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A DIFFERENT PERSPECTIVE ON STEM EDUCATION: A NARRATIVE REVIEW OF STEM IDENTITY[i]

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Abstract

Identity research, which helps to understand society and people, has been one of the ways to understand STEM education in the last few years. STEM education, which has a history of nearly 60 years, through the lens of identity, can give us information about how much we identify with STEM. STEM identity is a dynamic process related to how an individual sees themselves in the fields of science, technology, engineering, and mathematics, how they identify with these fields, and how they are perceived by others as part of this fields. This process is based on the continuous interplay between how a self recognizes itself through social interactions and experiences throughout its life and how it is recognized by others. The hands-on experiences and social interactions offered by STEM education provide an opportunity to support the development of STEM identity. While negative experiences in this process risk weakening identity development, the fact that identity can be changed and developed at any time also gives individuals the chance to reconstruct themselves and strengthen their scientific selves. This study is a narrative review aimed at understanding STEM identity models and perspectives. In addition to the sections summarizing the literature on STEM identity, STEM teacher identity, and how STEM identity is measured, STEM identity research topics are also discussed. Finally, the current situation regarding the place and importance of STEM identity research in Turkey is summarized. Although there is no accepted common view on STEM education and STEM practices, we find it important to look at STEM education from an identity perspective when STEM identity research continues rapidly and increasingly in Türkiye, as it sheds light on future STEM studies. This study serves as a literature summary for researchers who wish to investigate and understand STEM identity in the context of education.

Keywords: STEM education, STEM identity, STEM teacher identity

Stem Eğitimine Farklı Bir Bakış Açısı: Stem Kimliğinin Anlatısal İncelenmesi

Öz

Toplumu ve insanı anlamaya yardımcı olan kimlik araştırmaları son birkaç yıldır STEM eğitimini anlamaya yardımcı bakış açılarından biridir. Yaklaşık altmış yıllık bir geçmişe sahip olan STEM eğitimine kimlik merceğinden bakmak STEM'i ne kadar benimsediğimize dair bize bilgi verebilir. STEM kimliği, bir bireyin kendisini bilim, teknoloji, mühendislik ve matematik alanlarında nasıl gördüğü, bu alanlarla nasıl özdeşleştiği ve başkaları tarafından bu alanların bir parçası olarak nasıl algılandığıyla ilgili dinamik bir süreçtir. Bu süreç, bir bireyin yaşamı boyunca sosyal etkileşimler ve

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deneyimler yoluyla kendini nasıl gördüğü ve başkaları tarafından nasıl göründüğü arasındaki sürekli etkileşime dayanır. STEM eğitiminin sunduğu uygulamalı deneyimler ve sosyal etkileşimler, STEM kimliğinin gelişimini desteklemek için bir fırsat sunar. Bu süreçteki olumsuz deneyimler, kimlik gelişimini zayıflatma riski taşırken, kimliğin her zaman değiştirilebileceği ve geliştirilebileceği gerçeği, bireylere kendilerini yeniden yapılandırma ve bilimsel benliklerini güçlendirme şansı da verir. Bu çalışma, STEM kimliği modelleri ve görüşlerini anlamayı amaçlayan anlatısal bir derlemedir. STEM kimliği ve bu kimliğin nasıl ölçüldüğü STEM öğretmen kimliğine dair literatürün özetlendiği bölümlerin yanı sıra STEM kimliği araştırma konularına değinilmiştir. Son olarak Türkiye'de STEM kimliği araştırmalarının yeri ve önemine dair mevcut durum özetlenmiştir. Her ne kadar STEM eğitiminin ve STEM uygulamalarının ne olduğuna dair kabul edilmiş ortak bir görüş olmasa da Türkiye'de STEM kimliği araştırmalarının hızlı bir biçimde ve gittikçe artarak devam ettiği bu günlerde STEM eğitimine kimlik perspektifinden bakmanın gelecekteki STEM çalışmalarına ışık tutması yönüyle önemli buluyoruz. Bu çalışma STEM kimliğini eğitim bağlamında incelemek ve değerlendirmek isteyen araştırmacılar için bir literatür özeti niteliği taşımaktadır.

