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Article

Evaluating didactic strategies for teaching mathematics: A Policy–Driven approach to gender equity in Panama's education system

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Abstract: This article evaluates the Didactic Strategies for Teaching Mathematics (DSTM) program, designed to enhance the teaching of mathematical content in primary and secondary education in a hybrid modality. In alignment with SENACYT's Gender-STEM-2040 Policy, which emphasizes gender equality as a foundational principle of education, this study aims to assess whether initial teacher training aligns with this policy through the use of mathematical strategies promoting gender equality. A descriptive-correlational approach was applied to a sample of 64 educators, selected based on their responses during the training, with the goal of improving teaching and data collection methodologies. Findings indicate that, although most teachers actively engage in training, an androcentric approach persists, with sexist language and a curriculum that renders girls invisible, hindering the fulfillment of the National Gender Equality Policy in Science, Technology, and Innovation of Panama (Gender-STEM Policy 2040). Additionally, through a serendipitous finding, a significant gap in student activity levels, especially in secondary school, was discovered. While in primary school, activity levels were similar between genders, a decline in active participation among girls in secondary school was observed. This discovery, not initially contemplated in the study's objectives, provides valuable insights into gender differences in active participation, particularly in higher educational stages. The serendipity suggests the need for further exploration of social, environmental, and family factors that may influence this decrease in girls' active participation. The article concludes with a preliminary diagnosis and a call to deepen gender equality training and the effective implementation of coeducation in Panama's educational system.

Keywords: coeducation; gender perspective; training; mathematics education; equality; serendipitys

1. Introduction

Education serves as a means to produce, reproduce, and legitimize culture and power relations (Bourdieu and Passeron, 1996; Croizet et al., 2019). According to Domina et al. (2017) and Gómez (2015), inequalities persist and are even encouraged within schools, yet possibilities for social change and improvement also emerge. In this regard, Panamanian society has made significant progress in gender equality over the past decades through educational legislation that mandates equality in educational centers. However, this perspective has not yet permeated all areas and institutions, especially in education. Pasalagua and Durán (2023) acknowledge that educational spaces construct inequality towards women throughout their institutional life.

As Štech (2006) points out, the mathematics taught in schools is an overly abstract exercise used to classify students as talented (boys) or not talented (girls) and lacks strategies useful in their daily lives. This negatively impacts the school's role as a socialization agent, affecting its contribution to the development of psychological functions and, more importantly, to the development of children's personalities.

Vite et al. (2018) assert that power relations prevail in the teaching of mathematics at the higher education level, claiming that pedagogy sides with patriarchal hegemony. Gender roles that view women as less academically successful and less likely to complete university studies in exact sciences predominate in interactions between teachers and students.

Teachers tend to address men more during class, leading to lower participation from women. Consequently, there is less recognition, encouragement, or feedback that could foster confidence and self-esteem in women. The study concludes that women who excel in mathematics are often considered merely lucky, and when they achieve academic success, they still face insecurity due to being perceived as unattractive, boring, and unappealing.

Statistics highlighted by Ordorica (2015) confirm that in higher education, women are enrolled in social sciences, health areas, administration, and business, while fewer are in engineering, construction, and manufacturing, where the population is predominantly male. In basic education, science teachers prefer interacting with boys, while girls take on the role of spectators (Falkenheim and Alexander, 2023; Hickey and Cui, 2024; Silva-Martínez et al., 2023; Vite et al., 2018; Wang and Yu, 2023).

These historical inequalities can be understood because girls have been culturally taught their place in the world: female subordination. Public policy and the gender agenda promoted by UN Women and the United Nations Global Compact align in principles and practices that drive women's empowerment (UN WOMEN, 2018). An important achievement for empowering girls is to ensure their participation, confidence, achievements, and recognition in learning mathematics.

Following this line, Hernández et al. (2020) affirm that teachers' challenges must extend beyond the classroom, where their role is to construct learning. However, technological advancements, the growth of online content, and advances in cognitive science have combined to challenge traditional educational paradigms. Consequently, teachers have a significant impact on equality because their job is to educate the younger generation. Thus, it is imperative to prepare future teachers in a way that pursues and transmits justice, democracy, and quality education.

The Panamanian state has developed various measures to help reduce inequality between men and women, such as Law No. 4 of 29 January 1999, "Which establishes equality of opportunities for women". On 23 December 2008, the National Institute for Women (INAMU) was created by Law No. 71, aiming to formulate and implement the National Policy of Equality of Opportunities for Women according to its objectives, attributions, and functions. However, almost a decade later, Asián et al. (2015) still warn about the gap between theory and practice on this issue.

This article explores how survey CBUP/448/2021 can help identify strategies to empower Panamanian girls in mathematics knowledge and application within the framework of Panama's National Gender Equality Policy in Science, Technology, and Innovation (SENACYT/UNDP, 2023). While the survey initially focused on assessing family competencies in hybrid math education, unexpected patterns emerged, revealing significant differences in the perception and participation of boys and girls. These findings suggest variations in family support, motivation, and social interactions, indicating gender-based behavioral differences.

Notable patterns related to gender differences were observed. In analyzing family responses (item 36), it became evident that the level of support provided to children varies by gender, highlighting distinct familial backing for boys and girls. This finding underscores the influence of family context on perceptions of children's abilities, providing valuable insights to refine educational support strategies. Additionally, indicators of autonomy and motivation (items 17, 18, and 29) revealed that boys and girls develop skills and demonstrate motivation differently in a hybrid learning environment, opening new perspectives on adapting educational approaches to each group's specific needs.

Furthermore, the results suggest that the hybrid model may influence boys' and girls' social and academic interactions differently (item 30), emphasizing the importance of designing more inclusive educational strategies that address their distinct experiences. These discoveries not only inform the development of parental training programs that consider gender nuances in hybrid learning but also hold significant ethical value. The data collection methodology strictly safeguarded participant confidentiality, and these findings offer a promising path to enhance inclusive mathematics education without compromising privacy or participant rights.

Therefore, this study is important from a gender perspective as it reveals inequalities in access to mathematics education for both girls and boys and how to generate processes of change in teaching practice for gender equality and empowerment in learning mathematics, a discipline that has been predominantly male.

