

A SYSTEMATIC REVIEW OF STUDENTS' PHYSICS IDENTITY TRANSITION BASED ON GENDER AND SOCIOCULTURAL ASPECTS

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Abstract :

The aim of this study is to provide a comprehensive overview of the literature on physics identity transitions and to examine how gender and sociocultural contexts influence the formation and transformation of these identities. Additionally, this study will identify the methodologies used in previous studies. A systematic literature review (SLR) was conducted following PRISMA guidelines. Relevant articles were retrieved from three major databases (Scopus, ERIC, and Google Scholar) published between 2019 and 2025. Nine studies were selected for analysis using thematic analysis to identify contextual, social, and methodological patterns. The findings suggest that physics identity is shaped by the interaction of internal factors, such as interest, competence/performance, and self-efficacy, as well as external factors, including recognition, sense of belonging, and community support. The results also show that identity construction is not socially neutral but influenced by gender stereotypes, masculine norms, and sociocultural contexts that shape individual participation and legitimacy. Methodologically, the literature is still dominated by cross-sectional quantitative approaches, which limits the understanding of identity transition as a dynamic process. This study confirms that strengthening physics identity depends not only on the individual but also on the support of an inclusive, relational, community-based learning environment. It also encourages the development of more contextual, longitudinal research that uses a mixed methods approach.

Keywords: Physics Identity, Identity transition, Gender, Sociocultural

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INTRODUCTION

Physics identity is a key concept in understanding how individuals participate, commit, and build careers in the field of physics. Several studies define physics identity as an individual's understanding of themselves recognizing and perceiving them as a "physics person" based on their experience and engagement within physics learning environments (Avraamidou, 2014; Bottomley dkk., 2021; Hazari dkk., 2015; Hyater-adams dkk., 2018). This identity not only represents knowledge and skills in physics but also reflects one's self-perception as a member of the physics community. The development of physics identity plays a crucial role in influencing students' interest, confidence, and long-term career persistence in science. Research indicates that students with a strong physics identity are more likely to

pursue further study or professional careers in science (Avraamidou, 2020; Hazari et al., 2010; Hyater-adams et al., 2019; Lewis et al., 2016; Rodriguez et al., 2016; Wang, J., & Hazari, 2018).

The components that construct physics identity play a significant role in shaping the identity development of physics students, influencing their learning outcomes, career choices, and persistence in the field (Hazari et al., 2010; Kalender et al., 2019), this is highly influential in determining subsequent career choices in the field of physics (Hazari et al., 2010; Holmegaard et al., 2014; Wang & Hazari, 2018). A lack of support for physics students in developing a physics identity can negatively impact their future careers, especially for students from groups that are underrepresented in physics (Hyater-adams et al., 2019; Lewis et al., 2016; Rodriguez et al., 2016). Therefore, developing a strong physics identity in students is crucial, considering its impact both during their studies and on their future professional trajectories. However, understanding how this identity changes or develops throughout a student's academic journey still needs future exploration.

Research on physics identity refers to the framework proposed by Hazari et al., (2020), which includes four main dimensions: interest, recognition, competence/performance, and sense of belonging. While many studies have examined the factors that influence the development of a physics identity, most of these studies remain static and rarely explore the processes through which identities change or transition over time. Indeed, the development of students' physics identities may be influenced by a variety of experiences (Wang et al., 2022), including academic environments, scientific communities, and both formal and informal learning activities (Bennett et al., 2023; Bennett et al., 2021; Close et al., 2016; Fracchiolla et al., 2020; Prefontaine et al., 2021; Randolph et al., 2021; Rethman et al., 2021). The development of physics identity has been shown to be a dynamic (Gonsalves et al., 2023; Kim et al., 2025; Prefontaine et al., 2021), particularly during transitions from being physics students towards professional roles in physics-related fields. The dynamic nature of the concept of physics identity highlights the importance of understanding identity as a contextual and evolving process, particularly during periods of academic and professional transition. The transition of physics identity is therefore a significant issue, particularly as students move from learners to professional roles in physics, such as preservice teachers and other physics-related professions. During this period, individuals are required not only to maintain their identity as "physicists", but also to construct new professional identities, including as educators. Such transitions may involve role conflict and identity negotiation due to differences in values, goals, and expectations. Consequently, the development of a more profound comprehension of the transitions of physics identity is imperative for the promotion of sustainable and meaningful professional identity development in physics education and associated domains.

