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Academic Achievement and Postgraduate Career Commitment among Pre-Service Teachers: The Mediating Role of Science Identity

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Abstract: This cross-sectional study investigated the relationship between academic achievement (measured by GPA) and a science-related psychological variable, science identity, in higher education. Specifically, the study examined the mediating role of science identity in the relationship between academic achievement and commitment to a postgraduate career. Data drawn from 309 pre-service teachers were analyzed using structural equation modelling. The results revealed positive relationships between academic achievement, science identity, and postgraduate career commitment. Academic achievement and science identity significantly predicted pre-service teachers' postgraduate career commitments. Furthermore, science identity served as a mediator in the relationship between academic achievement and career commitment. These findings point to the benefits of effective interventions that support the development of science identity in teacher education and development to encourage pre-service and in-service teachers' commitment for postgraduate career. These strategies can foster pre-service and in-service teachers to engage in science-based practices, enhance their scientific competences, gain recognition from their colleagues or educators, and implement science-based practices in their own teaching.

Keywords: Science identity, postgraduate career, academic achievement, pre-service teachers

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The need to encourage young people and adults to engage in science—encompassing its branches of natural science and social sciences and humanities—is imperative given its significance to provide responses to the social, environmental, and economic challenges of our times (UNESCO, 2021). This necessitates the development of academic aspiration and science identity in students for various reasons. An obvious reason is to increase their interest in science with the perspective of encouraging them to start postgraduate studies and choose science-oriented occupations, especially when they belong to groups that are usually not recognized by themselves or others as prone to science (Bodnar et al., 2020; Stets et al., 2017). Science and research may be identified as an area in which, for example, women and ethnic minorities (Archer et al., 2020; Görkem Altunbaş et al., 2024; Sheldrake & Mujtaba, 2019) are not expected to navigate, because it is assumed to be reserved for experts, a group that is often believed to consist of male members of the majority society. In addition, non-expert participation may be discouraged by authorities (e.g., political actors, school managers, parents) as it potentially empowers them to question decisions made in their immediate environment (Whitney et al., 2012).

Against this backdrop, the call to give societal actors outside academia competences and "a voice in developing research that is compatible with their concerns, needs, and aspirations" (UNESCO, 2021, p. 14) underscores the crucial role of developing students' interest in natural and social sciences/humanities. Moreover, science identity as a self-concept is associated with hard work and the intention to contribute to the betterment of the community, thereby strengthening academic performance and creating an impact on society (Stewart, 2022).

From an educational perspective, the demand for a shift away from transmission-based forms of teaching towards educational practices in which learners and teachers adopt forms of systematic inquiry to develop awareness of global issues along with critical thinking and problem-solving has a long history. Nearly a century ago, Dewey (1933) noted that schools have the task of shaping a "scientific attitude of mind" (p. v) in the younger generations; the establishment of this attitude requires the development of science identity in teachers as well. Dewey's work has been influential as it highlights the need to promote reflective practice (i.e., the inquiry into own practices as well as the immediate and external environment). Reflective practice enables professionals to understand and develop their own beliefs, attitudes, and practices. Furthermore, reflective practitioners can better identify the needs of people in their immediate and wider social context to empower them and strengthen their agency, thereby contributing to social, economic, and technological progress at the local, national, and global level (Moon, 2004; Shelley et al., 2020; van Beveren et al., 2018). As a firm conclusion, the development of science identity in pre-service teachers and teachers is desirable.

Given the context of this study—pre-service teachers at a Turkish state university—an examination of science identity among undergraduate students enrolled in different departments, such as those in the natural or social sciences, and their commitment to postgraduate study appears particularly justified. While national educational policies have been initiated to encourage pre-service teachers and teachers to pursue postgraduate studies, previous research has shown that incentives to pursue academic careers are insufficient (Sevim & Akın, 2021). Various factors referring to both the educational system and the wider social situation exert adverse effects on pre-service and in-service teachers' willingness to enroll in postgraduate programs

(Koşar et al., 2020). Current problems in Turkish education (Şener, 2018; Yaraş & Turan, 2021), however, call for attempts to strengthen pre-service and in-service teachers' willingness to develop their science identity, which, in turn, enhances their commitment to postgraduate careers, so that they actively contribute to the development of educational policy and practice. It is noteworthy to point out that postgraduate career commitment, such as earning an MA or Ph.D. degree, can significantly influence career paths. Graduates may choose to become teacher educators and researchers in higher education or return to their roles in primary or secondary classrooms. In the former case, postgraduates are expected to make inquiry-based teaching a subject of their teaching at university. In the latter case, a more direct impact on school classrooms can be expected as the experience of doing research in postgraduate study may encourage teachers to implement inquiry-oriented elements in their instructional practice. This does not exclude utilitarian motives (economic gains, enhanced prestige) that may guide teachers and pre-service teachers in their intentions to undertake postgraduate studies (Harvey et al., 2005; Lohbeck & Frenzel, 2022).