At the core of this discourse lies a critical call for action. It urges stakeholders to transcend mere rhetoric and actively bridge the gap between policy intent and on-the-ground implementation. This necessitates not just structural reforms within educational systems, but a concerted commitment to challenge entrenched stereotypes and cultivate a nurturing learning environment conducive to the holistic development of all students, regardless of gender. As we navigate this terrain, collaborative efforts among policymakers, educators, and communities emerge as paramount Through such collective endeavors, meaningful strides can be taken towards realizing the transformative potential of education as a catalyst for societal change and genuine gender equality

2. Theoretical framework

The theoretical reference for this follow-up work is the Didactic-Mathematical Knowledge model of the mathematics teacher, known as the DMK model (Breda et al. 2018; Breda, 2020; Breda et al., 2021; Ledezma et al., 2024). This is based on constructs from the Ontosemiotic Approach-OSA (Godino, 2009; Pino-Fan et al.,

2018) with analytical tools from the gender perspective. The study will reveal inequalities in mathematics teaching, to problematize the exercise of power from roles and stereotypes stemming from patriarchal culture.

The gender perspective is for everyone and in all areas, implying an ideological break. Its premise is to show evidence of the conditions of men and women and the place they occupy in the field of mathematics in the school space. This can be interpreted from the construction of gender as a culturally indissoluble binary system (sex-gender), as a social construct in which attributions are assigned simply for being a man or a woman. Historically, the gender mandates that women must fulfill have been linked to their sexuality and maternity: life givers, caretakers of others, plants, the earth, animals, but less so of themselves. Conversely, the dichotomous and exclusive mandate for men establishes them as providers, operators in the public space, decision-makers, power exercisers, and owners of the earth's resources, including women's bodies. These backgrounds are codes that discipline us and reproduce inequality in the access and exercise of women's rights, mainly for this study, in access to scientific education and women's empowerment.

Empowerment is understood as the process in which women take control of their lives and set their own agendas, have the capacity to solve problems and decide on their resources and means in addition to developing self-management. Therefore, the gender perspective goes beyond an analysis tool. It not only seeks to unveil inequalities but aims and provokes a transformation of the school culture so that more and more girls and adolescents can access emancipatory mathematical knowledge that —for centuries of history- have been excluded from the margins of the mathematical discipline.

This is due to the need to visualize each girl/woman's own perspective and make this vision a reality. It's important to consider the vision or perception of the "self" and, according to Rogers (1985, cited in Sandoval (2013)), the "self" consists of different perceptions, established in a specific context in relation to herself and the social environment, assigning a specific value to her actions, values, and thoughts, giving direction to each woman's life project (Wang and Yu, 2023). Therefore, studying this cognition related to the empowerment process is very effective for understanding the relationship between her thoughts and values to guide them towards STEM professional training. Empowerment will have to call for participation, a sense of achievement, recognition, and confidence in girls learning mathematics.

OSA is based on a systemic-ecological model (Morin, 1977) that integrates the above components with environmental, physical, and social aspects (Maturana and Varela, 1984); a mathematical knowledge model based on semiotic elements (Eco, 1976); community-based instructional models (Brousseau, 1998), and epistemological models with a mathematical basis, based on anthropological/social perspectives (Chevallard, 1992; Radford, 2006).

Given the results of previous training studies, the use of instruction is validated by the teacher's acquisition of technical mastery, evidenced during the implementation of virtual training. This can be recognized in the submission of tasks through forums and email, based on the mathematical-didactic knowledge developed from DMK-OSA (Godino, 2009). This approach has allowed for the evaluation of teachers' professional competencies and the identification and development of different types of teacher knowledge (Pino-Fan et al., 2018). In particular, the use of the Recognition Guide for Objects and Meanings contributes to the didactic analysis of teaching and learning processes (Font et al., 2015).

All of the above allows us to respond to the objectives proposed in this research work on training models. This is synthesized in a scheme (**Figure 1**), which is dense and will not be explained in detail here. It is only necessary to mention that in the top right part of the scheme, we have some of the theoretical tools developed in the ontosemiotic approach to perform an analysis of mathematical activity in the teaching and learning processes of mathematics (Font et al., 2022).

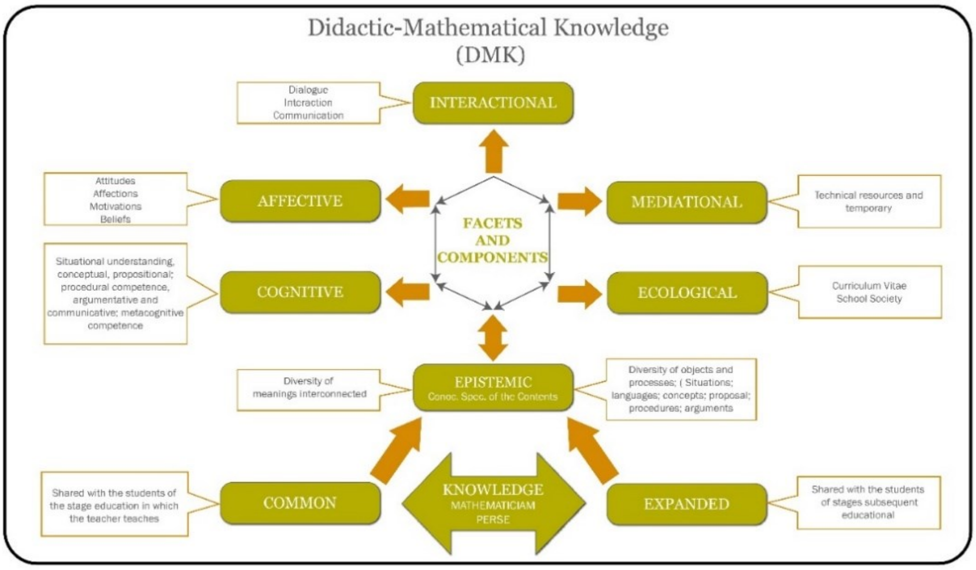

Figure 1. Theoretical tools and components of the ontosemiotic approach for analyzing mathematical activity in teaching and learning.
Facets and components of the teacher's knowledge (Godino et al., 2017).

