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A Four-Domain Theoretical Model of Factors Shaping Students' STEM Preferences

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Abstract

Although average differences in mathematical performance between men and women are generally small or statistically insignificant, these outcomes are strongly influenced by socio-cultural factors rather than innate ability (OECD, 2020; Hyde, 2014; Else-Quest et al., 2010).This article presents a four-dimensional theoretical model of factors shaping students' educational preferences in the context of STEM. Rather than attributing engagement in STEM solely to mathematical ability, the model emphasizes the interplay of motivational, identity-related, socio-cultural, and contextual influences—such as gender, teaching practices, and family attitudes—within which mathematical self-efficacy plays an important but not exclusive role. Particular attention is paid to the role of gender stereotypes in the perception of mathematical abilities, the influence of creative teaching strategies on interest in science and the importance of expectancy- value theory (EVT) in shaping educational decisions. The article emphasizes the need for further research on these factors, especially in the Polish educational context, where traditional beliefs about the division of gender roles in science persist.

Keywords: **STEM, creative self-efficacy, gender, gender stereotypes, motivation, educational context, expectancy- value theory (EVT).**

Czterowymiarowy model teoretyczny czynników kształtujących preferencje uczniów w kontekście STEM

Streszczenie

Chociaż przeciętne różnice w osiągnięciach matematycznych między kobietami a mężczyznami są na ogół niewielkie lub statystycznie nieistotne, wyniki te są w dużym stopniu kształtowane przez czynniki społeczno-kulturowe, a nie przez wrodzone zdolności (OECD, 2020; Hyde, 2014; Else-Quest i in., 2010). Niniejszy artykuł przedstawia teoretyczny czterowymiarowy model czynników kształtujących preferencje edukacyjne uczniów w kontekście STEM. Model ten, zamiast przypisywać zaangażowanie w STEM wyłącznie zdolnościom matematycznym, podkreśla znaczenie współoddziaływania motywacyjnych, tożsamościowych, społeczno-kulturowych i kontekstualnych uwarunkowań takich jak płeć, praktyki dydaktyczne czy postawy rodzinne. Poczucie samoskuteczności matematycznej odgrywa wśród nich istotną, lecz nie wyłączną rolę. Szczególną uwagę poświęcono znaczeniu stereotypów płciowych w postrzeganiu zdolności matematycznych, wpływowi twórczych strategii nauczania na zainteresowanie naukami ścisłymi oraz znaczeniu teorii oczekiwania-wartości (EVT) w kształtowaniu decyzji edukacyjnych. Artykuł podkreśla potrzebę prowadzenia dalszych badań nad tymi czynnikami, zwłaszcza w polskim kontekście edukacyjnym, gdzie wciąż utrzymują się tradycyjne przekonania dotyczące podziału ról płciowych w naukach ścisłych.

Słowa kluczowe: **STEM, twórcza samoskuteczność, płeć, stereotypy płciowe, motywacja, kontekst edukacyjny, teoria oczekiwania-wartości (EVT).**