Anahtar Kelimeler: STEM eğitimi, STEM kimliği, STEM öğretmen kimliği

Introduction

Today, it is difficult to come across a discussion in sociology or psychology where ethnic, gender, and continental identities are not discussed. The first definition of the concept of identity dates back to John Locke (1962-1704). Identity gained popularity in the 20th century through the works of Freud (1856-1939) and Erikson (1902-1994) (Öztürk, 2007). Various definitions can be made regarding an individual's identity in the context in which he exists. Erikson (1959) was one of the first researchers to define identity in educational studies. Erikson (1959), who argued that not only biological roots but also the culture and environment in which the individual lives are effective in human behavior, divides development into eight stages and mentions that each stage has its own crises to be managed. The fifth stage is the period during which identity formation versus identity confusion occurs during adolescence. During this period, the individual seeks an answer to the question "Who am I?" Marcia (1993), who conducted research on identity after Erikson, explained identity as statuses formed by the choices of adolescents who experience the confusion of "research" and "decision making." In addition, researchers have examined identity from different perspectives. For example, Berzonsky examined identity in the context of cognitive elements, Arnett examined identity development from the end of adolescence to the thirties; Grovetant examined identity development as a lifelong process, and Kegan examined identity as a process of finding meaning in life (Atak, 2011). With its multiple definitions, the origins of scientific identity research can be traced back to Gee (2000). Gee (2000) addresses the concept of identity in terms of how an individual is defined by others as one or more "types of person" when acting and interacting in any given context. The "type of person" referred to here can be variable and may simultaneously encompass more than one type. For example, through choices and interactions at that moment, a person can be defined as an "academic," a "teacher," a "talented student," or a "member of an association." Identity is the congruence and acceptance between the "types of person" individuals wish to be perceived as and the "types of person" accepted by others (Carlone & Johnson, 2007; Gee, 2000). Science identity refers to an individual's perception of themselves as a "scientist" by both themselves and their social circle, which includes family and close friends who are considered important (Paul et al., 2020; Carlone & Johnson, 2007; Kim et al., 2018). STEM identity expresses an individual's sense of belonging, identification, and commitment to the fields of science, technology, engineering, and mathematics (Stewart, 2022). This study aims to examine STEM education through the lens of identity, a concept previously explored in various fields and contexts. This narrative review examines the literature on the subject based on theoretical frameworks and models. The selection of research articles was purposefully made in line with studies that define and explain the theoretical models that have been decisive in the subject's development. The study explains the concepts of identity types, science identity, and STEM identity. It also explores STEM identity research topics, the measurement of STEM identity, and STEM identity in Türkiye. While this narrative review may not have the rigor of a systematic examination, it provides insightful information

for future directions and research for researchers who wish to investigate and understand STEM identity.

Social Identity

The foundations of the concept of social identity are based on Tajfel's (1960) studies on social perception, such as intergroup relations, conflict, prejudice, and discrimination. Elements such as ethnic and racial identities, gender identity, and national or geographical identity fall into the category of social identity. According to Stets and Burke (2000), social identity means that an individual sees himself/herself as a member of the same social category as a certain group. These groups vary in sizes; for example, being a member of a volunteer association or being a student at a college means that the individual adopts the norms and actions of this group and reflects them to his/her environment (Burke, 2020). Social groups have certain rules that give their members identity and shape their beliefs and behaviors (Hogg, 2016). These rules form prototypes that represent the identity of the group. Prototypes define the basic characteristics of social groups, revealing the qualities of a group and how they differs from other groups (Hogg & Smith, 2007). From a STEM identity perspective, the feeling of belonging to a STEM group, such as the feeling of belonging to a class or school, demonstrates the importance of STEM identity from a social identity perspective (Chiu & So, 2025; Kim et al., 2018).