In the Ontosemiotic Approach, the Mathematical Knowledge Model (MKM) for mathematics teachers was developed (Godino, 2009; Pino-Fan et al., 2015; Pino-Fan et al., 2018). One aspect of this model's development impacted the concepts of knowledge and skills. Moreover, within the framework of OSA, the competencies of mathematics teachers have also been studied (Font et al., 2015; Giacomone et al., 2018; Morales, 2019; Pochulu et al., 2016; Rubio, 2012; Seckel, 2016; Seckel and Font, 2020), highlighting the importance of teacher knowledge in the evaluation and development of skills. These studies led to the creation of a model called Mathematical Knowledge and Competency in Mathematics Teaching (MCKMT Model) (Breda et al., 2017; Godino et al., 2017; Pino-Fan et al., 2017; Rivadeneira et al., 2024).

To integrate a gender perspective into design, it is important to consider how mathematics teachers' competencies and knowledge can influence gender equality in the educational context. Although the provided text does not directly address this relationship, it can be linked through various strategies. These include incorporating gender awareness modules or activities into teacher training to reflect on gender roles in mathematics learning and promote an inclusive environment that challenges gender stereotypes. Additionally, the curriculum design for teacher training can integrate diverse examples and contexts that reflect gender diversity, fostering sensitivity towards the specific experiences and needs of students of different genders in mathematics learning.

Moreover, providing teachers with tools and pedagogical strategies to encourage equitable participation regardless of gender is essential. This may involve active teaching methods that promote collaboration and critical thinking, along with using educational materials that positively represent gender diversity. Lastly, training teachers to recognize and address gender barriers that students may face in mathematics learning, such as a lack of confidence or the internalization of negative stereotypes, can help foster self–esteem and self-efficacy, particularly among marginalized or underrepresented groups in STEM fields. Incorporating these strategies into the design can promote a more inclusive and equitable mathematics education for all students.

Based on these theoretical tools, a typology of knowledge and a typology of competencies have been developed that are connected. How is the idea of competence characterized in this model? Competence is understood as an effective action carried out in a certain context or in relation to content design to achieve a specific purpose. In this scheme (**Figure 2**), you can see a bit about how it is developed and evaluated.

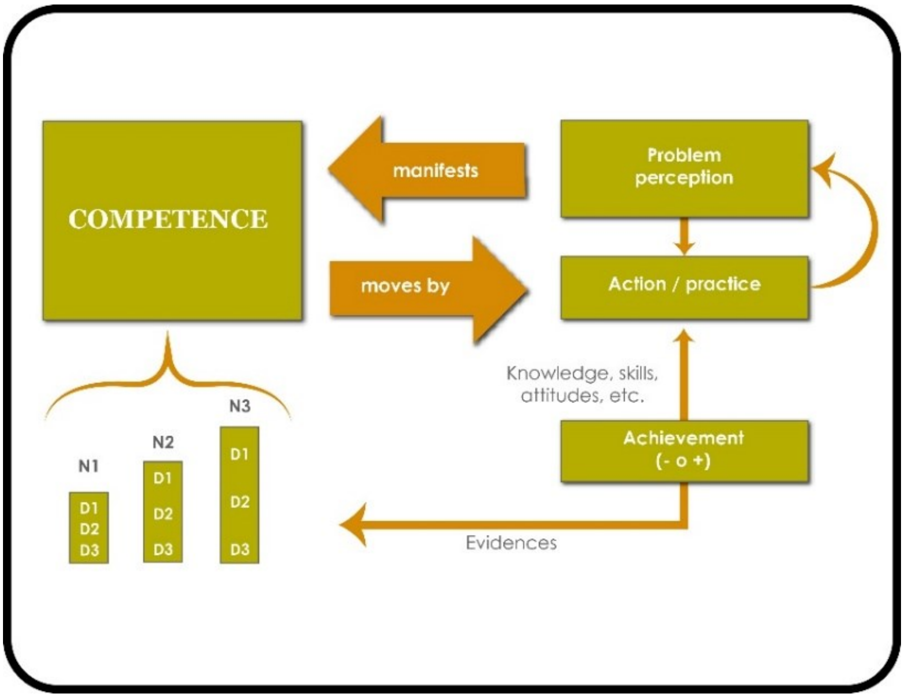

Figure 2. Competency Analysis Components and Didactic Intervention Skills.

When we have competence, for example in problem-solving, it is necessary to characterize it, define a level of development, and establish indicators for each level of development. To develop or assess this competence, tasks must be proposed, which in this case would be problems. Problems activate competencies and can demonstrate the level of competence through actions or practices that solve these tasks.

In the following illustration (**Figure 3**) of mathematical competence and competence in the analysis of mathematical activity, certain knowledge, skills, etc., could be operationalized. The practices resolving these tasks may achieve certain success or not. Based on the success, there is evidence of a specific indicator of a level of development of the competencies. This is the way to understand the concept of competencies.

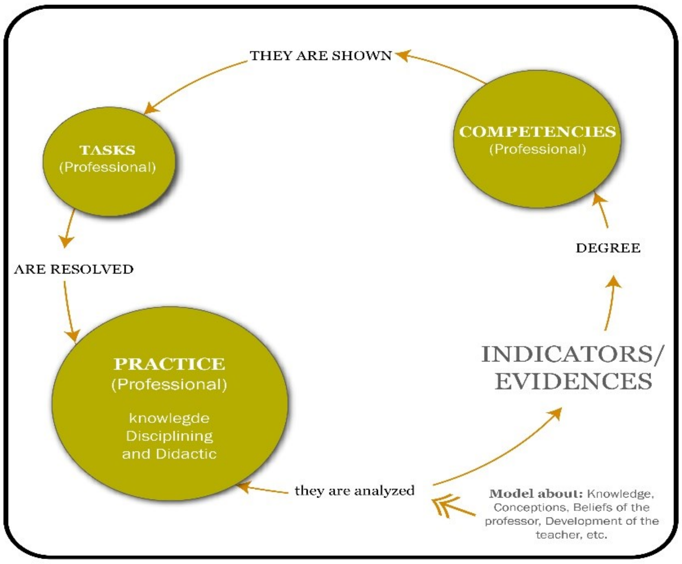

Figure 3. Outline of task process to perform ontosemiotic analysis.