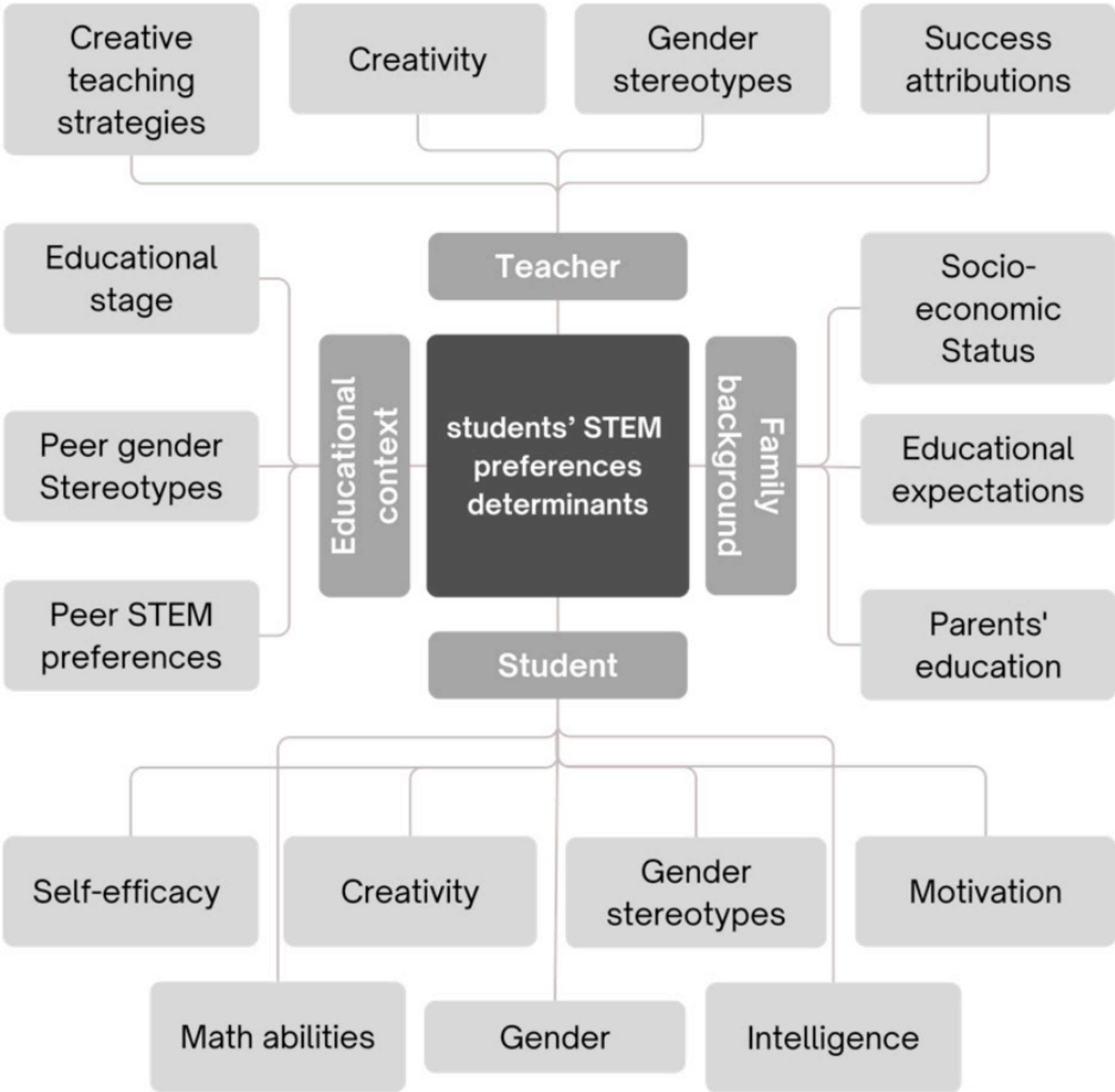
1. INTRODUCTION

Historically, girls have often been perceived as less competent in mathematics, a belief deeply rooted in cultural narratives and reinforced by educational and societal structures (Martinot & Désert, 2007). However, recent international performance assessments, such as those conducted by the OECD (2020), indicate that girls perform at a level comparable to boys in mathematics. Despite this parity in measured ability, the representation of women in scientific and technological domains continues to decline as they progress through successive stages of education and professional careers. This trend is consistently observed in both national contexts, such as Poland (PARP, 2020), and broader international studies (e.g., Makarova et al., 2019).

The persistence of this gender disparity in STEM fields cannot be explained by differences in cognitive ability alone. Instead, a complex interplay of psychological and socio-cultural factors contributes to the lower participation of women in these domains. Self-efficacy and motivation emerge as critical psychological determinants, influencing students' confidence in their mathematical and scientific capabilities. Additionally, external influences—such as teachers' beliefs, instructional practices, and parental attitudes—play a pivotal role in shaping students' educational trajectories. The broader educational environment further reinforces these dynamics, serving as a reference point for students' self-concept, aspirations, and long-term academic choices. Within this constellation of factors, creativity holds particular significance. Studies have demonstrated that creativity is not only a strong predictor of mathematical abilities (Kroesbergen & Schoevers, 2017) and academic achievement (Gajda et al., 2017), but it also serves as a mechanism for reducing stereotypes and biases that may otherwise limit students' aspirations (Groyecka, 2018; Groyecka-Bernard et al., 2021). Encouraging creative thinking and problem-solving skills within STEM education can thus foster a more inclusive and equitable learning environment, challenging rigid perceptions about gendered academic potential.This article introduces a four-domain theoretical model (Graph 1) designed to explain the key determinants of students' preferences for STEM education. Based on a narrative synthesis of literature on self-efficacy, motivation, educational contexts, and creativity, the model provides a more cohesive and theoretically grounded framework for understanding the multifaceted nature of gender disparities in STEM. The model draws on well-established psychological theories—i.e., attribution theory (Weiner, 1985), self-efficacy theory (Bandura, 1997), and the Expectancy-Value Theory of Motivation (Eccles & Wigfield, 2002)—all of which have been applied widely in educational choice situations. Its novelty is the theoretical synthesis of these models with creative self-efficacy and gender stereotypes and socio-cultural factors, particularly in the STEM-related choice situation. This perspective is especially relevant in school contexts, such as Poland, where patriarchal gender models remain dominant. By integrating these models into an integrative model, we aim to offer a new conceptual framework within which to think about the determinants of STEM preference development. It was the decision to produce a graphical illustration of the model (Graph 1) that was prompted by the necessity to organize and present the complex, multilevel interrelationship between these variables in a readily comprehensible and clear form. The model itself was theoretically informed by both theoretical literature and early findings from pilot studies of students' academic choices and teachers' beliefs. Its visual organization was meant to show how the relationships between student qualities, teacher qualities, home background, and school environment—potentially showing avenues by which these domains affect student interest in STEM education—may be modeled. The conceptual model is a precursor to the empirical stage of the project that succeeds it.

Moreover, this paper serves as the opening contribution to a broader research cycle, which will further explore and empirically validate the proposed theoretical model. Future studies within this series will examine how these factors interact in real educational settings, offering practical insights for educators, policymakers, and researchers seeking to address gender imbalances in STEM participation. The research will be of a mixed design and will consist of three consecutive stages: (1) a quantitative cross-sectional study of 8th and 12th grade students (4th year of high school) and their mathematics teachers, (2) observation of mathematics lessons to determine teaching methods and interactions, and (3) interviews with a purposive sample of students to learn about their learning preferences and perceptions. The study will test hypothesized relationships between creative self-efficacy, teacher characteristics (attributional style and stereotype endorsement), gender, and motivation in the context of students' interest in STEM education.