From the above, it is evident that the promotion of science identity—which is the competence to understand scientific content, the ability to engage in scientific practices and the recognition of oneself and by others as a science person (Carlone & Johnson, 2007)—along with the aspiration to pursue academic studies is desirable to raise people's interest and engagement in science. Pre-service teachers and in-service teachers with a strengthened science identity in their field are likely to embrace educational practices rooted in experiential and discovery learning principles in their own teaching (Zhai et al., 2024). Exposure to inquiry-based forms of instruction supplemented with psychosocial support, in turn, guides learners towards research practices and helps them gain a perspective of what science actually entails, that is to say science identity (Kuchynka et al., 2022). This mechanism is in line with accounts of social psychology of education that, for a long time, have recognized schools as a key factor in the learners' social environment to profoundly shape their perceptions and attitudes, thereby contributing to identity formation (Goodnow, 1992; McMillan, 1978). In sum, a teacher with a developed science identity is likely to contribute to science by doing research and to education by employing teaching methods and techniques that assign learners the roles of discoverers (Rushton, 2021), thereby strengthening educational practices at schools.

This study aims to contribute to previous research by exploring the following research question: What is the potentially mediating role of science identity in the relationship between academic achievement and postgraduate career commitment among pre-service teachers enrolled in various departments encompassing fields of natural or social sciences?

In the subsequent sections, we aimed to examine science identity in relation to postgraduate career commitment, explore academic achievement (measured by GPA) in relation to science identity and postgraduate career commitment, and outline the current situation of pre-service teachers' intentions to engage in a postgraduate study in Türkiye (officially changed country's name recognized by the United Nations as of June 1,2022) (United Nations Türkiye, 2022).

Conceptual Framework

Science Identity and Postgraduate Career Commitment

The study of identity explores the meanings that determine who a person actually is in terms of their unique characteristics, roles in society, memberships in groups, and belonging to

social categories. Identities develop in relation to and through interactions with others, making them inherently social (Burke & Stets, 2023). A person has multiple identities, and each identity is assigned a specific set of meanings (Huvard et al., 2020). Research on identity is concerned with a variety of aspects mirroring divergent theoretical considerations and research foci such as the stability of identities, how identities are constructed, and how affordances and constraints contribute to or impede identity formation (Vignoles et al., 2011).

Science identity, which applies to any field within the natural or social sciences and humanities, involves both an individual's sense of oneself as a scientist and their feeling of belonging to a scientific community (Huffmyer et al., 2022). Students may have science identity to varying degrees indicating the extent to which they are learning or are interested in science (Kim & Sinatra, 2018). The development of science identity is context-based and nurtured by the availability of communities of scientists or opportunities to engage in scientific practice. Communities can be provided in or outside schools (e.g., through science professionals in families), and they appear to be crucial to raising science aspirations (Aschenbach et al., 2010; Cameron et al., 2020; Syed et al., 2011; Wulff et al., 2018).

Science identity acts as a feedback loop between a person behaving, thinking, and discovering as a scientist and others understanding this meaning and restoring this identity to the original person (Carlone & Johnson, 2007). Drawing attention to the complex nature of science identity, Carlone and Johnson (2007) proposed a now widely recognized model that considers competence, performance, and recognition as interrelated dimensions underlying the formation of science identity. Specifically, competence refers to an individual's knowledge of scientific content and motivation to approach a problem systematically. Performance is the ability to apply competence in scientific practices (e.g., to employ methods or participate in scientific discourse) whereas recognition refers to how people see themselves as scientists or are perceived by others as scientists.

Similar to this model, Hazari et al.'s (2010) framework is appropriate to explaining the science identity of pre-service teachers. This framework consists of three components: recognition, interest, and performance/competence. Recognition refers to the pre-service teachers' perception of being seen or recognized as a scientist by others or educators. Interest represents the degree to which pre-service teachers long to learn more about science or desire to pursue a career in science through postgraduate study. Finally, performance/competence describes pre-service teachers' ability to demonstrate their scientific skills and science learning efforts to their students in their teaching practice. When pre-service and in-service teachers develop science identity, they can be expected to improve the quality of their teaching by inquiry-based forms of instruction so that their learners' interest in and commitment to science are likely to be developed as well (Godwin et al., 2016; Hazari et al., 2010).

Building science identity guides pre-service teachers into the direction of pursuing an academic career in postgraduate degree programs (Artess & Hooley, 2017; Carlone & Johnson, 2007). Commitment to a postgraduate career refers to an undergraduate student's or graduate's orientation towards attending an MA or Ph.D. program, meaning that it is closely connected to career planning and the disposition to appropriate academic efforts and study habits (İlter, 2020a; London, 1985). It is noteworthy that graduates taking up postgraduate studies do not comprise a homogeneous group but experience transition processes differently (O'Donnell et al., 2009) and are driven by several motivations, most often in combination.

Research conducted in different geographical contexts reveals that intentions for postgraduate study is induced by the desire to acquire skills and knowledge that improve career

prospects, to acquire a theoretical understanding of a field of study, to contribute to society, and to experience personal satisfaction or to receive economic gain (see Donaldson & McNicholas, 2004; Fényes et al., 2021; Harvey et al., 2005; Koşar et al., 2020; Lohbeck & Frenzel, 2022; Mellors-Bourne et al., 2014; Nas et al., 2016; Valencia-Arias, 2023). de Oliveira Pires (2009) noted that postgraduate intentions are multifaceted, and distinctions between, for example, professional and personal motives cannot easily be drawn: someone's wish to pursue an academic career to contribute to knowledge production and dissemination may actually be a way to receive personal satisfaction. The transition from undergraduate to postgraduate study, however, is also likely to be accompanied by feelings of uncertainty, disorientation, and anxiety (McPherson et al., 2017) because postgraduate studies force students to more rigorously engage in autonomous learning, analytical and critical thinking, and extensive academic reading and writing (Bamber et al., 2019; Lin et al., 2023).