Therefore, when a teacher typically needs to develop competencies, they usually encounter a list of competencies provided by official educational administration documents. These include competencies and sub-competencies, indicators, and levels of development. To address mathematical competence, they need to propose mathematical tasks that showcase and develop mathematical competencies. These mathematical tasks are solved to some extent and involve carrying out a mathematical activity to address the task.

Thus, the teacher must analyze the mathematical activity conducted by the student to find evidence of indicators of some level of competence development. To assess the mathematical competencies of students, teachers must conduct a thorough analysis of the mathematical activities performed by them. This analysis aims to identify evidence reflecting the level of competence achieved by the student.

In this process, the teacher plays two main roles: on one side, they develop and solve tasks, thereby demonstrating their competence in the mathematical discipline; on the other side, they examine the student's work to detect signs of progress in specific competencies, including the ability to analyze mathematical activity. This latter is considered a sub-competency within a broader one, known as didactic intervention competence.

In this educational framework, we emphasize two core competencies: mathematical competence, which pertains to the mastery of the subject matter itself, and competence in analysis and didactic intervention. The essence of the latter, as outlined by Pino-Fan, Font, et al. (2017) involves designing, applying, and evaluating one's own learning sequences and those of others. This is achieved by using didactic analysis techniques and quality criteria to establish cycles of planning, implementation, evaluation, and proposing improvements. This competency is crucial for effectively teaching and facilitating the learning of mathematics. Nonetheless, these fundamental competencies are augmented by a range of general skills that are vital for any educator. These include communication skills, the ability to engage in continuous learning, and digital literacy, among others.

Furthermore, we emphasize specific competencies for mathematics teachers, such as innovation and the initiation of research. To define mathematical competence more precisely, we rely on the framework provided by the Program for International Student Assessment (PISA), which includes seven key sub-competencies, such as critical thinking and the ability to argue. These are essential for the comprehensive development of students in this discipline. The teacher needs to develop tasks and solve them, hence demonstrating disciplinary competence (OECD, 2023).

Regarding the competency of analysis and didactic intervention, which is a key focus of this research work, we characterize it as follows: the ability to design, apply, and assess one's own learning sequences and those of others through didactic analysis techniques and suitability criteria. This process involves establishing cycles of planning, implementation, evaluation, proposing improvements, and teacher monitoring.

3. Material and methods

Figure 4 visualizes the implementation design of the hybrid training program for mathematics teachers. The methodological design of this study follows a mixed-methods approach, combining a descriptive-correlational framework with teacher training strategies and surveys administered to parents and educators. A questionnaire-based instrument was used to collect quantitative data on perceptions and attitudes toward mathematics education, with a particular focus on gender inequalities. This methodology allowed for the identification of behavior patterns and attitudes that reflect gender differences in student participation and performance in the mathematical field, highlighting the influence of social and cultural factors on mathematical education. All participants provided informed consent prior to their involvement in the study, ensuring transparency, ethical considerations, and respect for participants' rights throughout the data collection process.

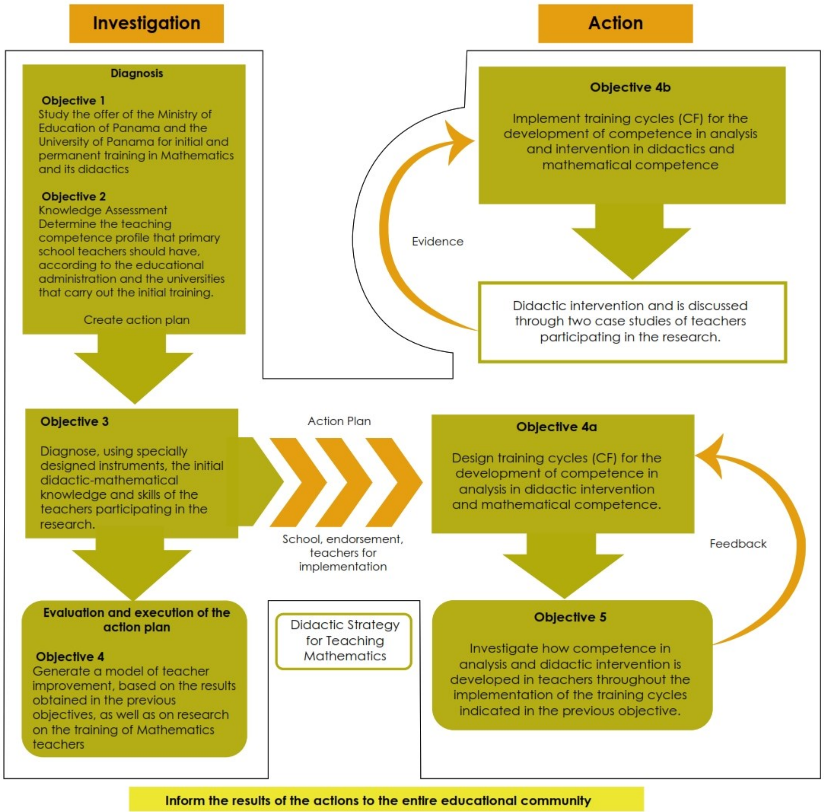

Figure 4. Design of the implementation of teacher improvement through hybrid methods aimed at strengthening decision–making in public policy.

The implementation design for teacher improvement through hybrid methods aims to enhance decision–making in public policy. This design entails utilizing a combination of in–person and virtual training strategies to bolster participants' skills and knowledge. In the context of gender equality, this design is particularly relevant for ensuring that educational policies and practices promote gender equity and inclusion. For instance, the teacher training program may incorporate specific modules addressing gender stereotypes in education and provide strategies for fostering an inclusive educational environment for all students, regardless of gender. Additionally, integrating a gender perspective into the assessment and monitoring of the program can ensure that women and other marginalized groups have equal opportunities to participate in and benefit from the teacher improvement process. In summary, this design seeks not only to enhance teachers' teaching skills but also to promote gender equality in the educational sphere through a comprehensive and equitable approach.