Graph 1 ***Hypothetical Model of Determinants of Students' STEM Preferences***



In this model mathematics has been selected as representative of STEM for several key reason. It forms the foundation for other STEM fields, developing analytical thinking skills essential in physics, chemistry, technology, and engineering (Krutetskii, 1976). It is universally taught at all educational levels, making it widely known and understood by students (OECD, 2020). Mathematics enables the use of existing data and educational tools to analyze students' educational preferences (Baddeley, 1968). Mathematical skills are strongly linked to general cognitive abilities such as logical thinking and problem-solving (Bicer et al., 2020). It also fosters creativity through tasks that require critical thinking (Haylock, 1997). There is a rich body of literature examining gender differences in mathematics, facilitating easier reference to existing research and theories (Tiedemann, 2000; Turska & Oszwa, 2018). Studies show that girls and boys differ in their perceptions of their mathematical abilities, influencing their educational and career decisions in STEM (Jacobs et al., 2002; Tiedemann, 2002). Moreover, mathematics serves as a key factor in students' educational choices, despite similar mathematical achievements (Gajda & Weremczuk-Marczyńska, 2025 in press). These findings align with other studies showing that mathematics plays a crucial role in decisions regarding educational paths in STEM (Gajda et al., 2022). The selection of mathematics as representative of STEM is justified by its fundamental role, universal teaching, impact on cognitive skills, and empirical support from previous studies. By selecting mathematics as the focal point of this study, one can leverage its foundational role, consistent presence in the curriculum, and the extensive empirical support available. This approach ensures a robust and focused investigation into the factors influencing STEM engagement and gender disparities, while maintaining feasibility and coherence in the research design. Moreover, this subject usually covers the greatest number of teaching hours, is covered by the system of external examinations, and its' implementation is associated with a high commitment of teachers.

This is the outcome of a narrative literature review conducted from January 2023 to March 2024. The literature search involved databases such as Scopus, Web of Science, ERIC, and Google Scholar, using keywords such as STEM preferences, gender stereotypes in math, creative self-efficacy, expectancy-value theory, and STEM teaching strategies. Peer-reviewed, empirical and theory-based research written in English or Polish published in the years between 2000 and 2024 was considered, with priority given to investigations relevant to the Polish school system. Inclusion criteria leaned in favor of the studies investigating psychological and socio-cultural determinants of interest in STEM among students from primary and secondary schools.

2. TEACHER-RELATED FACTORS

The role teachers play in influencing students' educational choices is extensively recognized, with perceived support from being an important determinant for continuing specific subjects (Mujtaba & Reiss, 2012). The early secondary school years are pivotal, with the quality of teacher-student interactions significantly impacting students' science perspectives and career inclinations (Cerini et al., 2003). Notably, teachers facilitate STEM interest through instructional support, serving both as role models and as guides in students' educational choice processes (Sjaastad, 2012).

2.1. Attribution styles and expectations

Although it is an obvious assumption that the goal of teachers is to support students in making satisfying career choices, the question arises as to how they perceive the possibilities of achieving success. This issue is directly related to attributional theories. Attribution theory, as proposed by Weiner (1985), seeks to decipher the reasons behind specific events or behaviors. This framework explains how people interpret the causes of human behavior - individuals explain and understand their own or others' actions and characteristics, leading to the ability to predict and potentially influence future events. However, this process can be subject to cognitive errors, leading to incorrect perceptions of reality. Individuals who engage in external attribution believe that events occur beyond their control, attributing outcomes to chance or external factors. Attribution theory also influences motivation, linking successes and failures to four key determinants: ability, luck, effort, and task difficulty. Upon experiencing success or failure, people first seek reasons for the outcome, then form conclusions, and finally assess the likelihood of future success or failure. The causes are categorized based on their locus within the person or the environment. Internal factors are considered personal, while external factors are environmental. This categorization was further expanded to include stable and variable factors. Teachers often attribute student achievement to ability, effort, task difficulty, and luck (Tirri & Nokelainen, 2010). Notably, while both "ability" and "effort" are internal attributions, they differ in stability. Ability and task difficulty are seen as stable, while effort and luck are viewed as unstable. A teacher who ascribes a student's success to inherent ability may hold higher expectations for them, while associating success with effort might imply concerns about future consistency in performance due to its perceived instability (Riley, 2014).

Teacher's interactions with a student can shape the student's self-perception. Georgiou et al. (2002) noted that teachers were more empathetic and less frustrated with students when low performance was linked to inherent ability, seen as a fixed trait. Conversely, they displayed more irritation when poor results were attributed to a lack of effort (controllable by the student). Consequently, students perceiving their shortcomings as due to innate ability might feel despondent, given its perceived permanence. In contrast, if students believe their achievements result from effort, they may become uncertain about their innate capabilities (Shaukat et al., 2010).