Research on science identity has particularly dealt with the science identity of students in science, technology, engineering, and mathematics (STEM) and groups underrepresented in academic and scientific domains in order to better understand underlying mechanisms. Studies point to the provision of mentored programs in which learners can experience scientific inquiry as pedagogical interventions conducive to forming science identity (Atkins et al., 2020; Chemers et al., 2011; Hunter et al., 2006; Z. Jiang et al., 2020; McCartney et al., 2022; Robnett et al., 2015; Syed et al., 2019; Vincent-Ruz & Schunn, 2018). Such interventions are not restricted to certain age groups. Cases documented in the literature report on programs and projects in which, for instance, sixth graders are assigned with the roles of scientists (S. Jiang et al., 2020), partnerships between high schools and medical research centers are established (Rocha et al., 2023), or undergraduates in mentored research projects present results of their own studies at conferences (Robnett et al., 2018).

Studies also have considered the effects of cognitive processes for science identity. For instance, Guo et al. (2022) showed epistemological beliefs about science and reflective thinking exert effects on science identity. A branch of research has shown that science identity predicts science career aspiration (Alhadabi, 2021; Bodnar et al., 2020; Merolla & Serpe, 2013; Robinson et al., 2018; Vincent-Ruz & Schunn, 2018). Stets et al. (2017) stated: "that only the science identity itself, among all the factors considered [such as science self-efficacy, performance approach, or mentoring], influences moving into a science occupation upon graduation, [while] other processes indirectly influence entering a science occupation through the science identity" (p. 12). In sum, strong science identity encourages young people and adults to engage in science-related studies and occupations, especially when they belong to minority groups whose right to participate in science is far from settled.

Academic Achievement and its Role in Science Identity Building and Postgraduate Career Commitment

Academic achievement refers to the intended outcomes of formal instruction, often measured in grade points, thereby testifying to a student's performance. Academic achievement awarded by teachers or an examining body is therefore a gatekeeper that decides whether or not, for example, a graduate will have access to postgraduate programs (Butera et al., 2021). Plausibly, students are interested in receiving high scores, which makes the grade point average (GPA) a widely employed measure in educational research.

Related to science identity and postgraduate study intention as the other two variables explored in this study, the role of GPA can be summarized as follows: Stets et al. (2017)

identified GPA as a main factor influencing science identity. The authors pointed to the observation that individuals resolve positive discrepancy (i.e., when others' judgements about someone's science identity are more positive than one's own judgment), their science identity improves so that it becomes a better fit to how they are recognized by others. A high GPA score would strengthen someone's science identity because the science identity is then a better fit for their academic achievement. In a nutshell, science identities are calibrated against academic achievement.

Claiming a reverse direction, White et al. (2019) hypothesized a model with science self-efficacy as a mediator in the relationship between science identity and academic achievement. The authors reported a full mediation effect of science self-efficacy, as science identity had a statistically significant indirect effect on GPA but no statistically significant direct effect. Previous research has consistently indicated that students with high GPAs are more likely to pursue postgraduate studies (Kim-Prieto, et al., 2013; Scarbecz & Ross, 2007; Strayhorn, 2007). Given that academic achievement influences both science identity and postgraduate study intention, it is expected that science identity mediates the effect of academic achievement on postgraduate study intention. Merolla and Serpe (2013) reported similar findings, stating that "Students with high levels of science identity salience are more likely to translate high college GPAs into graduate school matriculation compared to students with lower levels of science identity salience" (p. 591).

Postgraduate Education for Teachers in Türkiye

It is important for teacher education in the 21st century that teachers gain scientific self-efficacy and science identity, communication, collaboration skills, and new teaching and alternative assessment approaches as well as improving their professional and field knowledge through postgraduate education. Against this backdrop, teacher education and instructional practice delivered at schools in Türkiye have been identified as areas that require drastic steps in terms of guiding teachers towards enhanced professional development and postgraduate education. International comparative studies show that Turkish teachers' low cognitive abilities correlate with low student performance (Hanushek et al., 2019), and teacher participation in professional development remains unsatisfactory (OECD, 2019) in spite of attempts to provide more inquiry-based professional development programs shifting away from predominant centralized top-down delivery of training (Özer & Suna, 2023). These problems lead to transmission-based instructional practices observed in Turkish schools depending on a variety of factors encompassing multiple-choice exams, large classes, unsuitable materials and working conditions of teachers (Şener, 2018; Yaraş & Turan, 2021).