Role Identities

The roles that an individual assumes in society and the behaviors required in these roles constitute role-based identity. Roles are common expectations based on societal social positions (Stets & Serpe, 2013). For example, being a student is a role identity. An individual with a student role identity expresses this role by fulfilling tasks such as going to school and studying. Each role identity has at least one opposing role identity, and interaction with thise opposing role identity is necessary for fulfilling the role (Burke, 2020). In the student example, the teacher identity is the opposing role identity. How much the student fulfills his/her roles and how much he/she adopts his/her identity can be understood through his/her interaction with the teacher. In an environment where there is no teacher, tasks associated with the student role identity, such as doing homework or attending class, cannot be fulfilled. The same applies to the teacher; in an environment without students, tasks associated with the teacher's identity, such as lecturing, conducting experiments, or providing guidance, cannot be fulfilled. Opposing roles can be more than one; for the student role identity, the school principal is one of the opposing roles along with the teacher. The interaction between these opposing roles is also reciprocal. Just as the teacher and the school principal are essential to the student role identity, the student and the school principal are also important to the teacher role identity. Similarly, the student and the teacher are necessary to the school principal role identity.

Personal Identities

Personal identity, unlike the other two types, is shaped by the individual's inner world. Personal characteristics constitute the individual's identity as elements that distinguish the individual from others. The behaviors that the person consciously performs or does not

perform over time and the meaning of these behaviors determine the person's identity (Burke, 2020). Consistency of behaviors ensures that the identity becomes clear; otherwise, inconsistency, i.e., a state of identitylessness, may occur. According to Burke (2020), personal identity gains meaning through evaluation throughout life, and a person's identity cannot be correctly interpreted based solely on momentary behavior. According to Burke (2003), a person's identity is shaped by the interaction of personal identity (such as being shy, enterprising or tolerant), social identity (family, group, association membership), and role identity (scientist, student, teacher). Identity allows the individual to establish relationships with society or social groups in two ways (Burke, 2020). While the first aspect provides existential meaning by showing individuals who they are; the second aspect shows individuals how they expect others in the social environment to behave and what is expected of them (Burke, 2020). Beyond understanding the individual, identity is also an essential concept for understanding society and schools, as stated in Gee's work (2000). According to Gee (2000), "identity" is a certain "type of person" in a certain context. This context is a structure that is shaped by changing social conditions and the individual's performances in society and can be multiple. This multiple structure means that it is inevitable for the individual to have more than one identity. For example, an individual can simultaneously have the identities of scientist, mother, and sibling.

From Science Identity to STEM Identity

Identity research has begun to gain momentum with studies conducted in the context of disciplinary identity in educational research, especially with the creation of the science identity model by Carlone and Johnson (2007). Carlone and Johnson (2007) created a science identity model while seeking an answer to the question "How do we define a person with a strong science identity. There are three components in Carlone and Johnson's (2007) science identity model. These are: Competence refers to an individual's sufficient knowledge and understanding of science. Performance is the ability to carry out science-related practices and activities, to communicate, and to use tools. Recognition refers to an individual perceiving themselves as a scientist and being recognized as such by their environment. Recognition also provides identity verification. Identity verification is the individual's perception that others see them as they see themselves (Stest & Serpe, 2013). Individuals with a strong science identity are considered to have competence, performance, and recognition regarding science. Following Carlone and Johnson's (2007) science identity model, Hazari et al. (2010) conducted studies on disciplinary identity and investigated the relationship between experiences in high school physics courses and career expectations with physics identity. The identity framework Hazari et al. (2010) used in their study includes recognition, interest, performance, and competence dimensions. In the model, physics identity is considered a part of personal and social identity (Hazari et al., 2010). Hazari et al. (2010), explain the components of the physics identity framework as follows: "Interest is the desire to learn/understand more physics and volunteer activities in this field. Competence is the belief in the ability to understand physics content. Performance is the belief in the ability to perform the necessary physics tasks.