2.2. Gender stereotypes in teacher perceptions

Numerous studies corroborate that educators often discern the mathematical aptitudes of male and female students through different lenses. Specifically, teachers tend to perceive average-ability girls as less gifted in math compared to their male peers (Copur-Gencturk et al., 2020; Tiedemann, 2002). Moreover, they believe girls must exert more effort to reach a similar mathematical proficiency as boys (Tiedemann, 2000; Turska & Oszwa, 2018). The extent of a teacher's stereotypical mindset plays a pivotal role. Educators leaning heavily on gender stereotypes view math as less consequential for girls' futures compared to boys. They perceive boys' mathematical prowess as inherently valuable and advantageous for future endeavors (Tiedemann, 2002; Turska & Oszwa, 2018). This mindset further colors their attribution of students' success in math. Teachers entrenched in these stereotypes often credit girls' successes to effort, whereas boys' achievements are ascribed to innate abilities (Tiedemann, 2002; Turska & Oszwa, 2017). Interviews with educators mirror these findings, a prevalent sentiment among teachers is the association of girls with humanities and social sciences and boys with exact science. Such educators maintain that boys inherently possess higher mathematical abilities, ideational flow, and problem-solving creativity (Gajda et al., 2022).

2.3. Teaching strategies and creativity

The teaching strategies employed by the teacher are also of significant importance. Lou et al. (2012) emphasizes that educators, when engaged in innovative instruction, can tap into their utmost potential, provided they have a profound grasp of their subject. Furthermore, inventive teaching methodologies have been associated with enhancements in students' academic growth, competence, and overall learning outcomes (Richards, 2013). Such innovative pedagogy not only stimulates students' creative processes (Rosyidi et al., 2022) but also directly enhances their motivation to learn. In their innovative pedagogical endeavors, educators' inventive instructional techniques, offer illustrative examples, instill essential values, and curate an environment conducive to learning (Andi & Selamat, 2023). The study of Othman et al. (2022) explored the effects of a creative teaching module in STEM education on high school students. The module, focusing on energy literacy and sustainability education, included outdoor activities led by two science teachers, based on the directed creative process model incorporating constructivism, discovery inquiry, problem-based, and project-based learning strategies. Results indicated that these approaches increased students' interest in STEM, enhanced creativity, and problem-solving skills (Othman et al., 2022). Also, engaging in project-based courses affect student perceptions of STEM skills, perceptions of the utility value of participating in STEM courses, and STEM career aspirations (Beier et al., 2019).

Creativity is understood as a potential for future creative work which can manifest in particular ways of perceiving and solving problems (Craft, 2005; Runco, 2003) and is associated with both cognitive components (creative skills) and personal-motivational factors (Urban, 2005). The classic approach ties creativity with, among others, divergent thinking, which consists of three partial abilities – namely, fluency, flexibility, and originality of thinking as well as sensitivity to problems (Guilford, 1978) and the ability to refine ideas or elaboration (Torrance, 1962). Its' role in the planned study is focused on three areas related to (i) creative teaching (teacher creativity and creative teaching strategies), (ii) positive association with learning (students' creativity and its role in learning and developing STEM preferences), (iii) reducing stereotypical thinking (the relationship between cognitive fluidity and personality factors with lower levels of stereotypical thinking).

Creativity in education extends to the adoption of transformative strategies, methods, and practices, all aimed at bolstering students' academic achievements (Ghanizadeh & Jahedizadeh, 2016). Recent studies have increasingly underscored a significant correlation between the creativity manifested by educators through innovative educational strategies and heightened student engagement in the learning process (Nurhikmah et al., 2022). The recognition of one's creative capabilities within a specific realm, such as creative self-efficacy in mathematics, is intricately linked with outcomes in mathematical achievement (Gajda, Weremczuk-Marczyńska, 2025 in press), mathematical creativity (Bicer et al., 2020), and overall success in STEM disciplines (Wingard et al., 2022). In this context, the creativity of educators plays a pivotal role. The inventive approaches and strategies employed in the teaching process substantially influence student motivation and interests. A crucial aspect of mathematics education is the development of students' capacity for divergent thinking, innovative problem-solving, and the establishment of novel concept linkages. This process necessitates the cultivation of a learning environment that not only encourages risk-taking and supports inquiry-based learning but also emphasizes the importance of problem-solving and problem-posing activities. Such an environment fosters the growth of students' creative abilities in tandem with traditional mathematical competencies (Cox, 1994; Haylock, 1997). Creativity in mathematics education highlights the cross-disciplinary nature of mathematics, showing students how mathematical concepts apply in various real-world contexts and other subject areas (Williams et al., 2016). Both mathematics and creativity involve a high degree of problem-solving skills. Creative approaches in mathematics education encourage students to explore multiple solutions to problems, fostering innovative thinking. Moreover, mathematics requires abstract thinking, a skill closely related to creativity. Creative teaching strategies in mathematics help students visualize and conceptualize abstract concepts, making them more accessible and understandable (Krutetskii, 1976). Both mathematics and creativity demand the development and use of higher-order thinking skills such as analysis, synthesis, and evaluation. By integrating creative strategies in mathematics education, these skills are honed, preparing students for complex problem-solving in various contexts (Anderson & Krathwohl, 2001). The emerging branch of research on creativity and stereotypes confirms that it can be used to reduce stereotypical thinking by promoting stereotype-confronting thinking (Groyecka-Bernard et al., 2021). Processes such as cognitive flexibility, openness to experience, and perspective taking, which are common correlates of low prejudices, promote creativity and diminish stereotypes (Groyecka, 2018). Encouraging creative thinking can also disrupt the dependency on stereotypes and boost creativity, leading to decreased use of stereotypical thinking (Tan et al., 2022).