Addressing these conditions, the Scientific and Technological Research Institution of Türkiye (TÜBİTAK, 2005) identified strengthening teacher education by establishing a career system and promoting postgraduate opportunities for teachers as one of the aims in the "Vision 2023 Technology Foresight Project. Education and Human Resources Results Report and Strategy Document". The Turkish Ministry of National Education (MoNE, 2017, 2019) has defined general competencies for teachers that are in line with the goal of increasing the number of teachers who take up postgraduate programs to reach global standards in educational policy. Recent legislative novelties provide opportunities to gain the status of a chartered teacher by earning a master's degree or to gain a principal by earning a PhD degree (Gül & Dikbaş, 2023). In spite of those incentives, teachers' willingness to engage in postgraduate education is hampered by several factors. While teachers and pre-service teachers are aware of the potential

to meet needs for personal and professional development, and they desire to start an academic career (Sevim & Akın, 2021; Vural & Başaran, 2021), workload, lack of financial support, requested efforts in postgraduate studies as well as personal circumstances discourage teachers from pursuing academic careers (Can, 2019; İlter, 2020b; Koşar et al., 2020).

Study Context

Study Purpose

Social, environmental, and economic challenges necessitate the education of young people and adults who can address current problems with scientific approaches. From the perspective of teaching and learning, exposing pre-service teachers to research is fundamental in fostering inquiry-based teaching methods, which are proven to promote more effective learning. This approach not only enhances their own understanding of science but also plays a crucial role in helping students develop a strong sense of identity in science (Havu-Nuutinen et al., 2019). Additionally, it can be assumed that pre-service teachers and teachers will be equipped with the ability to respond to problems in their own educational context.

Based on these assumptions, we investigated the question of whether science identity plays a mediating role in the relationship between academic achievement (measured by GPA) and commitment in postgraduate career among pre-service teachers. The decision to examine the potential mediating role of science identity as an independent variable was guided by the role of science identity and sense of belonging to science as stimuli for pre-service teachers' future academic career choices (Rodriguez et al., 2017; Stets et al., 2017; Trujillo & Tanner, 2014) as well as the significance of GPA as a factor in undergraduates' decision to enroll in postgraduate degree programs (İlter, 2020a; Kim-Prieto et al., 2013; Scarbecz & Ross, 2007; Strayhorn, 2007).

Building on existing research that demonstrates the influence of science identity and a sense of belonging on pre-service teachers' career choices, this study aims to examine a more complex mechanism by examining science identity as a mediating factor between academic achievement and commitment to a postgraduate career. While previous research emphasizes the direct effect of science identity on career choices, this study extends this perspective by proposing that science identity may serve as a crucial link between academic achievement and postgraduate career commitment among pre-service teachers. By examining this mediating effect, we aim to provide a deeper understanding of how undergraduate academic achievement can translate into career aspirations, particularly through the development of a strong science identity. This approach offers a novel contribution to the literature by suggesting that science identity might be a vital process through which pre-service teachers' academic achievement fosters their commitments to a postgraduate career in teacher education programs and teacher development. Furthermore, the interplay of science identity, postgraduate career commitment and academic achievement have not been examined in a Turkish per-service teacher context to the best of our knowledge.

As it is known, science identity in any domain of natural or social sciences is widely identified as the primary driving force that encourages people to pursue scientific careers. Other variables (e.g., goals, self-efficacy, and attitudes) operate via mechanism of science identity (Stets et al., 2017). In this study, the selection of GPA as the other exogenous variable is justified based on two considerations. First, it is an objective indicator for academic achievement (Richardson et al., 2012). Second, there is evidence that it influences both science identity and

commitment to pursue a postgraduate career (Merolla & Serpe, 2013). Our participants, pre-service teachers enrolled in undergraduate programs at a Turkish university, appeared to be a study group conducive to improving understanding of how academic achievement and science identity interact and potentially influence the commitment for a postgraduate career.

Examining interactions can help determine whether interventions designed to increase participation in postgraduate education should focus on science identity or academic achievement, or whether a dual intervention approach—improving both academic achievement and science identity—is most effective. It is therefore essential to examine whether science identity mediates the relationship between pre-service teachers' academic achievement and their commitment to a postgraduate career. As pre-service teachers' postgraduate career aspirations may be influenced by other external factors, it is not yet clear whether career commitment can be explained synonymously with their academic performance and scientific identity. This study is important in terms of expanding our understanding of the factors that support pre-service teachers' pathways to a postgraduate career commitment.

Hypotheses of Study

In this study, we formulated the following hypotheses (H) to explore the relationships between pre-service teachers' academic achievement, their perceptions of science identity and their commitment to a postgraduate career:

H1. Academic achievement predicts science identity.
H2. Academic achievement predicts commitment to a postgraduate career.
H3. Science identity predicts commitment to a postgraduate career.
H4. Science identity mediates the relationship between academic achievement and commitment to a postgraduate career.