Beyond academic factors, the formation and transition of physics identity are also influenced by gender and sociocultural aspects. In the global literature, various studies show that gender (Archer et al., 2021; Avraamidou, 2020; Cwik & Singh, 2021, 2022; Gonsalves, 2018) and sociocultural (Bottomley dkk., 2024; Masri dkk., 2025; Moshfeghyeganeh & Hazari, 2021; Nehmeh & Kelly, 2021) factors play a significant role in shaping physics identity. Physics is often perceived as a masculine domain, leading women and minority groups to face challenges in gaining recognition as members of the physics community. The representation of a "physicist" is frequently associated with masculine, academic, elite, or professional scientist stereotypes. Inequities in perceived belonging between men and women in physics have been shown to contribute to lower levels of wellbeing for women (Seyranian et al., 2018). Nissen and Shemwell (2016) found that female students reported lower confidence in their ability to complete physics-based tasks and demonstrated weaker identification with physics compared to their male counterparts. Consistent with these findings, Bottomley et al., (2024) showed that men exhibit significantly higher levels of self-efficacy and stronger identification with physics than women. Further research examining gender differences in algebra-based introductory physics course at a large public research university in the United States revealed that even in subfields where women are not underrepresented, they still report lower self-efficacy and weaker physics identities than their male peers (Cwik & Singh, 2021, 2022).

In addition to gender stereotypes, sociocultural factors such as social norms, professional stereotypes, and local cultural values also influence the extent to which individuals feel accepted or able to identify themselves as physicists. Physics identities are constructed within a sociocultural context and shaped by local cultural values and social expectations, not solely by individual academic achievement (Moshfeghyeganeh & Hazari, 2021). The transition from being a physics student to a professional role,

such as becoming a physics teacher, is therefore not only a pedagogical shift, but also a sociocultural process in which individuals renegotiate their sense of competence, recognition, and belonging within a new professional community. In the Indonesian context, identity negotiation can be further complicated by sociocultural factors, including strong hierarchical relationships, collectivist values, and culturally embedded expectations regarding the role and status of teachers (Suryani, 2020). In collectivist societies, such as Indonesia, young people often exhibit a greater degree of dependence on their parents and family members. Consequently, career aspirations and decisions are frequently shaped by the influence of parents, siblings, relatives, and peers. Conversely, young people in many Western societies tend to exhibit greater autonomy in making career-related decisions. In Indonesia, teachers are traditionally regarded as the most knowledgeable members of society and are expected to disseminate knowledge and provide moral guidance. However, despite this traditional respect, the social and economic status of teachers in Indonesia remains relatively low compared to other professions and teachers in neighboring countries (Suryani, 2017). Consequently, prospective teachers in Indonesia may experience heightened pressure to conform to institutional and social norms, which could potentially exacerbate identity conflicts during the transition to professional life. Therefore, a comprehensive understanding of physics identity transitions within specific cultural and gender contexts is imperative for the development of sustainable and meaningful physics teacher education. In this regard, the physics identity is shaped not only by factors internal to the individual but is also continuously negotiated within a social context embedded with cultural norms and expectations.

Although research on physics identity is growing, no systematic review has examined the interplay between identity transition, gender, and sociocultural influences in the context of physics education, especially in under-researched regions like Indonesia (Sundari & Hidayati, 2023). The existing literature is fragmented and often discusses these issues separately without mapping the conceptual and methodological relationships among them. Therefore, this review aims to address this gap using a systematic literature review approach. Specifically, the study will provide an overview of the literature on physics identity transitions, examine how gender and sociocultural contexts influence the formation and transformation of physics identities, and identify methodologies used in previous studies. The findings are expected to reveal existing research gaps and provide new directions for developing more inclusive, socially relevant, and contextually grounded physics identity research, particularly in physics education.

RESEARCH METHOD

This study used a Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize research results discussing the transition of physics identity and the influence of gender and socio-cultural context in physics education. The review process follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as a systematic and transparent framework for literature search, selection, and analysis (Haddaway et al., 2020).