3. STUDENT CHARACTERISTICS

3.1. Gender, motivation, and creative self-efficacy

The "gendering" of scientific fields identified by teachers and behaviors manifested by students set off a chain reaction. Boys are more likely to have more favorable attitudes towards school science than girls, a pattern observed in all education systems and also corroborated by more recent studies (Wang & Degol, 2017; DeWitt et al., 2013). Attitudinal differences are the cause of gender differences in the selection of post-compulsory science study. A notable worry is the underrepresentation of women in science studies, which leads to potential talent losses in the workforce and highlights gender-based inequalities in opportunities (Bell, 2009). Despite efforts, the share of women in fields related to science continues to decline at subsequent levels of education and career stages, as indicated by the results of Polish (PARP, 2020) and international research (Makarova et al., 2019). Several reasons have been proposed for women's underrepresentation in STEM, ranging from biological differences, poor science attitudes from childhood, a lack of female role models, to science curricula not resonating with girls and cultural pressures aligning with traditional gender roles (Archer et al., 2013). Even in countries where girls outperform boys academically, like the UK, Ireland, and the US, gender remains a determining factor in choosing advanced physics as a major field (Gill & Bell, 2013). Early research depicted science enthusiasts predominantly as male, leading many students to associate STEM fields with males (Mendick, 2005). Recent cross-national studies still show gender playing a decisive role in STEM preferences, with females leaning towards medical or biology careers and males towards engineering (Sikora & Pokropek, 2012). Also, students with a robust science self-concept are more inclined to continue in the field, but girls often have a lesser self-concept in science, potentially influenced by inadequate acknowledgment of their achievements in the field (DeWitt et al., 2013).

In the realm of educational decision-making, the concept of self-efficacy, as elucidated by Albert Bandura, emerges as a pivotal factor, transcending mere cognitive abilities. Bandura's theory postulates that self-efficacy is forged through four primary sources: personal accomplishments, emotional states, verbal persuasion, and vicarious experiences. While educators wield significant influence over the first two aspects through evaluative feedback and task selection, the latter two pathways, often underexplored, play an equally crucial role in molding educational aspirations, particularly in the STEM fields. Self-efficacy beliefs may condition the pursuing or avoiding of certain behaviours. A high level of self-efficacy, associated with greater persistence in achieving the goal, lowers the inhibitions and fears associated with a specific action. Academic self-efficacy also varies depending on the students' gender and field. Boys usually have higher self-perceptions in mathematics than girls (Turska & Oszwa, 2018), while girls are superior to boys in language self-perceptions (Jacobs et al., 2002).

Creative self-efficacy includes various categories such as creative confidence beliefs, self-awareness, and self-image (Karwowski et al., 2019). Creative confidence beliefs refer to one's ability to think and act creatively in different activities (Karwowski et al., 2019). This encompasses a creative self-concept and self-efficacy. Bandura (1997) defines creative self-efficacy as the belief in one's ability to generate new and valuable ideas, products, or behaviors (Beghetto, 2006) and complete creative work (Tierney & Farmer, 2002). Unlike creative self-concept, which is tied to self-esteem in creative thinking and actions (Karwowski & Lebuda, 2016), creative self-efficacy focuses on the belief in potential success (Choi, 2004). A high degree of creative self-efficacy often correlates with greater creative achievements (Tierney & Farmer, 2002) and acts as a motivational mechanism for creative activities (Liu et al., 2016). It influences commitment and persistence in creative endeavors (Haase et al., 2018). People with high creative self-efficacy view tasks requiring creative thinking as interesting and doable (Liu et al., 2016), while those with low self-efficacy may doubt their chances of success and lose interest (Karwowski & Barbot, 2016). Creative self-efficacy is shaped by socio-cognitive and environmental factors, including mastery experiences, vicarious experiences, social persuasion, and physiological responses related to creative activities. Significant creative experiences and feedback from influential figures like teachers and parents enhance one's belief in their creative abilities (Bong & Skaalvik, 2003). These mechanisms link creative self-efficacy with both creative performance and achievements (Liu et al., 2016) as well as creative potential (Haase et al., 2018). According to Bandura's socio-cognitive theory (1997), self-efficacy should be analyzed in the context of specific tasks. Since individuals differ in their skills across various domains (Bandura, 2006), research on students' creative self-efficacy often focuses on classroom settings, including areas like math and language (Karwowski et al., 2015). This approach is particularly relevant in educational research, where these subjects are predominant.