Methodology

Participants

This study used a cross-sectional design research model. Participants were 309 pre-service teachers enrolled in different programs covering natural and social sciences of a faculty education at a state university located in the Mediterranean Region of Türkiye. We purposefully recruited participants who were in their fourth-year of their undergraduate education because it was assumed they would have a deeper understanding of science and higher awareness of postgraduate study opportunities (Akgun & Kaya, 2020). In addition, as undergraduate students progress through their education, their interests often begin to overlap with their career goals (Beggs et al., 2008). Among our participants, 83 (25.4%) were male and 225 (68.8%) were female. The majority of the participants being female was expected as faculties of education in Türkiye are more frequented by female students than male students, an indicator of the feminizing of the teaching profession observed in Türkiye and elsewhere (Sari, 2012; Yüce et al., 2013). For example, a similar gender distribution was observed in a longitudinal study of Çiftçi and Karadağ (2024) that involved 32 faculties of education in Türkiye. Participants were aged 20–38 years, with a mean age of 21.5 years. The majority were Turkish (N = 296, 95.79%), and the other ethnic groups included Syrians (N =13, 4.21%). Participants were enrolled in six departments: elementary mathematics education (N= 64, 20.71%), science teaching (N = 63, 20.39%), English language teaching (N = 58, 18.77%), social studies education (N = 54,

17.48%), guidance and psychological counseling (N = 43, 13.92%), and Turkish language teaching (N = 27, 8.73%). The pre-service teachers took the following courses as defined by the Council of Higher Education (CoHE, 2018) during their four-year undergraduate program: science and research ethics, science, technology, and society; nature and teaching of science; and history and philosophy of science.

Measures

Science Identity Scale

This scale, thereafter referred to as SciID, has been developed by Chemers et al. (2011) and translated into Turkish by İlter (2023). It is a six-item measure assessing the extent to which participants believe that being a scientist (including scientists in social sciences/humanities) is part of their personal identity. The scale used a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating a stronger science identity. Sample items included: "In general, being a scientist is an important part of my self-image," "I am a scientist." These items reflect students' self-perceptions of science identity and how they believe others perceive them in science-related tasks and activities (Aschbacher et al., 2010). Confirmatory factor analysis (CFA) supported the construct validity of the SciID, yielding fit indices of $\chi 2$/degrees of freedom (df) = 2.27, Goodness of Fit Index (GFI) = .95, Tucker Lewis index (TLI) = .94, Comparative Fit Index (CFI) = .95, and Root Mean Square Error of Approximation (RMSEA) = .057 (İlter, 2023). Following Taber (2018), the scale demonstrated satisfactory internal consistency, with a Cronbach' s alpha of .85 in our study.

Postgraduate Career Commitment

This scale, thereafter referred to as PgCC, originally developed in Turkish by İlter (2020a), is a six-item measure designed to assess participants' intentions to pursue a postgraduate career. The items were scored on a five-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). High scores on the PgCC indicated strong a commitment to pursuing postgraduate study. Sample items included: "I believe in it is necessary to complete a postgraduate program after graduating with an undergraduate degree," "I am interested in postgraduate education due to my desire to pursue an academic career,", "I intent to undertake postgraduate education after completing my undergraduate degree," "Postgraduate study is an opportunity to enhance my academic-oriented personal skills and performance." Construct validity of the PgCC was examined through a CFA conducted by İlter (2020a). The fit indices of the scale were as follows: χ^2/df= 2.24, GFI = .92, CFI = .95, TLI =. 92, and RMSEA = .061. The RMSEA of .061 was slightly above the more stringent threshold of .05 but below .08, which indicated acceptable model fit (Kline, 2016). Similarly, RMSEA values ≤ .08 are generally considered indicative of a good fit, whereas values ≤ .10 suggest an acceptable fit (Kenny et al., 2015). In our study, the Cronbach's alpha for the PgCC scale is .88, indicating a high level of internal consistency (Taber, 2018).

Academic Achievement

Academic achievement (AcA) was measured by the participants' cumulative GPA. This independent variable included the GPA of the participants during the undergraduate education

period, from year 1 through year 4. GPA was selected as an independent measure because it is a widely recognized and easily accessible indicator of academic achievement, commonly used by students, teachers, and academics (Gladstone et al., 2018). Grades in higher education play a crucial role in shaping students' academic trajectories by influencing the quality of the university experience (Parker et al., 2012). In Türkiye, GPA is frequently used as a criterion for increasing career prospects in higher education, after undergraduate graduation, and for admission to postgraduate programs (CoHE, 2016). Researchers have noted that GPA is considered an objective indicator of students' academic achievement (Bae, 2022; Gutiérrez-Braojos, 2015; Richardson et al., 2012; Sticca et al., 2017; Sucuoğlu, 2018). In addition, it is considered an objective measure of the successful performance of student science identity (Stets et al., 2017). In our study, GPAs reported by students ranged from 2.00 to 4.00 points, with higher scores indicating higher levels of academic achievement in undergraduate education. Participants had an average GPA of 3.12, with scores ranging from 2.18 to 3.85.

Data Collection

The study was conducted with the permission of the Social and Human Sciences Ethics Committee of a higher education institution with the decision dated 06.12.2021 and numbered E. 81222. Prior to administering the study measures, participants were provided with an informed consent form to confirm their willingness to participate. We informed participants about the aims and protocols of the study and shared that their participation was voluntary and that they could withdraw from the survey if they wished. All measures used were filled out face-to-face and using pen and paper. We also explained to participants that their data would not be shared with third parties and that their responses would be kept confidential to avoid social desirability bias. Participants took approximately 20 minutes to complete the measures which included items on their demographic characteristics. Data were gathered between October 2022 and December 2022.