Recognition is being recognized by others as a physics person." An individual who sees himself as a "physics person" is expected to have interest, recognition, performance, and competence in physics. Along with studies investigating disciplinary identities (Cribbs et al., 2015; Godwin et al., 2013; Hazari et al., 2010), the other view considers STEM as a science identity (Singer, 2020). While the disciplinary identity view tends to investigate STEM professions and undergraduate and postgraduate career goals, the STEM identity view as a whole, such as science identity, generally tends to investigate pre-graduate school, home, and social life. Dou and Cian (2021), in their structural model of STEM identity, showed four dimensions, similar to the previous science identity model. This model is shown in Figure 1. Dou and Cian (2021) positioned the variables associated with STEM identity as gender, ethnicity, home support, parental education, and science talk.

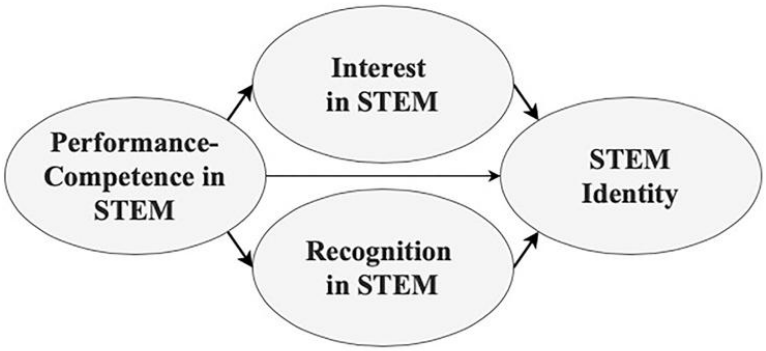

Figure 1. *STEM identity structural model.* (*From Constructing STEM identity: An expanded structural model for STEM identity research, by R. Dou & J. Cian, 2021, Journal of Research in Science Teaching, 59(3), 458–490. doi:10.1002/tea.21734*)

STEM Teacher Identity

The models mentioned so far have explained STEM identity from the perspective of the learner. Teacher roles are also significant in a STEM learning environment, along with students. Slavit, Nelson, and Lesseing (2016) investigated the roles of teachers in developing and implementing a new and inclusive STEM vision and established a connection between the nature of STEM teachers and the roles they should have and teacher identity. In the same study, it was stated that STEM teachers' learning, risk-taking, and questioning qualities contribute to their identities. Following this research that drew attention to teachers' STEM identities, Galanti and Holincheck (2022) proposed the STEM teacher identity model in their studies. This model was a combination of the teacher identity models proposed by Hanna et al. (2020), Hazari et al. (2010), and Carlone and Johnson (2007). Integrated STEM Teacher Identity Proposed by Galanti and Holincheck (2022) This is the identity combination in which STEM is integrated with the aspects of the learner and teacher. Motivation: Why do I teach STEM? Self-image: How do I see myself as a STEM teacher? Self-efficacy: How competent do I think I am in teaching integrated STEM? Task perception: What is my role as an integrated STEM teacher? Teaching interest: What do I think and understand in STEM teaching? It has the dimensions. The basis of STEM education is the use of knowledge and skills related to the solution of a real-life problem and the expression of this entire process with engineering design

(Bybee 2013; El Nagdi, 2018; Ulutaş, Elmas, Karakaya, & Yılmaz, 2023). It is under the guidance of the teacher to relate science education to real life in accordance with the design and application, and to guide students throughout the entire process (Akarsu, Akçay, & Elmas, 2020; El Nagdi, 2018). Slavit et al. (2016) defined STEM teachers as "a complex mixture of learners, risk takers, questioners, curriculum designers, negotiators, collaborators, and teachers" (p.7). Although there are few studies using the STEM teacher identity model in the literature (Eren, 2024; Fitzpatrick, 2024; Holincheck & Galanti, 2023; Yang, Wu, Yin & Xu, 2025), it is believed that investigating this integration will contribute to STEM identity. The validation of the model can produce valuable results regarding the reasons for teachers' desire or reluctance to integrate STEM into their lessons.