3.2. Expectancy-Value Theory as applied to students' motivation

The desire to learn science is also strongly connected to the value assigned to it. In this context, the Expectancy-Value Theory of Motivation (EVT) (Eccles & Wigfield, 2002) appears to be the most appropriate. Primarily developed by Jacquelynne Eccles and her colleagues in the 1980s, this theory has been influential in understanding how individuals' expectations of success and the value they place on a task influence their motivation to engage in that task. This theory suggests that a person's motivation to engage in a task is determined by two key factors: Expectancy which refers to an individual's belief about how well they will do on an activity or task, and Value which encompasses the individual's perceived value or importance of the task. Value can be broken down into different components: Intrinsic value: The enjoyment or interest a person finds in doing the task; Utility value: How useful or relevant the task is in terms of meeting current or future goals; Attainment value: The personal importance of doing well on the task, often tied to a person's identity or personal standards and Cost: This isn't a value component per se, but it represents the perceived negatives associated with engaging in the task. It includes considerations like time investment, emotional stress, and potential lost opportunities for engaging in other activities. This theory is particularly useful in educational settings for understanding why students might choose to engage more in certain subjects or activities over others. For example, a student might be highly motivated to study mathematics if they believe they are good at it (high expectancy) and see it as important for their future career (high utility value), even if they don't find the subject intrinsically enjoyable. Though Expectancy-Value Theory (EVT) is a broad motivational theory applicable to all domains of academics, its application has been particularly prominent in STEM research. In this context, EVT posits that students' views and the value they attach to STEM disciplines significantly influence their choice of enrolling in courses. Those with greater expectancies and attributed value toward mathematics and science show an increased propensity to select STEM-related majors

(Fong et al., 2021). The perception of value and expectancy within STEM fields is shaped by a confluence of factors, including individual background, educational context, and gender (Appianing & Van Eck, 2018). The case of female students is particularly telling; their valuations and expectations in STEM are critical indicators of their motivation and persistence in these domains (Zucker et al., 2021). As mentioned above, research on Expectancy-Value Theory (EVT) has extensively examined the factors influencing gender differences in STEM education, highlighting the importance of motivation, cultural contexts, and gender stereotypes. Despite the global focus, there is a notable gap in such studies within the Polish context. This underscores the need to implement similar research in Poland, where traditional gender roles and conservative views on academic domains persist (Gajda et al., 2022; Malisz, 2021).

One significant study by Guo et al. (2015) utilized EVT to explore the relationship between mathematics motivation (academic self-concept and task values) and student background variables in predicting educational outcomes. Using latent-variable models with latent interactions, they found that boys and girls exhibited similar levels of math self-concept and values. However, girls achieved higher in mathematics and had greater educational aspirations. Interestingly, the study also revealed that family socioeconomic status was more strongly linked to educational aspirations for boys. These findings highlight the complex interplay between gender, socioeconomic background, and educational outcomes, affirming the robustness of EVT across diverse contexts. Building on the importance of cultural context, Hu et al. (2019) investigated the role of national culture in shaping student mathematics motivation and achievement. Their study analyzed PISA 2012 data from 418,498 students across 52 countries, employing multilevel path analysis to account for student, school, and country-level influences. They found that cultural dimensions such as uncertainty avoidance and long-term orientation were associated with lower student motivation but not necessarily lower achievement. This emphasizes the mediating role of motivation in the relationship between culture and educational outcomes. The study underscores the necessity of considering cultural factors in educational research and demonstrates the applicability of EVT in explaining motivational differences across varied cultural settings. Further extending the discussion on social influences, Henschel et al. (2023) examined how gender stereotypes held by students, parents, teachers, and classmates affect students' mathematics motivation and anxiety. Their analysis of data from the German Trends in Student Achievement study revealed that gender stereotypes significantly influenced students' self-concept, interest, and anxiety, with distinct differences between boys and girls. The study found that parents' stereotypes had a notable impact on girls' motivation, while classmates' stereotypes affected both boys' and girls' motivational outcomes, highlighting the importance of addressing social influences in educational settings.

Despite comprehensive international studies, Poland remains under-researched in this domain. Traditional views often steer girls towards humanities and boys towards sciences, reinforcing gender disparities in STEM fields. Hanson and Krywult-Albańska's (2020) study focus on gender and access to STEM education and occupations in Poland within a cross-national context. While Polish girls perform well in secondary STEM education, they are significantly underrepresented in STEM occupations. Socio-economic factors as well as, cultural, and political factors specific to Poland, such as GNP, gender inequality, and religion, impact these trends. The authors highlight the unique challenges faced by Polish women in STEM, emphasizing the need for targeted research and interventions. Addressing these stereotypes through focused research can inform interventions aimed at promoting gender equity in STEM education. The lack of studies employing multilevel analysis and EVT to explore gender differences in Poland represents a significant gap in understanding the unique cultural and educational dynamics at play. Conducting such research in Poland is crucial for several reasons. Firstly, it can provide valuable insights into the factors influencing STEM participation and achievement among Polish students. Secondly, findings from this research can inform policymakers and educators about effective strategies to mitigate gender disparities in STEM, leading to more inclusive educational practices. Lastly, given Poland's conservative views on gender roles and academic domains, this research can contribute to changing perceptions and encouraging a more balanced approach to STEM education for both boys and girls.