Data Analysis

We analyzed the data using IBM SPSS 22 (Version 22) and AMOS (Version 22). Participants' demographic characteristics were summarized using descriptive statistics. Before conducting the mediation analysis, we examined the three specific constructs—academic achievement, science identity, and commitment to a postgraduate career—for their interrelationships using Pearson correlation. Subsequently, we tested the mediating role of science identity in the relationship between academic achievement and commitment to a postgraduate career. Structural equation modeling (SEM) with maximum likelihood estimation was used to examine the direct and indirect relationships between the variables, using AMOS (Version 22).

To test the study hypotheses, the mediated analysis framework proposed by Baron and Kenny (1986) was employed. Initially, the measurement model was verified, followed by testing the causal relationships between the variables using path analysis. In the first stage of the SEM analysis, the measurement model was assessed to confirm its theoretical validity, based on the framework outlined by Kline (2013). The measurement model was evaluated using CFA. Model fit was assessed using the following fit indices: χ^2 goodness of fit, RMSEA, CFI, GFI, the ratio of χ^2 to degrees of freedom (CMIN/df), and TLI (Hu & Bentler, 1999). For CFI, TLI and GFI values .85 or over; for RMSEA, values under .08 are accepted as good fit values (Kline, 2013).

Before conducting any analysis, we first assessed whether our data set met the assumptions required for SEM. Within the scope of this study, the relationships between the variables were examined, and the homogeneity of the variables was tested. First, missing data and extreme-value analyses were performed on the data set (Field, 2009). Analysis results showed that there was no missing data in the data set. Multivariate extreme-value analysis was analyzed in accordance with Mahalanobis distance values $p < .001$ (Büyüköztürk, 2014). Seven data points outside the ±3 range by the Z-score were not included in our analysis. In order to determine the multi collinearity of the data, tolerance value ($1\text{-}R^2$) and variance inflation factor (VIF) values were analyzed. Tolerance value and VIFs are used to assess the potential multicollinearity problem. When the VIF value is 10 or higher, it is considered to be highly dependent (Smith & Campell, 1980). For our data, VIF values ranged between 2.61 and 3.57 and tolerance values ranged between .37 and .88 for all factors. As the VIF value was below 10 and the tolerance values were above .1, indicating that the absence of multicollinearity assumption was satisfied (Field, 2009). In our study, p value < .05 was accepted as statistical significance.

Prior to conducting the analyses, kurtosis and skewness values were examined to assess whether the data met the assumption of normality. Skewness coefficients of the total scores of academic achievement, science identity, and postgraduate career commitment were -.124, .073 and -.113, while the kurtosis coefficients were -.736, -.371 and -.689, respectively (see Table 1). Kurtosis and skewness values were within an acceptable range between -1.5 and +1.5, indicating normal distribution (Tabachnick & Fidell, 2013).

Results

Descriptive Results

The Pearson correlation coefficients, skewness and kurtosis values for the variables are presented in Table 1.

Table 1.
Descriptive Statistics and Correlations for Variables

	1	2	3	Skewness	Kurtosis
1.AcA				-.124	-.736
2.SciID	.346**			.073	-.371
3.PgCC	.389**	.512**		-.113	-.689

Note. **$p < .001$, PgCC = Postgraduate career commitment, AcA = Academic achievement, SciID = Science identity.

As seen in Table 1, the results of the correlation analysis revealed statistically significant positive relationships among the variables. Academic achievement was positively correlated with science identity ($r = .346$, $p < .001$), and science identity was positively correlated with postgraduate career commitment ($r = .512$, $p < .001$). Furthermore, a positive relationship was observed between academic achievement and postgraduate career commitment ($r = .389$, $p <$ 001).

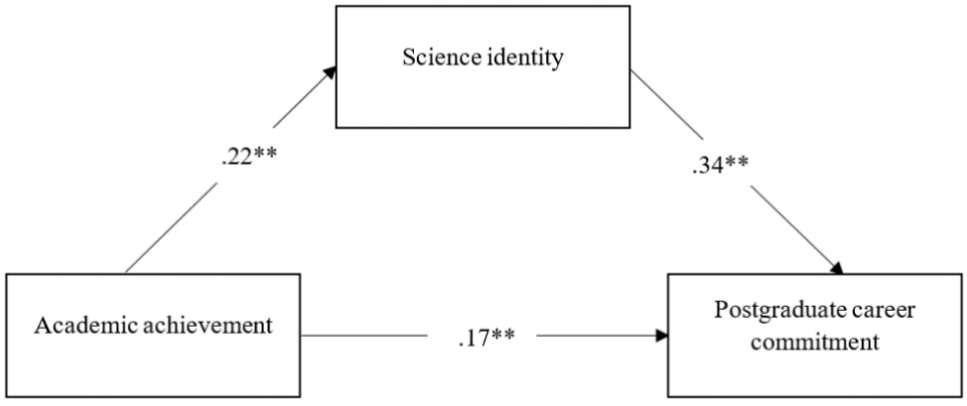
Measurement Model

The measurement model was evaluated using CFA. As the first step of the SEM analysis, the measurement model was tested to verify its theoretical appropriateness. In SEM, the initial step involves evaluating a measurement model in which all variables in the model are modeled together. This model, which defines the relationships between observed variables and latent variables, is examined using CFA. The measurement model serves to explain the relationships between observed variables and latent variables (Kline, 2013). Our measurement model had three observed and three latent variables. Academic achievement, science identity, and career commitment were treated as latent variables. In our model, academic achievement was defined by a single latent variable, formed by students' overall undergraduate GPA. As the SciID consisted of six items and one dimension, it was added to the model as a single latent variable. PgCC was added to the model as a single latent variable consisting of six items. The measurement model was tested with CFA using the AMOS. CFA results showed that the model fit indices for the measurement model are within acceptable ranges, as suggested by Kline (2013) [$\chi^2/df = 2.11$, $p < .05$, CFI = .95, Incremental Fit Index (IFI) = .94, TLI = .93, RMSEA = .061].