Articles were searched in three main databases, (i.e., Scopus, ERIC, and Google Scholar) with a publication period of 2019–2025, using the following combination of keywords: "*physics identity*", "*identity transition*", "*gender*", "*sociocultural context*", "*physics education*", "*preservice physics teacher*". The search was also conducted on titles and abstracts to obtain literature which is relevant to the research focus. The selection process followed the four stages of PRISMA, namely identification, screening, eligibility determination, and final inclusion. The inclusion criteria are listed in Table 1.

Table 1. Article inclusion and exclusion criteria

No.	Aspect	Criteria
1	Inclusion criteria	1. Peer-reviewed journal articles published between 2019 and 2025. 2. Focus on physics identity or identity transition in physics 3. Involve gender perspectives and/or socio-cultural contexts. 4. Use empirical methods (qualitative, quantitative, or mixed methods).

5. Available in full text.

The literature selection process was carried out in four stages in accordance with the PRISMA 2020 flow, namely identification, screening, eligibility determination, and final inclusion which can be seen in Figure 1.

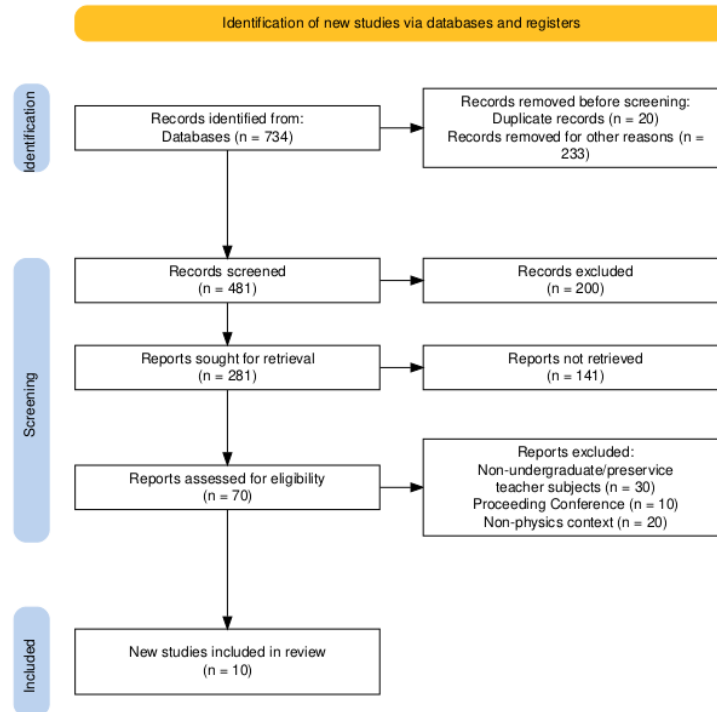


Figure 1. PRISMA flowchart showing the process of study selection

The screening stage was carried out by reviewing the titles and abstracts to evaluate their suitability for the research focus. Articles that passed this stage were examined for feasibility by reading the full text, then finally selected based on inclusion criteria. The final number of articles analyzed were determined after the selection stage is complete. A total of nine articles that met the inclusion criteria were analyzed using a thematic analysis approach to identify conceptual, methodological, and contextual patterns related to physics identity transition. Each study was coded based on its focus on aspects of identity transition, gender influence, and sociocultural context. The results of the analysis were then synthesized narratively to describe the trends in the findings, research gaps, and opportunities for future study development, especially in the context of physics education in Indonesia.

RESULTS AND DISCUSSION

This section presents the results of an analysis of nine selected articles that reveal various patterns and perspectives on how physics identity is constructed, negotiated, and undergoes transition. The findings show that the formation of physics identity is not only influenced by individual factors, but also by gender, social recognition, and academic culture. To clarify the trends found across studies, the synthesis results are organized into three main themes, namely (1) Physics Identity Development & Transition Process, (2) Gender Negotiation and Sociocultural Context Influence, and (3) Research Gaps, Educational Implications, and Future Directions. The following discussion details the findings in each theme and the relationships between concepts relevant to the objectives of this study.