4. EDUCATIONAL AND PEER CONTEXT

Studies indicate that attitudes towards science tend to wane with age, especially in high school, with favorable views on school science significantly diminishing from the age of 10 (Bennett & Hogarth, 2009). While George (2006) confirms this trend among American middle and high school students, other research suggests that attitudes towards STEM don't necessarily deteriorate during secondary education (DeWitt et al., 2013). Nevertheless, it's clear that positive early attitudes towards science correlate with later science participation, with preferences at 14 predicting subject uptake in areas like Biology and Physics (Lamb & Ball, 1999). Notably, early formation of career aspirations in science, as early as 13, emphasizes the necessity of engaging students well before their subject choices (Tytler & Osborne, 2012). Students often select university courses based on subjects they enjoyed and excelled at in school, with a notable correlation between enjoyment and interest in pursuing the subject further. Their choices in STEM-related fields are greatly influenced by their subject teachers and parents. By year 10, 60% of students have a general idea of their field of study, but most decisions about a specific degree (80%) and university choice (73%) are made between years 11 and 12, emphasizing the importance of secondary STEM engagement activities during these years (Dawes et al., 2015).

Student's interest, engagement, and performance in STEM subjects can be also significantly influenced by their peers. Students are more likely to develop an interest in STEM subjects if they are surrounded by peers who value and are engaged in these subjects. If a peer group places a high value on academic achievement in STEM, this can positively influence the academic efforts and outcomes of its members (Raabe et al., 2019). Peers can also influence students' future aspirations related to STEM fields. Exposure to peers who are interested in pursuing STEM careers can inspire similar aspirations in others (Denworth, 2019). Gender stereotypes in STEM can be perpetuated or challenged by peer groups. For instance, girls might be more inclined to pursue STEM if they have female peers who are engaged in these subjects, countering the traditional gender stereotypes (Cheryan et al., 2017; Wang & Degol, 2017). Conversely, the feeling of connection that female students has with their peer group does not show a relationship with their success in earning a STEM degree. In the context of selecting STEM fields that are heavily focused on mathematics, a stronger feeling of belonging to peers is inversely related to the achievement of a degree in such math-intensive STEM fields (Luo et al., 2022). The planned study will provide new insights into how gender stereotypes in STEM, as discussed by Cheryan et al. (2017) and Wang and Degol (2017), are either perpetuated or challenged within peer groups. This is particularly relevant considering the inverse relationship found between peer belonging and achievement in STEM degrees among females.

While some studies highlight a waning interest in science among older students, others like DeWitt et al. (2013) suggest that attitudes towards STEM might not necessarily deteriorate. This inconsistency points to a need for more nuanced understanding of how attitudes evolve across different age groups and educational settings. The role of peers in shaping STEM interest and aspirations is acknowledged but not deeply explored. Especially, how peer dynamics interact with gender stereotypes in STEM is an area ripe for detailed investigation. While the influence of gender stereotypes on STEM engagement is recognized, there is limited understanding of the mechanisms by which these stereotypes are perpetuated or challenged within peer groups, particularly in a school setting.

5. FAMILY ENVIRONMENT

Parental influence, manifested through attitudes, beliefs, and behaviors, critically molds students' motivation and choice to pursue STEM subjects (Aleksieva et al., 2021; Craig et al., 2021). Students whose mothers have attained an intermediate level of education exhibit greater interest in science, technology, engineering, and mathematics (STEM), including architecture and technology, as per Sáinz and Müller (2018). As facilitators, parents endorse STEM disciplines by embodying role models, thus making these fields accessible and desirable (Sjaastad, 2012). Despite their integral role, disparities in encouragement, particularly for girls, remain evident (Lloyd et al., 2018). Parental involvement is recognized as pivotal for fostering STEM aspirations, which can be fortified through initiatives designed to augment parents' self-efficacy and perceived utility of STEM (Šimunović & Babarović, 2020). When it comes to expectances, parents exert a significant impact on their children's science achievements that surpasses the children's own beliefs in their science capabilities. Evidently, parents play a crucial role in their children's success in science. It appears that, especially in elementary science, parents have a greater influence than teachers on children's personal expectations and their success in achieving these goals (Sáinz & Müller, 2018). Moreover, girls are often victims of low parental expectations and personal belief in their abilities, especially in STEM fields. This leads them to choose humanities/social sciences over technical/scientific studies despite having potential or interest in the latter. Trusz (2015) on the other hand, found that boys who chose humanities and social sciences—furthermore, in spite of the stereotypically feminine nature of those subjects—were likely to make their choices in line with high parental expectations. This suggests that in such cases, the alignment between parental attitudes and students' decisions can facilitate a coherent academic identity, even if the chosen discipline is less typical for their gender.

Students' decisions regarding STEM education are also intricately linked to SES, which, albeit indirectly, influences their perceived capabilities and available opportunities (Blenkinsop et al., 2006; Thomson & De Bortoli, 2008). Higher SES often equates to greater exposure and access to different learning resources, positively correlating with enrollment in STEM disciplines (Bottia et al., 2022). Conversely, students from lower SES brackets may exhibit risk-averse tendencies, constraining their pursuit of STEM majors due to concerns over future financial stability (Sovansophal, 2020). The interplay of SES with other demographic factors, such as gender, further nuances the landscape of STEM participation (Niu, 2017). Cultural factors, including family values and attitudes, further delineate the likelihood of choosing STEM, with conservative sociocultural backgrounds correlating with increased STEM engagement among male students (Osikominu et al., 2020).