Mediation Analysis

In the model, we examined both the direct and indirect effects of academic achievement on postgraduate career commitment, with science identity as the mediating variable. SEM analysis was conducted to assess the predictive power of academic achievement and science identity on postgraduate career commitment. The structural effects and relationships between the observed variables in the proposed model are illustrated in Figure 1, which presents the mediation analysis results.

Figure 1.
Default Model Findings
Note. $^{**}p < .001$



As seen in Figure 1, academic achievement positively significantly predicted science identity ($\beta = .224$). In addition, academic achievement directly significantly predicted postgraduate career commitment ($\beta = .173$) and science identity also significantly predicted career commitment ($\beta = .342$). Path analysis with the exclusion of science identity as a mediating

variable showed that academic achievement directly predicted the variable of career commitment. The examination of the path coefficient revealed a meaningful increase (β = .250, p < .05), while the effect decreased when science identity was included as a mediator in the model (from β = .250 to β = .173). Despite this reduction in the effect of the exogenous variable of academic achievement and commitment, the effect was statistically significant. This suggests that science identity serves as a partial mediator in the relationship between academic achievement and commitment, although its mediator effect was close to full mediation.

To test whether the indirect effect of science identity was significant, we conducted bootstrap analysis (5000 re-sample) and examined the confidence interval values as shown in Table 2. Bootstrapping analysis showed that the indirect effect was significant (p < .01). This is because there was no zero between the lower and upper limits of the confidence interval (bootstrapping coefficient = .142, SE = .096, 95% CI [.43, .75]). This suggests that science identity development mediates the relationship between pre-service teachers' GPA and their commitment to a postgraduate career. Together, all variables accounted for 32% of the variance in postgraduate career commitment. The fit indices of the model were $\chi 2/df$= 2.32, RMSEA = .059, CFI = .95, IFI= .94, GFI = .93, TLI = .94, indicating a good fit of model (Kline, 2013). The effect size of the predictor variables on career commitment, as measured by Cohen's d, was d = .35 for academic achievement and d = .53 for science identity. Both effect sizes can be interpreted as medium (Cohen, 1988), with science identity playing a more significant role in predicting postgraduate career commitment than academic achievement.

Table 2

Direct and Indirect Effects and 95% Confidence Intervals for the Structural Model

Pathway	Standardized Effects		95% CIs (5000 Bootstraps)	
	Direct Effects	Indirect Effects	Lower Bound	Upper Bound
PgCC ← AcA	.173**	.122*	.043	.075
PgCC ← SciID	.341**			
PgCC ← SciID ← AcA	.221**			

Note. *p < .01, **p < .001, bootstrap re-sampling=5000, CI= Confidence interval, AcA = Academic achievement, SciID = Science identity, PgCC = Postgraduate career commitment

Discussion

This study examined the mediating role of science identity in the relationship between academic achievement and commitment to pursuing a postgraduate career among pre-service teachers. The correlation analysis revealed significant relationships between the variables. The findings supported our hypothesized model as they provided evidence that:

- Academic achievement significantly predicts science identity (H1),

- Academic achievement has both direct and indirect effects on commitment to a postgraduate career (H2),
- Science identity significantly predicts commitment to a postgraduate career (H3),
- Science identity mediates the relationship between academic achievement and commitment to a postgraduate career (H4.

These findings support the central role of science identity in the formation of undergraduate students' postgraduate career commitment or aspiration to pursue a science career (Alhadabi, 2021; Bodnar et al., 2020; Stets et al., 2017). Our results also underscore the role of academic achievement as a predictor for intentions to pursue postgraduate study (Kim-Prieto et al., 2013; Scarbecz & Ross, 2007). Moreover, this study provides evidence for the significant role of GPA in the development of science identity (Stets et al., 2017) and its influence on students' interest and intentions to pursue post graduate education and careers in science (Merolla & Serpe, 2013). Our results suggest that students' career commitment is more affected by their perceptions of science identity than their academic achievement scores. Another important finding is that science identity partially mediates the relationship between academic achievement and postgraduate career commitment.