Pearson's correlation coefficient was used to establish the relationship between the variables: mathematics teaching and empowerment (greater teaching skills and knowledge) of the participants. This descriptive statistic allowed us to determine the intensity and direction of the relationship between these variables. According to the following **Table 1**, a positive significance was found, indicating a positive correlation between both variables.

The choice to use Pearson's correlation coefficient, also known as the product–moment correlation coefficient, stems from its suitability for measuring the linear relationship between two continuous variables. In this context, the variables examined are mathematics teaching and empowerment, specifically focusing on the enhancement of teaching skills and knowledge among participants. Pearson's correlation coefficient provides a quantitative measure of the strength and direction of this relationship, allowing for a deeper understanding of how changes in one variable may be associated with changes in the other.

Table 1. Pearson's correlation coefficient.

	Empowerment	**Teaching mathematics**
Empowerment Pearson's Correlation	1	0.820(**)
Sig. (one–sided)		0.000
N	64	64
Teaching Mathematics Pearson's Correlation	0.820(**)	1
Sig. (one–sided)	0.000	
N	64	64

**The correlation is significant at the 0.01 (one-sided) level.

The comparison of data across collection methods established a trend in the effectiveness of various teaching strategies aimed at fostering interest in mathematics. These strategies included problem-solving scenarios, competitive mathematical activities, and games to reinforce and demonstrate mathematical knowledge. However, a recurring issue emerged: these activities were designed without considering the gender of the students, potentially limiting girls' opportunities to showcase their mathematical abilities and engage fully in the subject.

The primary objective of this study is to analyze gender equity in mathematics education, as reported by Panamanian educators. Specifically, the study aims to identify strategies that empower girls in Panama to expand their mathematical knowledge and skills and to document aspects of teacher training that promote gender equity in math education. To meet these objectives, the study incorporated sociodemographic variables (such as gender, age, and location) and occupational factors (years of experience and educational level taught) into the instrument.

The instrument itself was divided into two parts. The first section aimed to capture educators' perceptions of gender stereotypes, academic performance, life aspirations, participation, self-esteem, leadership, teaching strategies, and the family context that surrounds mathematics education in Panama. The second section focused on assessing the impact of a diploma course on math education taken by four cohorts of teachers trained between 2017 and 2022. This multi-faceted approach provides a foundation for understanding and addressing gender-related challenges in math education, ultimately guiding efforts to promote equitable learning environments for all students.

A total of 64 in-service educators participated. To select these ten educators, the criterion of years of service was considered to ensure the inclusion of educators with extensive teaching experience as well as new teachers with little or no teaching experience. The analysis used in this study adopts a methodological approach based on the researcher's perspective, as defined by Lerman (2001) and Planas (2006).

The instrument included closed-ended single-selection questions and open-ended questions to identify the educators' perceptions of teaching mathematics in the classroom and was distributed and completed using Google Forms over a period of four months. The data processing from the instrument was carried out using the Statistical Package for the Social Sciences (SPSS), where different descriptive analyses were performed using Likert (1932) and Guttman (1944) scales.

4. Results and discussion

This section presents the main findings from the application of the SSP-MT instrument, disaggregated by gender and educational level (preschool, primary, middle school, and high school). On one hand, it allowed for the identification of teaching experiences in mathematics from a gender perspective, and on the other hand, it recognized the experience in mathematical training according to the grade and level of education taught by the educators.

4.1. Educator characteristics

The instrument was answered by 64 educators, of which 34% were men and 66% women. The prominent age ranges were 34 to 41 years (31%), where women accounted for 22%, and 42 to 49 years (23%), with a participation of 19% of women primarily (**Figure 5**). In this sense, it could be said that the results on mathematics teaching generally express the experience of female educators both from their perspective as women and from their years of professional experience.

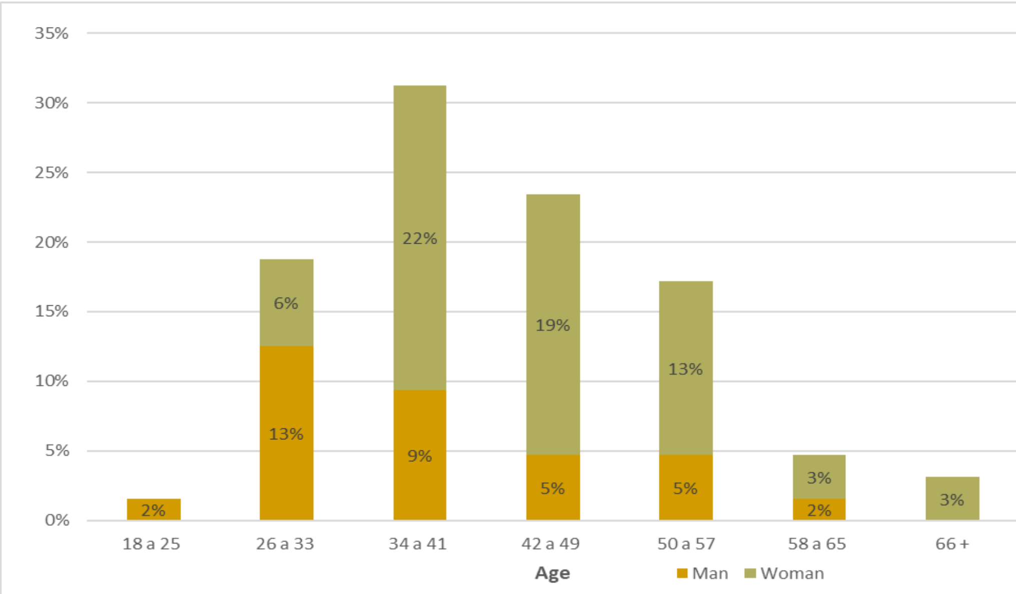

Figure 5. Percentage distribution of teachers surveyed by age group and gender based on the survey, 2023.

Source: Own elaboration based on the survey, 2023.