Table 2. Themes of Reviewed Manuscripts

Themes	Literature	
	Titles	Method
Physics Identity Development & Transition Process	Comparison of men and women's motivation of choosing physics teaching or nonteaching trajectory (Yang et al., 2023)	Quantitative

Gender Negotiation and Sociocultural Context Influence in Physics Identity	• The context dependence of physics identity: Examining the role of performance/ competence, recognition, interest, and sense of belonging for lower and upper female physics undergraduates (Hazari et al., 2020)	Qualitative
	• Impact of informal physics programs on university student development: Creating a physicist (Rethman et al., 2021)	Mixed Methods
	• Being a physicist: Gendered identity negotiations on the pathways to becoming an elite female physicist in the United Kingdom (Miller-Friedmann et al., 2025)	Qualitative
	• Identities in/out of physics and the politics of recognition (Avraamidou, 2022)	Qualitative
	• Gendered patterns in the construction of physics identity from motivational factors (Kalender et al., 2019)	Quantitative
	• Women Have Lower Physics Self-efficacy and Identity Even in Courses in Which They Outnumber Men: A Sign of Systemic Inequity? (Cwik & Singh, 2023)	Quantitative
	• Gender and the Social Cure in Undergraduate Physics Students: Physics Identity, Self-efficacy, Belonging, and Wellbeing (Bottomley et al., 2024b)	Quantitative
	• Effect of culture on women physicists' career choice: A comparison of Muslim majority countries and the West (Moshfeghyeganeh & Hazari, 2021)	Qualitative

Theme 1: Physics Identity Development & Transition Process

The first theme focuses on how physics identity develops throughout the academic and professional transition process in physics students and prospective physics teachers. In general, findings from several studies show that the development of physics identity is influenced by the interaction between internal factors such as interest, performance/competence, and self-efficacy, and external factors such as recognition and community support (Hazari et al., 2020; Rethman et al., 2021; Yang et al., 2023). Yang et al. (2023) found that the motivation to choose a physics career path is primarily driven by intrinsic interest, while lower recognition of competence and self-efficacy, especially for women, poses a challenge in maintaining physics identity. This study also shows that differences in professional paths (*teaching vs. non-teaching*) have a stronger influence on physics identity than gender differences, emphasizing that academic experiences and learning environments play a crucial role in shaping that identity. This study employs a quantitative approach informed by survey research to examine the impact of initial motivation on career choices in the field of physics, distinguishing between those who pursue careers in teaching and those who do not. The utilization of statistical analysis is imperative for the identification of the relationship between motivational factors and career choices.

Hazari et al. (2020) make a significant contribution by showing that the construction of physics identity is contextual and develops over time, particularly among female students. This finding indicates a shift in the sources of identity legitimacy, from external validation to internalisation of competencies and membership of physics communities. However, although this study successfully mapped the relationship between identity dimensions, the approach used was cross-sectional, so it was not fully able to capture the dynamics of identity change over time in the same individuals. Consequently, this study more accurately represents differences between groups at a single point in time than the ongoing process of identity transition. This shows that, although identity dimensions can be measured statistically, the process of negotiating identity still requires a more longitudinal and qualitative approach to understand the underlying mechanisms of change.

Further studies by Rethman et al. (2021) add significant perspectives on how informal learning experiences, such as open laboratories, physics clubs, outreach activities, and scientific competitions, can serve as transitional spaces for identity development from "physics student" to "physicist".
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Engagement within informal communities of practice provides opportunities for students to build competency, test their knowledge in authentic contexts, and gain recognition from mentors and peers. This environment facilitates the development of self-efficacy and a sense of belonging, thereby strengthening professional identity beyond the boundaries of the formal classroom. This study employs a mixed-methods approach, integrating survey and interview data to investigate the impact of an informal physics program on the academic identity of its participants. This approach enables the execution of both quantitative and qualitative analyses of each study.

Across the reviewed studies, physics identity development is consistently described as shaped by both internal factors, such as interest, competence/performance, and self-efficacy, external factors, including recognition, sense of belonging, and community support (Hazari et al., 2020; Yang et al., 2023). While intrinsic interest motivates entry into physics, sustained identity commitment appears highly dependent on recognition and sense of belonging within academic communities. Importantly, cross study comparison reveals that identity development does not depend solely on academic ability. Even when competence/performance remains stable, variations in recognition and sense of belonging significantly influences identity strength. The findings reported by Rethman et al. (2021) are consistent with the broader body of research presented by Prefontaine et al. (2021)), this further suggests that informal learning environments function as transitional spaces that reinforce recognition and provide authentic participation opportunities. These environments have the potential to strengthen self-efficacy and professional identification beyond formal classroom contexts.

