition, students' science identity is a dynamic construct influenced by science-related experiences, interactions with scientists, and the structure of the society in which they live (Brickhouse, Lowery, and Schultz 2000). This situation indicates that experiences influence science identity because many studies have reported that experiences increase students' interest in science, increase their efficacy beliefs, and, consequently, affect their science identity (Alhadabi 2023; Burke and Navas Iannini 2021; Vincent-Ruz and Schunn 2018). Therefore, a new theoretical assumption should be tested in future studies by adding the dimension of 'experiencing science' in research focusing on science identity.

In addition to, there may be some internalization problems in the practical implementation of the SSIQ. Due to its nature, the SSIQ is intended to determine the general science identity of adolescents in high school (Chen and Wei 2022). However, in the Turkish education system, science education during high school is specialized according to specific disciplines. Accordingly, there may be difficulties in answering the SSIQ by students primarily taking physics, chemistry, or biology courses as this limits them to a single science identity. Therefore, it may be necessary for practitioners to consider this and adjust their instructions accordingly.

Finally, different frameworks developed on scientific identity (Carlone and Johnson 2007; Chen and Wei 2022; Hazari et al. 2010) show no uniform scientific identity. Both qualitative studies (Avraamidou 2020; Chen et al. 2021) and findings from quantitative studies (Chemers et al. 2011; Guo et al. 2022; Vincent-Ruz and Schunn 2018; Wulff et al. 2018) show that scientific identity is open to development and involve many different components. In this study, gender and socioeconomic status were related to science identity. However, including other variables, such as science capital, discretionary science learning experiences, passion for science, or values toward science – which still need to be addressed – may lead to a different understanding of science identity.

When these results are evaluated in the context of Turkish culture, it becomes apparent that science identity cannot be understood separately from the sociocultural structure of the country, especially when it comes to economics and gender. Vincent-Ruz and Schunn (2018) maintain that scientific knowledge is constructed by females and males embedded in a culture. The findings show that males are more likely to see themselves as competent in science and also have a greater chance of being recognized as scientists by others. This may be related to science stereotypes frequently referenced in the literature (Esen, Türyılmaz, and Alkış Küçükaydın 2022; Brickhouse et al., 2000; Çınar 2022). As a matter of fact, this representation is already noticeable in high school course selection. Data from Turkey reinforces the notion that male students are more often drawn to science fields, whereas females tend towards language and literature.

In addition, changes in the level of science identity based on socioeconomic status can be explained by the perception that scientifically-based careers are only available to certain groups. Sáinz and Müller (2018) point out that in developed countries, internal gains rather than external phenomena are more effective in young people's career choices. This highlights the dominant power of external factors, such as lack of opportunities based on a lower household income, neighborhood dynamics, and the difference in education quality between private and public schools. Consequently, one's gender and socioeconomic status play a significant role in Turkish culture and science identity

Limitations and recommendations for future studies of study 1 and study 2

In this study, the science identities of high school students were examined in the Turkish context with the goal of revealing differences in terms of various demographic variables. However, there were some limitations in the study. First of all, it is recommended to expand the study by incorporating additional variables into the same context. With hierarchical linear models, the relationship of science identity with other contexts (type of school, geographical feature, parent or teacher support) can be revealed.

Another limitation of the study is related to the social desirability bias generally reported in self-report scales. The convenience sampling technique was implemented with the students, and information regarding their science identity was obtained. In this context, data were collected from a region that we can describe as average in terms of parental education levels and socioeconomic status. Future studies, ought to consider data from the regions of the country that are considered more and less prosperous to broaden the scope.

Lastly, the procedures applied in this study were limited to CFA. Cross-validation and criterion validity studies may be included in further research to provide additional evidence of the validity of the science identity instrument. In addition, while examining the reliability of the science identity instrument in this study, only Cronbach's alpha and CR values were calculated. In further studies, the reliability of the instrument in terms of stability can be revealed by examining the test-retest reliability.

Conclusions

In this study, SSIQ was adapted to Turkish and implemented upon 755 high school students from different socioeconomic statuses, studying at different grade levels with parents who had completed different levels of education. At the end of the adaptation, it is apparent that the four-factor structure of the SSIQ is valid in the Turkish culture. Group comparisons were also included in the study. Accordingly, male students' science identity scores were observed to be higher than female students in the science learning competence and recognition factors. In addition, students who reported that they were of high socioeconomic status got higher scores in all sub-dimensions of the instrument than students who reported that they were of another status. Also, there was no significant difference in science identity scores according to the grade level of the students and the education level of their parents. The findings show that SSIQ can be used in the Turkish language and culture; thus, it can be an effective instrument in revealing the science identity of students.

Disclosure statement

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

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ORCID

Menşure Alkış Küçükaydın http://orcid.org/0000-0003-4410-1279
Seher Esen http://orcid.org/0000-0002-3569-1185
Hakan Çite http://orcid.org/0000-0002-1224-9570
Sümeyra Gürbüzer http://orcid.org/0000-0003-4932-0008

Data availability statement

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

Ethics approval

All participants took part on a voluntary basis and gave written informed consent to their participation. All data were collected and analyzed anonymously. The study was in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. An ethical committee proposal was submitted to the Selçuk University Ethical Committee before data collection, and it was approved with the commission date and the number of 2022/34.

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