According to **Table 2**, 23% of educators have up to four years of teaching experience, 19% have between 15 to 19 years, and another 19% have between 20 to 24 years of experience. The age groups of educators within these experience ranges are 34 to 41 years (31%) and 42 to 49 years (23%). Therefore, the perception of mathematics teaching from a gender perspective presents an interesting outlook since educators, as the trainers of future professionals, identify and recognize the strengths and weaknesses of students both inside and outside the classroom, especially in the case of girls.

Table 2. Percentage distribution of years of teaching experience by age group.

		Years of teaching experience									**Total**
		0 to 4	**5 to 9**	**10 to 14**	**15 to 19**	**20 to 24**	**25 to 29**	**30 to 34**	**40 to 44**	**45 to 50**	
Age Group	18 to 25	2%	0%	0%	0%	0%	0%	0%	0%	0%	2%
	26 to 33	13%	5%	2%	0%	0%	0%	0%	0%	0%	19%
	34 to 41	6%	8%	9%	8%	0%	0%	0%	0%	0%	31%
	42 to 49	0%	0%	6%	8%	6%	3%	0%	0%	0%	23%
	50 to 57	3%	3%	0%	3%	5%	3%	0%	0%	0%	17%
	58 to 65	0%	2%	2%	0%	0%	0%	2%	0%	0%	5%
	66 or more	0%	0%	0%	0%	0%	0%	0%	2%	2%	3%
Total		23%	17%	19%	19%	11%	6%	2%	2%	2%	100%

Source: Own elaboration based on the survey, 2023.

Otherwise, it would not be possible to make visible practices unfavorable to the formative development of girls and address them as needed. González (quoted in Sáenz (2012)) mentions that the teacher reaffirms the teaching differences by sex in recognizing the interests and expectations between boys and girls.

Adding to the above, it was observed that in all cases, the Didactic Suitability Criteria (DSC) index (García et al., 2021) is above 1.5, considered the threshold from which the analyzed material can be deemed to have a certain didactic suitability. This value is situated right in the middle of the 0–3 range, which measures each suitability. Half of the educators who participated in the study scored between 2.6 and 1.7, nearing what could be considered acceptable suitability concerning the didactic sequences they have designed and implemented.

Observing these results from the perspective of the teaching experience of the participating educators in the study, a notable regularity emerges: the more years of teaching experience, the higher the DSC index obtained, suggesting a relationship between teaching experience (measured in years) and the ability to design suitable didactic sequences, from the viewpoint of the analysis proposed by the EOS.

We can see that 23% of teachers with the least professional experience have the lowest scores on the DSC index. These findings indicate that activities play a significant role in the planning and development of teachers and that less experienced teachers may not incorporate innovative activities and methods into their designs as effectively. Judging by an assessment of their academic knowledge, they are likely to score high on each DSC.

The results show that the lack of professional experience leads teachers to think of knowledge in terms of what they want rather than scientific evidence (in pedagogical knowledge of the subject), leading them to try practices that, didactically speaking, are not the most suitable.

Regarding the educational level the educators teach, shows that 41% of the educators are assigned to the primary level, mainly in the Province of Panama (23%). Twenty–three percent teach in grades one through six, distributed as 19% in third grade, 15% in fifth grade, 12% in fourth grade, and 8% in second grade.

Thirty–six percent of the educators are assigned to the high school level, where 39% teach in tenth grade and 22% in eleventh grade. Finally, 22% mentioned belonging to the middle school level, where 36% are in charge of eighth and ninth grades, and 29% in seventh grade.

In this sense, the results predominantly show the context of the primary and high school levels. Therefore, it was considered necessary to disaggregate the information (**Table 3**) at this level since they are different experiences regarding the process of training in mathematics teaching according to the age of the students and how the teacher perceives behaviors and situations.

Table 3. Educational level by region based on the survey, 2023.

Educational level	**Region**							**Total**
	Chiriqui	**Colón**	**Darien**	**Los Santos**	**Panama Oeste**	**Panama**	**Other**	
High school	3%	2%	2%	2%	14%	14%	0%	36%
Middle–school	0%	2%	0%	0%	11%	9%	0%	22%
Primary	2%	8%	0%	2%	5%	23%	2%	41%
Preschool	0%	0%	0%	0%	2%	0%	0%	2%
Total	5%	11%	2%	3%	31%	47%	2%	100

4.2. Gender stereotypes

In the field of education, institutions are not neutral regarding inequalities, as roles and stereotypes still permeate school interactions and tasks. The binary system of sex–gender differentiates characteristics, attitudes, values, symbols, and roles for men and women that are exclusionary and rigid. Care jobs and attention to others, along with domestic activities for women, contrast with the skills of leadership, strength, decisiveness, and adventure attributed to men.

The project focuses on cooperation in areas aligned with the achievement of the Sustainable Development Goals (SDGs). Specifically, it addresses issues associated with gender and equality, culture, and development.

Gender and Equality: We focus on promoting gender equality by improving education in math and STEAM (Science, Technology, Engineering, Art, and Math). This guidance aligns with the principles of gender and equality, as our goal is to reduce and eliminate gender stereotypes in education, empowering girls to become actively involved in traditionally male–dominated areas. This is achieved through the specialization of mathematics teachers who contribute directly to this purpose. A long–term effect is that by improving the quality of education and encouraging girls' interest in science, we can increase their insertion into these areas, thereby improving their employment prospects and personal growth.

Culture and Development: The cultural dimension plays a crucial role in our approach to education. Our project promotes a culture of gender equality in classrooms and society. It also fosters cultural diversity by adapting curricular content to be relevant to students from diverse cultural backgrounds. Given the current and repeated migratory movements in the region, this adaptation becomes essential to honor and appreciate cultural diversity and to foster an inclusive and tolerant environment in the classroom, thus promoting a culture of peace and the reduction of inequalities through the development of capacities in vulnerable populations.

Other Conjunctural or Structural Areas: While the proposed article focuses mainly on the quality of education, its impact is not limited to this area alone. We believe it can cover other structural areas since high–quality education positively influences several aspects of the lives of students, their families, and their community.