Synthesizing the findings, the identity transition from physics education to prospective physics teacher appears to follow a multi-stage process:

1. Initial disciplinary identity formation, grounded in interest and perceived competence/performance.
2. Identity negotiation, mediated by recognition, sense of belonging, and alignment with new professional norms.
3. Contextual disruption, occurring during academic to professional transition, particularly when shifting from students to teaching roles.
4. Stabilization or tension, depending on the degree of institutional support and inclusivity

This process indicates that identity transition is not merely pedagogical but sociocultural. Tensions often arise when the norms of academic physics (e.g., competence/performance) differ from the relational and pedagogical expectations of teaching. Thus, identity transition involves renegotiating legitimacy, competence/performance, interest, recognition, and sense of belonging within a new professional community.

Furthermore, in terms of methodology, studies in this area tend to be dominated by quantitative, survey-based approaches. However, these approaches tend to be cross-sectional, which makes them less effective at capturing the dynamics of identity transitions over time. A mixed-methods study of attendance Rethman et al. (2021) demonstrates the potential of a more comprehensive approach to capturing not only patterns of relationships between variables, but also students' subjective experiences and meanings when constructing a physics identity. Nevertheless, the number of studies employing this approach remains limited. Therefore, more research using mixed-methods designs, even longitudinal ones, is needed to capture the process of physics identity transition as a dynamic, contextual and evolving phenomenon over time.

Theme 2: Gender Negotiation and Sociocultural Context Influence in Physics Identity

Unlike the first theme, which focuses on the academic and professional development of physics identity, the second theme highlights how the negotiation of identity is shaped by gender, culture, and social structure. Studies in this theme emphasize that the politics of recognition, gender stereotypes, and symbolic exclusion play an important role in shaping or inhibiting the development of physics identity, especially for women in the physics community.

Miller-Friedmann et al. (2025) revealed that women's journey toward identifying as physicists is a complex social negotiation process, in which female students must constantly deal with a masculine and exclusive physics culture. This study employs a qualitative, narrative approach to investigate the role of women in the construction of their identities as elite physicists. The data were collected through in-depth interviews and subsequently analyzed using a thematic approach. This study shows that the

formation of a physics identity is not only determined by academic ability or cognitive achievement, but is greatly influenced by the dynamics of recognition, sense of belonging, and experiences of gender stereotypes that affect self-legitimacy. Participants described physics as a competitive space that often minimizes women's contributions and requires them to "prove themselves twice as hard" in order to gain professional validation. Identity negotiation occurs through adaptive strategies such as adjusting behavior, managing stereotypes, or seeking support from alternative communities, which shows that women's physics identity is the result of a social process fraught with structural barriers. These findings confirm that physics identity is highly sociocultural and political, and reinforce the argument that women's success in physics is influenced by institutional structures and gender-biased recognition mechanisms. Therefore, increasing women's representation in physics requires more than academic interventions, it necessitates a cultural transformation of physics to create an inclusive and equitable environment for all aspiring physicists.

A study by Avraamidou (2022) explores the construction of physics identity through the perspective of the politics of recognition, focusing on how social recognition, identity narratives, and experiences of involvement in the physics community influence the process of becoming part of the discipline of physics. This study is qualitative and narrative, using an in-depth case study approach on young women participating in informal and formal physics education programs. This article analyzes how personal experiences, social relations, learning opportunities, and self-representation depend on the socio-cultural context and power structures. The findings show that physics identity is not solely an individual construction, but is influenced by access to recognition, support, and opportunities for meaningful participation. Furthermore, symbolic exclusion and gender stereotypes in the physics community often become barriers that cause participants to question their sense of belonging. This study emphasizes the importance of creating an inclusive learning environment that recognizes the diversity of experiences to enable students to position themselves as "physicists".