Our findings point to the underlying mechanism that describes the experience of academic achievement as mediating a more pronounced science identity, which, in turn, enhances students' aspirations for a career in their specialized field, whether in natural or social science. This aligns with theoretical explanations and empirical evidence that science identity can contribute to developing career pathways. Furthermore, the results suggest that an increase in academic achievement can positively influence students' career trajectories in science by increasing the quality of their science identity over time. This explanation is supported by social cognitive career theory, which posits the need to develop enduring career-related interest by developing self-efficacy beliefs and positive outcome expectations generated in direct, indirect, and vicarious experiences (Lent et al., 2002). It is the task of schools to provide such experiences by establishing compelling programs that value the diversity of interests and backgrounds of learners, thereby contributing to the dynamic construction of identities in children (Oyserman & Destin, 2010), adolescents (Vondracek & Skorikov, 1997), and young adults (Lundberg, 2010). Undergraduate programs are particularly important for developing a science identity to nurture commitment to postgraduate education because students' career trajectories are often formed during their undergraduate studies (Wisker, 2007). Although teacher learning is undoubtedly a process that continues throughout a teacher's career, integrating inquiry-based activities initially provided in the teacher preparation program will foster pre-service teachers' science identity building (National Research Council, 2010).

In this study, we examined pre-service teachers enrolled at a faculty of education in the final year of their undergraduate programs. Existing studies suggest that pre-service teachers preparing for and teachers practicing in teaching-intensive contexts may hold vague or simplistic understandings of science (Akgun & Kaya, 2020; Peters-Burton et al., 2023; Schouteden et al., 2016). These understandings prevent them from implementing research-validated practices into their teaching, applying inquiry-based forms of instruction in their classrooms, and self-inspection of their instruction through research practice (Colognesi & März, 2023; Ronda & Danipog, 2022). Therefore, the implementation of inquiry-based activities in teacher education and development is imperative to introduce pre-service and in-service teachers to research so they can perform scientific practices in their area, develop competence, and experience

recognition by educators, thus benefiting from the sources of science identity (Carlone & Johnson, 2007).

As inquiry-based learning is cognitively challenging —and, thus, more likely to yield better learning outcomes—scaffolding is imperative to provide academic achievement, and, consequently, to strengthen science identity and commitment to a postgraduate career (Atkins et al., 2020; Kuchynka et al., 2022). Additionally, the value of a school environment that demonstrates institutional commitment to involving learners in science cannot be underestimated. Approachable teachers, advisory sessions for learners and parents, extracurricular activities such as open science days, and cooperation with outside partners generate spaces for learners to negotiate their science identities (Kuchynka et al., 2022; Ramos-Montañez & Pattison, 2022). Teachers intending to attend postgraduate programs may not be driven by ambitions to leave the domain of teaching and become full-time researchers but to improve their knowledge and skills related to their current occupation (Vural & Başaran, 2021). However, this should not be seen critically because we can assume that their enhanced science identity guides them toward the delivery of experiential learning and reflective teaching (Rushton, 2021).

Conclusions

This study highlights the mediating role of science identity in pre-service teachers' decisions to pursue postgraduate education offering insights into the factors shaping postgraduate career pursuits. The findings have significant implications for policymakers and curriculum designers as they underscore the need to implement inquiry-based forms of teacher education and professional development. Providing adequate mentoring can help ensure academic success, which can also encourage teachers to pursue postgraduate studies. In turn, this may enhance the quality of teaching, as future generations of students will have greater opportunities for experiential and discovery-based learning, fostering deeper engagement and stronger science identities across natural and social sciences and humanities (Rushton, 2021).

However, this optimistic perspective should be considered alongside structural constraints such as fixed curricula, limited resources, and schools' economic priorities. Assumed benefits of teachers with postgraduate qualifications do not inherently resolve systemic challenges in education. Additionally, some teachers may transition into academic or research careers, which can potentially reduce the number of highly qualified educators in schools. Nevertheless, those who remain in the classroom will bring advanced competencies that enable them to address current educational problems in Türkiye and beyond. It is also important to note that this study specifically examined the mediating role of science identity in the relationship between academic achievement and postgraduate career commitment. The current study design does not allow for causal conclusions regarding the relationships among these variables.

Limitations and Recommendations for Further Research

This study has some limitations. First, the use of a longitudinal design, particularly with investigations into instruction in teacher education, would offer distinct advantages. Researchers could more closely examine the impact of research opportunities in undergraduate teacher education programs on the development of science identity and track the extent to which pre-service teachers pursue postgraduate studies. Furthermore, this study does not provide information about the research experiences participants may have gained during their studies or

elsewhere. To expand the scope of future research, it would be beneficial to qualitative data collection methods, such as observing students during inquiry-based activities their undergraduate studies or eliciting narrative accounts of their experiences.

Moreover, with the inclusion of academic achievement in the default model, only one dimension contributing to the science identity was considered. The formation of science identity and career aspiration, however, is influenced by multiple factors. In addition, the demographics of the participants in this study were heavily skewed toward female students, as faculties of education in Türkiye are more commonly chosen by women (Yüce et al., 2013). Although it would be interesting to examine gender differences in science identity, this was beyond the scope of the present study. Future studies should explore multiple group variables (e.g., age, gender, race) using SEM.

Finally, the participants in this study were pre-service teachers at a Turkish university. Expanding the study to include pre-service teachers from different locations or exploring the science identity of practicing teachers and its manifestation in instructional practices and/or commitment to postgraduate careers could offer valuable insights. Another important aspect for future research is the role of expected economic gains and increased prestige in influencing teachers' decisions to pursue postgraduate studies.

Despite these limitations, this study makes a significant contribution to the literature by focusing on postgraduate career commitment and exploring the interplay between academic achievement and science identity among pre-service teachers.

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