4.3. Attributions

Teachers were asked to indicate, according to their perception, which attributions they associate with each gender. The results shown in **Table 4** indicate that, according to the teachers, girls were perceived as having better attributes in grooming (83%) and cooking (70%). In contrast, boys are considered more restless (86%) and active (55%). These findings are consistent with Whyte (cited in Sáenz, 2012), who discusses the association and expectations between boys and girls during their educational trajectory (**Table 4**). It is expected that boys will show cognitive improvement, while girls will do so in behavior and obedience.

Table 4. Attributions according to gender based on the survey, 2023.

Attributions		Educational level				Total
		Preschool	Elementary	Middle School	High School	
Restless	Girls	0%	2%	9%	3%	14%
	Boys	2%	39%	13%	33%	86%
Active	Girls	2%	20%	11%	13%	45%
	Boys	0%	20%	11%	23%	55%
They make grooming better	Girls	0%	31%	20%	31%	83%
	Boys	2%	9%	2%	5%	17%
They cook better	Girls	2%	31%	14%	23%	70%
	Boys	0%	9%	8%	13%	30%

Source: Own elaboration based on the didactic strategies for teaching, 2023.

4.4. Restless

The survey conducted with educators and parents revealed a significant finding regarding student behavior, specifically in terms of restlessness and agitation, which varies significantly by gender. Educators consider middle school girls (9%) to be more restless, followed by high school girls (3%). In contrast, primary school boys (39%) are more restless, followed by high school boys (33%) and middle school boys (13%). While the activity levels in primary school are similar between both genders, the gap in secondary school is significant, with a decrease in the percentage of active girls. This discovery, which was not part of the initial objectives of the survey, provides valuable information on how activity levels differ by gender, particularly in the higher education levels. The serendipity of the analysis suggests the need to examine social, environmental, and family factors that may be influencing the decrease in active participation among girls in secondary school.

4.5. Active

From the serendipity observed in the survey conducted with teachers and parents, unexpected patterns were identified that reveal gender differences in physical activity levels and participation among students across different educational stages. This emerging finding suggests that, among boys, 55% are considered active (23% in high school, 11% in middle school, and 20% in primary school), reaching their highest activity level in high school. In contrast, among girls, 45% are considered active, with a distribution of 13% in high school, 11% in middle school, and 20% in primary school. While the activity rate in primary school is similar between both genders, a significant gap appears in high school, where the percentage of active girls decreases.

This discovery, which was not part of the initial objectives of the survey, provides valuable insights into how activity levels vary by gender, particularly in the upper stages of education. The serendipity of the analysis suggests the need to examine social, environmental, and family factors that may be influencing this decline in girls' active participation in high school. Thus, these data open new avenues for research to design educational interventions that promote more equitable physical and academic participation, strengthened by family and teacher support, helping to reduce gender gaps in activity and academic performance.

4.6. Better at cleaning

In this attribute, girls represent 87% of the total, with 31% in high school, 20% in middle school, and 31% in primary school considered better at cleaning. Meanwhile, boys have a very low representation in this attribute with 17% of the total, only 5% in high school, 2% in middle school, and 9% in primary school are considered better at cleaning.

4.7. Better at cooking

70% of the girls cook better, while only 30% of the boys do. Among girls, it is represented by 23% in high school, 14% in middle school, and 31% in primary school. Among boys, 13% in high school, 8% in middle school, and 9% in primary school are considered better at cooking.

4.8. Academic performance

Teachers were asked about who are more diligent, creative, and who seek more guidance (**Table 5**). The results showed that, in general, 86% of teachers indicated that girls are more diligent with their tasks. The highest percentage of girls was recorded at the primary education level (38%), followed by high school (28%), middle school (19%), and preschool (2%). For boys, it represented just 14%, where the highest percentage is in the high school level (8%), followed by primary and middle school with 3% each.

Regarding the development of greater creativity in problem–solving within the classroom, 52% indicated that boys exhibit greater creativity in problem–solving, while 48% pointed out that girls do. In terms of educational level, the highest percentage for both girls and boys are found at the high school level (36%). This allows us to infer that teachers perceive boys to demonstrate greater creativity in problem–

solving in preschool, primary, and middle school levels, though at the high school level (20%), girls exhibit greater creativity in problem–solving.

Table 5. School performance by educational level according to gender based on the survey, 2023.

	Educational level				**Total**
	Preschool	**Primary**	**Middle School**	**High school**	
School performance					
Girls	2%	38%	19%	28%	86%
Boys	0%	3%	3%	8%	14%
Total	2%	41%	22%	36%	100%
Creativity					
Girls	0%	19%	9%	20%	48%
Boys	2%	22%	13%	16%	52%
Total	2%	21%	22%	36%	100%
Clarify doubts					
Girls	0%	19%	14%	19%	52%
Boys	2%	22%	8%	17%	48%
Total	2%	41%	22%	36%	100%
Performance impact					
Girls	0%	9%	3%	6%	19%
Boys	2%	31%	19%	30%	81%
Total	2%	41%	22%	36%	100%

Source: Own elaboration based on the survey, 2023.

Regarding the percentage distribution of who more frequently asks to clarify doubts by gender and educational level, 52% of educators report that girls more frequently ask to clarify doubts, while 48% said that boys do. At the educational level, the highest percentage for both girls and boys are found at the primary level (41%), where 22% of boys more frequently seek support from their educators; followed by high school (36%), where girls do so more frequently (19%).

Regarding the impact on academic performance due to confinement by the pandemic, it was identified that boys were more affected (81%) compared to girls (19%). In terms of educational level, it is shown that primary (41%) and high school (30%) levels were identified where boys had lower performance.

4.9. Creative and innovative thinking

Educators noted that boys more easily develop problem–solving skills in mathematics in other contexts or disciplines (70%) (**Figure 6**). In contrast, only 30% of girls had satisfactory development regarding the use of technology for solving mathematical problems, 59% consider that boys carry it out more easily, and 41% indicated that girls; finally, in the application of knowledge, boys surpass girls by 4%, represented by 48%.