Furthermore, Kalender et al. (2019) show that the construction of physics identity is gendered: interest, self-efficacy, and perceived recognition contribute differently to male and female physics identities. This study utilizes a quantitative approach informed by survey methodology to examine gender-based differences in the formation of physics identity, with a focus on motivational variables. The utilization of statistical analysis is imperative for the purpose of conducting a comparative analysis of the contributions of various factors across different gender demographics. Women rely more on recognition of competence and social support to develop their identity than men do. This implies that the formation of physics identity is not a neutral process and requires interventions based on specific needs. Practically speaking, Kalender et al. (2019) findings underscore the need for focused interventions, such as strengthening recognition and programs that build mastery so that women have greater access to professional legitimacy in physics.

Cwik and Singh (2023) show that women continue to have lower self-efficacy and physics identity than men even in physics classes where they are the majority of students. The present study employs a quantitative approach, utilizing a survey design to assess the dimensions of self-efficacy and physics identity among the student population. The objective of this study is to utilize an analytical approach to identify potential disparities in gender expression within the context of the physics classroom. These findings provide strong evidence that the issue of physics identity gap is not solely caused by the number of women represented, but is rooted in systemic inequalities embedded in physics norms and culture. This study reveals that women often experience a lack of recognition of their competence from instructors and peers, and face academic norms that marginalize their involvement even though they perform equally or better academically. Factors such as stereotype threat, performance pressure, and masculine norms that dominate the structure of physics classes cause internalization of self-doubt and barriers to the formation of a sense of belonging. Thus, numerical presence does not automatically result in an inclusive learning experience, and interventions to increase representation alone are not sufficient to address this issue. These findings emphasize that a reconstruction of physics culture and more equitable recognition mechanisms are necessary to strengthen women's physics identity and promote equal participation in the discipline of physics.

Bottomley et al. (2024) highlight how physics identity, self-efficacy, sense of belonging, and wellbeing interact in shaping the academic experiences of physics students, particularly in the context of gender differences. This quantitative study shows that women in physics undergraduate programs

tend to have lower levels of self-efficacy, physics identity, and sense of belonging than men, even though they have equivalent academic achievements. These findings indicate that the challenges faced by women's identity do not stem from a lack of academic capability, but rather from social and cultural barriers, such as symbolic marginalization, traditional gender expectations, and masculine learning environment dynamics. The concept of social cure in this study explains that the existence of strong social support through inclusive communities, role model representation, and recognition of equal competence plays an important role in improving psychological wellbeing and strengthening women's physics identity. This study emphasizes that efforts to reform physics education must go beyond individual approaches, shifting the focus towards structural and relational transformations that provide a safe space and legitimacy for women's experiences. Thus, the formation of an equal physics identity requires gender-aware and social health-based community interventions to address long-entrenched cultural inequalities in physics.

Moshfeghyeganeh and Hazari (2021) highlight how cultural factors and social norms influence women's career choices in physics by comparing the contexts of muslim-majority countries and Western countries. Through a quantitative survey-based approach targeting female physicists and physics students in various countries, this study shows that cultural differences significantly shape women's motivation, access to social support, and the process of negotiating their professional identity in the field of physics. The study finds that in muslim-majority countries, women's decisions to pursue careers in physics are more influenced by family values, economic stability, and parental support as sources of social legitimacy. Conversely, in Western countries, women's motivation is more driven by intrinsic interest, academic recognition, and opportunities for professional development. Despite different cultural contexts, both groups face similar structural challenges, such as entrenched gender stereotypes, a lack of female role models, and minimal recognition of competence in male-dominated physics communities. These findings confirm that the development of female physicists' identities is negotiable and highly influenced by social structures and local cultural values. Therefore, strategies for empowering women in physics cannot be applied uniformly, but must be based on cultural sensitivity to ensure that women have fair access to recognition, support, and opportunities to participate fully in the global physics community.

Overall, the studies in Theme 2 emphasize that the issue of women's physics identity cannot be resolved simply by increasing the number of women in physics or improving academic abilities, but requires broader cultural and social structural transformation. Recognition, a sense of belonging, and the existence of a supportive community are key components that significantly influence the development of women's physics identity and the sustainability of their careers. Hierarchical structure of influences, across studies, physics identity operates at three interconnected levels as follows: (a) individual levels- interest, competence/performance, self-efficacy; (b) relational level-recognition by instructors and peers, sense of belonging; and (c) structural level-gender norms, institutional culture, sociocultural expectations. Identity tensions arise when gender norms and structural norms constrain relational recognition despite stable individual competence/performance. Identity disparities are reinforced not only by personal belief but also by systemic gender and cultural dynamics embedded in physics communities. Thus, the creation of inclusive physics spaces, community-based interventions, mentoring for women, and culturally sensitive education policies are essential to ensure fair access and sustainable participation of women in physics. Therefore, future efforts should move beyond increasing representation alone and instead prioritize restructuring recognition practices, fostering inclusive classroom culture, and embedding gender-sensitive mentoring systems within physics education programs.