6. CONCLUSION

This article presents a theoretical model that both outlines and hypothetically addresses significant gaps in our understanding of students' educational choices in STEM fields. While the model is not empirically grounded, it represents a conceptual map that synthesizes very established theories to propose new research avenues. While previous research, as highlighted by Mujtaba and Reiss (2012) and Cerini et al. (2003), acknowledges the significant role of teachers in student learning, comprehensive studies examining the precise ways in which teacher beliefs and behaviors influence STEM engagement remain scarce. By incorporating Weiner's attribution theory (1985), this model offers a fresh perspective on how teachers' perceptions of student success can shape academic aspirations, an aspect that has received limited attention in prior studies. Furthermore, it contributes to the understanding of gender stereotypes in STEM education, building on insights from Copur-Gencturk et al. (2020) and Tiedemann (2002), which suggest that such biases may significantly skew students' academic choices, particularly for female students. Additionally, the inclusion of innovative pedagogical approaches, as proposed by Ghanizadeh and Jahedizadeh (2016) and Lou et al. (2012), introduces a unique dimension to the model. By emphasizing the role of creative teaching strategies, the framework highlights how innovative instructional methods can foster student engagement and stimulate interest in STEM disciplines.

The theoretical foundations of the model borrow from existing theories, including Weiner's attribution theory, Bandura's self-efficacy theory, and Eccles and Wigfield's Expectancy-Value Theory. These have been extensively applied to describe educational decision-making. The novelty of the suggested model lies in its integrative framework, which brings these together with the theory of creative self-efficacy and points out their intersection with gender and socio-cultural factors in the STEM context. By synthesizing this body of research, the model presents a novel vision for guiding ensuing empirical inquiry. Building on this foundation, the proposed theoretical model embarks on an innovative exploration of the intricate interplay between student gender, creative self-efficacy in mathematics, and motivation, and how these elements collectively shape STEM-related educational preferences. Expanding upon Bandura's concept of self-efficacy, the model extends its application to the domain of creative self-efficacy in mathematics, examining its intersection with gender within the STEM education landscape. While self-efficacy has long been recognized as a key determinant in educational decision-making, the specific role of creative self-efficacy in mathematics—and its nuanced interaction with gender dynamics—remains an underexplored yet crucial area of inquiry. Furthermore, the model integrates the Expectancy-Value Theory of Motivation to provide a deeper understanding of how students' beliefs and perceived value of STEM disciplines influence their academic choices. By addressing both expectancy (students' beliefs about their likelihood of success) and value (the perceived importance or usefulness of STEM subjects), this framework offers a more comprehensive perspective on the motivational mechanisms underlying STEM engagement.

Additionally, this theoretical model sheds light on the role of peer groups in either reinforcing or challenging gender stereotypes in STEM. Understanding these social dynamics could provide valuable insights into how group interactions shape students' long-term educational trajectories. By incorporating diverse attitudes toward STEM across early and late adolescence, the model proposes potential points of intervention where educational strategies may be most effective in fostering gender equity and broadening participation in STEM fields.

While parental influence is widely acknowledged as a key factor in shaping children's STEM choices, there remains a significant gap in understanding how this influence varies depending on the child's gender—particularly in terms of parental expectations and beliefs about their children's abilities in STEM subjects. Although existing research highlights the role of cultural factors and family values in guiding STEM-related decisions, a detailed examination of how these elements interact and influence students' academic trajectories is still lacking. The proposed theoretical model addresses this gap by considering the differential impact of parental attitudes, expectations, and behaviors on boys' and girls' aspirations and choices in STEM. By adopting a more nuanced perspective, this framework allows for a deeper exploration of the gendered dynamics of parental influence, offering insights into how these perceptions shape students' academic self-concept and long-term career aspirations. Moreover, this broader approach facilitates an analysis of the interplay between cultural and family values in shaping STEM choices. Specifically, it examines how these factors interact with both gender and socioeconomic status (SES) to influence students' decision-making processes. Understanding these complex interconnections is essential for developing targeted interventions aimed at reducing gender disparities in STEM participation and fostering a more inclusive educational environment.

Finally, by emphasizing the impact of creative skills on students' interest in STEM subjects, this model offers a deeper understanding of the relationship between creativity and educational choices, addressing a critical gap in current academic discourse. It highlights the importance of exploring the effectiveness of creative teaching strategies and their potential to enhance student engagement and motivation in STEM fields. Moreover, by drawing attention to the role of creative thinking in challenging and dismantling stereotypes within STEM education, the model opens new perspectives on fostering diversity and inclusivity in these disciplines. This is particularly relevant considering ongoing efforts to reduce gender and cultural biases that continue to shape STEM participation. Additionally, examining the relationship between creative self-efficacy and STEM achievement could provide valuable insights into how students' confidence in their creative abilities influences both their academic performance and their willingness to pursue STEM-related careers. By integrating creativity as a key component of STEM education, this framework underscores the potential of innovative pedagogical approaches to broaden participation and cultivate a more equitable learning environment.

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