Research Topics in STEM Identity

The view that identity development generally begins in adolescence and is consolidated in adulthood has caused identity research to focus on high school, especially the university years. Studies investigating university students' STEM identity (including science identity) (Goff et al., 2019) have focused on topics such as professional work life (Kelly et al., 2020), career goals (Dou, Cian, & Espinosa-Suarez, 2021), racial and ethnic perspectives on identity (Collins, 2018; Mark, 2018), and groups underrepresented in STEM fields, such as women and Black individuals (Singer et al., 2020). The idea of seeing oneself as a STEM student dates back to middle school or earlier (Hachey, 2020). Some studies examining STEM identity from preschool to high school (Hughes et al., 2013; Kang et al., 2019; Kim et al., 2018; Stringer et al., 2020; Cardullo & Burton, 2022; Grimalt-Álvaro et al., 2022) are included in the literature. Studies emphasizing the importance of early STEM experiences in identity formation (Dou et al., 2019; Hachey, 2020) recommend investigating STEM identities of younger individuals.

Measuring STEM Identity

The number of quantitative studies, along with qualitative studies, has increased in recent years to determine STEM identity. Qualitative aspects of identity studies in STEM education have been examined through studies investigating how identity develops over time, individuals' discourses (Paretti & McNair, 2012), their thoughts about themselves and others (McAlpine, Amundsen, & Turner, 2014), and how identity develops within a specific cultural context (Godwin, Cribbs, & Kayumova, 2020). Quantitative studies investigating STEM identity have focused on how an individual sees themselves as a particular type of person or role and the identity related dimensions, such as interest, performance, competence, and recognition, at that moment. Few scales have been developed in the literature to directly measure science-STEM identity. Dou et al. (2019), using previously developed scales (Godwin et al., 2013; Hazari et al., 2010) to determine discipline identities for undergraduate students, developed a valid and reliable 7-item scale with "interest" and "recognition" dimensions to determine STEM identity. Lockhart et al. (2022) developed a 31-item scale with exploration and engagement dimensions to measure high school students' science identity, and reported reliable results. Chen and Wei (2022) developed a 24-item science identity scale for middle and

high school students, and found it produced reliable results. Paul et al. (2020) developed a 26-item instrument to measure four dimension "competence", "interest", "self-recognition", and "recognition by others". STEM role identities in elementary school students, with the scale also yielding reliable results. Eren and Dökme (2024) conducted a validity and reliability study on the Turkish version of the 2024 STEM Role Identity Scale. Unlike multiple-item scales, (McDonald et al., 2019) investigated the validity and reliability of a single-item STEM professional identity overlap scale. The scale actually contains overlap schemas. The scale serves to measure STEM professional identity by having participants select the image that best describes the overlap between their current self-image and their image of what a STEM professional is. In addition to these studies, there are studies measuring science identity as a dimension of another scale. For example, the measurement tool used in a study examining the relationship between research experience self-efficacy and science identity included five items related to science identity (Robnett et al., 2015). Another scale developed to measure undergraduate students' motivation for science courses includes five items with the science identity sub-dimension (Skinner, 2017). Another example is the identity scales previously used for gender, race-ethnic social identities (Cameron, 2004; Wilson & Leaper, 2016), which were changed to STEM identity by Starr et al. (2020), and the effect of classroom experience performance on undergraduate students' STEM motivation-identity, career aspirations, and course success was examined. Qualitative studies contribute to seeing the details of what it means or how to be a "STEM person" or have a STEM identity. However, quantitative studies have gained prominence/become prominent in determining whether students in a larger groups have a STEM identity and in evaluate,nge this in terms of identity dimensions.

STEM Identity in Türkiye

STEM research in Türkiye has shown a rapid increase in recent years (Dökme, Açıksöz, & Koyunlu Ünlü, 2022; Şat, Yardımcı, & Canbazoğlu Bilici, 2025). However, can be said that STEM studies in Türkiye are concentrated on scientific process skills, interest, professional interest, and design skills while being intense in academic success and attitude-dependent variables (Eren & Dökme, 2022; Herdem & Ünal, 2018). Although we have ideas about how STEM affects students' interests, motivations, and successes; we still have limited information about students' identification with STEM i.e., their identity. We can say that there are studies on STEM occupation and career interest studies that can be considered close to STEM identity in the context of Türkiye (Eroglu, Bektas & Karaca, 2025; Irmak, & Kaptan, 2023; Koyunlu Unlu, Dokme, & Unlu, 2016). Although students show positive career-occupation interests (Çalışkan & Şenler, 2024) with STEM education, career interest provides limited information about identity (Zhao, Mathews, Mulvey, et al., 2023). For example, according to social cognitive career theory, the components of career interest are self-efficacy, interest, choice goals, choice actions, and outcome expectations (Bandura, 1986; Lent & Brown, 1996). Career and occupational interests provides information about individuals' future choice preference for a STEM-related profession. Identity provides information about how much an individual identifies with STEM. In this respect, we can see that career interest studies differ from identity