In addition to the substantive findings discussed above, the second theme has distinct methodological characteristics compared to the first. In terms of methodology, the second theme differs from the first. A review of the existing literature reveals an increasing tendency to use a combination of quantitative and qualitative approaches in research related to this theme. While quantitative studies offer a general overview of gender disparities in self-efficacy and physics identity, qualitative studies provide a more in-depth analysis of identity negotiation processes and experiences of exclusion within socio-cultural contexts. However, most quantitative studies continue to use cross-sectional designs, which limits our understanding of how identity transforms over time. Furthermore, cross-cultural studies remain limited and often fail to integrate qualitative approaches to explain the mechanisms behind

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contextual differences. Moreover, findings in the broader literature suggest that physics culture is not universal and cannot be generalised directly across contexts (Kanim & Cid, 2020). Values, norms and practices within the physics community can vary between countries and institutions. Therefore, understanding physics identity requires a contextual approach that considers how local Indonesian culture and institutional cultures shape individuals' experiences, recognition and sense of belonging in physics.

Building upon the discussion of the two major themes, Table 3 synthesizes the key patterns emerging across the reviewed studies. Rather than merely listing findings, the table organizes the literature into interconnected mechanisms operating at individual, relational, and structural levels, while also identifying converging trends and notable variations. This integrative mapping clarifies how identity transition in physics is simultaneously shaped by personal agency and sociocultural structures.

Table 3. Thematic Synthesis of Physics Identity Transition Across Reviewed Studies

Main Theme	Subtheme	Key Mechanism	Level of Influence	Converging Patterns Across Studies	Diverging/ Notable Variations	Representative Studies
1. Physics Identity Development & Transition Process	Interest and Competence Formation	Intrinsic motivation and perceived competence initiate identity formation	Individual	Interest and self-efficacy are strongly associated with initial physics identity strength	Interest alone insufficient without recognition	Hazari et al. (2020); Yang et al. (2023)
	Recognition and sense of belonging	External validation reinforces identity commitment	Relational	Recognition by instructors and peers strongly associated with identity persistence	Gender differences in access to recognition	Hazari et al. (2020); Kalender et al. (2019)
	Informal Learning as Transitional Space	Authentic participation builds legitimacy and professional identification	Relational / Structural	Informal environments enhance belonging and self-efficacy	Impact varies by program design and mentoring quality	Rethman et al. (2021); Prefontaine et al. (2021)
2. Gender Negotiation & Sociocultural Context	Gendered Recognition Patterns	Unequal acknowledgment of competence	Relational	Report lower physics identity and self-efficacy, often linked to reduced perceived recognition	Magnitude varies by classroom composition	Cwik & Singh (2023); Bottomley et al. (2024)

Masculine Physics Norms	Competitive culture influences belonging	Structur al	Masculine norms linked to reduced belonging among women (Some qualitative studies suggest)	Some supportive environme nts mitigate effects	Miller- Friedmann et al. (2025)
Self- Efficacy Disparities	Gendered confidence gap	Individu al / Relation al	Persistent gender gap in physics self- efficacy	Gap persists even where women are majority	Cwik & Singh (2023)
Cultural Values & Family Influence	Local norms shape career decision and identity negotiation	Structur al	Cultural expectation s mediate professiona l identity developme nt	Stronger cultural expectation s and social norms in collectivist contexts	Moshfeghyega neh & Hazari (2021)

Educational Implications for Supporting Physics Identity

Based on the synthesis of findings across the two main themes, this study highlights several educational and professional implications for supporting physics identity development. Findings from the previous theme show that the development of students' physics identity does not only depend on academic ability and formal learning experiences (Theme 1), but is also greatly influenced by gender, culture, and the dynamics of recognition within the physics community (Theme 2). Therefore, the educational implications that emerge emphasize the need for a learning environment design that can facilitate competency development, attract interest, and provide space for fair social legitimacy and recognition, especially for marginalized groups such as women and students from minority cultural backgrounds. Educational institutions and the physics community need to position themselves as socially safe spaces where students can build self-efficacy, a sense of belonging, and professional identity without the pressure of stereotypes and exclusive masculine norms.