studies. We can say that STEM identity studies are still very new in Turkey. In Turkey, we have only come across a few studies with a general "STEM identity" search in databases. It has been determined that STEM identity studies have increased in Turkey since 2020, and most of these studies have been conducted with prospective teachers (Eren, 2025). Although studies on STEM applications are common in Turkey, the number of identity-related studies has increased in recent years. For example, one study examined how middle school students' identities (general identity, recognized, performance competence, interest) and stereotypical beliefs (feminine, masculine, socioeconomic status) are affected in the four STEM disciplines and to what extent these explain existing identity predictions (Kaya, 2024). Another thesis study investigated the STEM identity of disadvantaged students in the context of their interest in STEM, active participation in design, student-peer researcher training, and self-identity perception through extracurricular STEM activities (Akkor, 2024).

A study examining the students' identification with mathematics, technology, engineering, and science identities was conducted through semi-structured interviews to determine the STEM disciplinary identities of female university students (Gülen & Dönmez, 2021). In this study, it was determined that although female students, considered it possible to pursue a career in STEM fields, they had negative thoughts about it. Another study is the adaptation of the validated STEM identity scale for teacher candidates to Turkish culture (Hacıömeroğlu, 2020). A quantitative large-sample study has not yet been conducted in the context of Türkiye. One reason for this is the limited number of quantitative measurement tools. A study is being prepared to test the suitability of the scale, which aims to determine the STEM Role identities of secondary school students, in Turkish culture (Eren & Dökme, 2022). We hope that in the coming years, more studies on STEM identity will contribute to the literature through the development or adaptation of measurement tools.

Conclusion

Having a STEM identity means having an interest, competence, recognition, and performance in these fields. This situation has the potential to positively affect students' learning processes and direct them toward careers in these fields. For example, STEM identity is expected to affect the mathematics, science, technology, and engineering fields in terms of interest, competence, and performance (Hazari, 2013). Similarly, Godwin et al. (2016) showed in their studies that university students' engineering identities were related to their mathematics and physics identities. We believe that determining the extent to which teachers and students identify with STEM in education, especially science education, will provide a new perspective for future STEM research. We believe that determining the positive effects of STEM with limited-time applications and activities in research provides a superficial view of STEM. Students may develop positive attitudes, curiosity, motivation, and interest at the end of a STEM activity or lesson, but how does this change affect their identities? Nevertheless, we believe that this cross-sectional/momentary view is important in STEM education. Knowledge of the extent to which individuals whose motivation, interests, and successes increase, see themselves as STEM oriented individuals (or scientist) people, and how much they identify

with this situation plays a critical role in shaping STEM education and predicting individuals' future choices. While the multidimensional nature of existing identity models (Galanti & Holincheck, 2022) presents challenges in measuring STEM identity and potentially hinders the design of experimental studies, further research will contribute to overcoming these difficulties. In Turkey, the increasing prevalence of STEM education is creating more environments and opportunities to support the identity development of both students and teachers. STEM identity research is a scientific way to assess the current state of STEM education, the extent to which STEM has been adopted, and whether it has become a part of identity. Research in this area will provide information to educators and researchers about learning environments and materials that will support students in developing a STEM identity. In addition, further examination of factors such as gender, ethnic and demographic differences in STEM identity (Dou & Cian, 2021) and science capital (Cohen et al., 2021) will help increase our understanding of the development of STEM identity. Finally, it is recommended that a scale be developed to measure STEM teacher identity and that longitudinal studies be conducted to reveal the development and change of STEM identity.

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