Various studies emphasize that pedagogical approaches and institutional policies must go beyond traditional academic achievement enhancement strategies, towards interventions that emphasize recognition, community building, mentorship, and meaningful access to professional physics practice. Consistent with the broader literature, informal physics programs such as laboratory assistants, physics outreach, or physics clubs, have been shown to play a significant role as Communities of Practice (CoP) that provide authentic experiences, social legitimacy, and opportunities for participation that strengthen the construction of physics identity (Close et al., 2016; Fracchiolla et al., 2020; Prefontaine et al., 2021; Rethman et al., 2021). Institutional efforts such as providing female role models, increasing transparency in academic evaluation, designing collaboration-based curricula, and developing peer-support communities can reduce perceived competency gaps and overcome stereotype threats that have hindered women's involvement. Additionally, physics education policies must be culturally sensitive, taking into account family social values, local norms, and access to social support, given that the process of negotiating physics identity can vary across contexts.

Overall, the results of this study suggest that fostering a strong sense of identity in physics depends not only on individual student efforts, but also on a supportive educational environment and culture. Therefore, physics education should focus on creating an inclusive, relational, community-based learning ecosystem where every student has an equal opportunity to be recognized as a future physicist. These results also underscore the importance of collaboration among educational institutions,

professional communities, and informal physics programs to create equitable learning environments and sustain participation in physics.

Although none of the reviewed studies were conducted in an Indonesian context, the synthesized findings suggest that similar identity negotiation dynamics may be relevant in contexts with comparable sociocultural characteristics. In contexts characterized by collectivist values, hierarchical relationships, and strong social expectations in education, such as Indonesia, the process of identity transition may be influenced by relational factors, such as recognition and a sense of belonging, as well as structural factors, such as gender norms, institutional culture, and sociocultural expectations. However, these implications should be interpreted with caution as they are derived from international literature rather than direct empirical evidence from Indonesia. Therefore, future research is needed to examine how the transition of a physics identity unfolds within the Indonesian context, particularly in relation to gender dynamics and local sociocultural influence.

CONCLUSION

The results of this systematic literature review (SLR) indicate that physics identity formation is a multidimensional process influenced by the interaction of academic, social, and cultural factors. The development of a student's physics identity is a multifaceted process that is influenced by various learning experiences. These experiences have the potential to enhance students' interests, competence and performance, recognition, self-efficacy, and sense of belonging. However, the findings also reveal that this process is not neutral and static. Rather, it is influenced by gender negotiations and sociocultural structures. Women and minority groups face systemic barriers such as stereotypes, symbolic exclusion, and limited professional legitimacy despite their comparable academic performance. Consequently, educational implications underscore the significance of cultivating inclusive and community-based learning environments, along with the reinforcement of programs such as mentoring, the presence of female role models, and informal physics programs. These initiatives serve as pivotal spaces for the establishment of legitimacy and the facilitation of identity transitions.

Despite its important contribution, this study has several limitations that require critical examination. First, most of the analyzed studies used a quantitative, cross-sectional design, failing to capture the dynamic process of physics identity development over time. This limits the ability to gain an in-depth understanding of the identity negotiation process. Second, the literature analyzed is dominated by Western and Middle Eastern contexts, limiting the relevance and generalizability of the findings to other sociocultural contexts, especially Indonesia. Based on these limitations, further research is recommended in two main areas.

- a) First, more longitudinal research is needed to understand the ongoing development of physics identity, as well as the use of qualitative and mixed methods to capture the complexity of identity negotiation processes.
- b) Second, contextually, research should focus on non-Western contexts, including Indonesia, to examine how local cultural values, institutional practices, and gender norms influence the formation and transition of physics identity. Such research is crucial for generating a more contextualized understanding and supporting the development of inclusive, socioculturally relevant physics education.

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