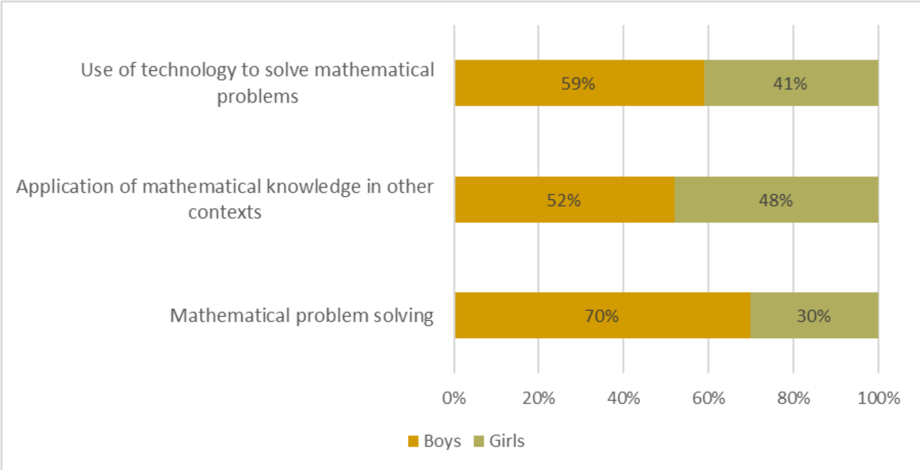

Figure 6. Mathematical problem–solving, 2023.

Source: Own elaboration based on the didactic strategies for teaching, 2023.

Regarding creative and innovative thinking, García (2003) discusses creative and innovative thought and asserts that women perform better on mathematical calculation tests, have greater perceptual speed to identify matching objects, excel in verbal fluency and motor coordination tests, whereas men excel in spatial tasks, have greater motor and complex abilities, as well as in mathematical reasoning tests.

In terms of the development of creative and innovative thinking by educational level (**Table 6**), it was found that at the primary and high school levels, there is an acknowledgment of the development of boys' creative and innovative thinking, and at the middle school level, it is highlighted that girls apply mathematical knowledge in other contexts or disciplines (13%), while the other attributes are mainly associated with boys. Therefore, educators consider that boys, compared to girls, perform better in mathematics.

Table 6. Percentage distribution of the development of creative and innovative thinking by educational level based on the survey, 2023.

		Educational level				**Total**
		Preschool	**Primary**	**Middle–School**	**High school**	
Solve mathematical problems through different and innovative processes	Girls	0%	13%	9%	8%	30%
	Boys	2%	28%	13%	28%	70%
Application of mathematical knowledge in other contexts or in other disciplines	Girls	2%	19%	13%	16%	48%
	Boys	0%	22%	9%	20%	52%
They find solutions other than mathematical exercises or theorems with the support of information technologies for problem solving	Girls	0%	17%	8%	16%	41%
	Boys	2%	23%	14%	20%	59%

4.10. Academic performance

Although boys are considered to have greater creative and innovative thinking, it is the girls who achieve higher academic performance in the subject of mathematics. According to **Figure 7**, girls have better grades in mathematics with 61% representation compared to boys who have 39%. It is also observed in the solving of mathematical problems that girls represent 52% of the total, surpassing boys by 4%.

Finally, in solving mathematical exercises, girls surpass boys with 56% of the total while boys have 44%.

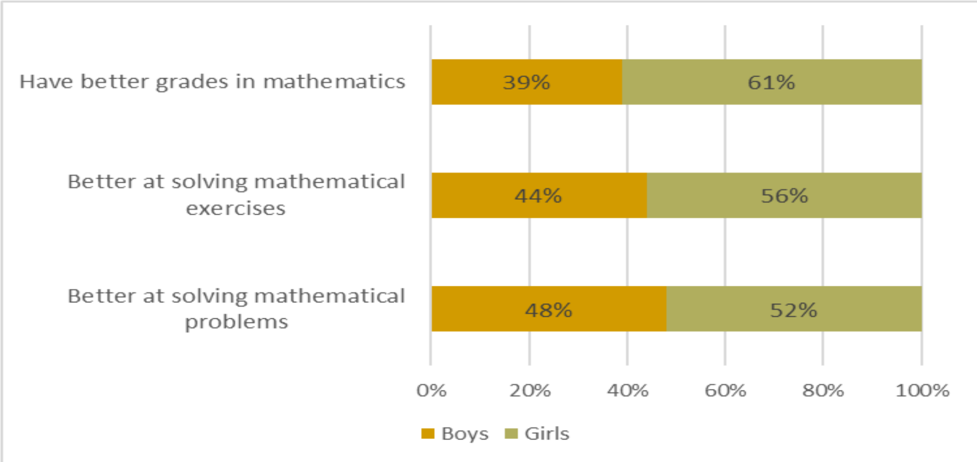

Figure 7. School performance by gender based on the didactic strategies, 2023.
Source: Own elaboration based on the didactic strategies for teaching, 2023.

At the primary education level (41%), it was identified that girls (25%) solve mathematical exercises better than boys (16%). At the middle school level, girls represent 13% and boys 9%. Finally, in high school, girls (19%) surpass boys by two percentage points (**Table 7**).

Table 7. Percentage distribution of mathematical solving by educational level according to gender based on the survey, 2023.

	Educational level				**Total**
	Preschool	**Primary**	**Middle School**	**High School**	
Solving mathematical exercises					
Girls	0%	25%	13%	19%	56%
Boys	2%	16%	9%	17%	44%
Total	2%	41%	22%	36%	100%
Resolution effectiveness					
Girls	0%	22%	13%	17%	52%
Boys	2%	19%	9%	19%	48%
Total	2%	41%	22%	36%	100%
Taking advantage of the assemblagture					
Girls	2%	25%	14%	20%	61%
Boys	0%	16%	8%	16%	39%
Total	2%	41%	22%	36%	100%

The data also indicate that high school boys (19%) are better at solving mathematical problems compared to girls (17%). However, at the primary and middle school levels, girls are more outstanding. In general, according to the percentages provided in the table, there does not seem to be a significant difference between girls and boys in terms of better solving mathematical problems in the classroom. The percentages are relatively similar across all educational levels.

Regarding academic achievement in the subject, girls show a higher percentage than boys in having the best grades in mathematics across all educational levels with 61% of the total, while boys represent 39% of the total. At the primary level, there are the best grades in mathematics equally represented by 25% for girls and 16% for boys. At the middle school and high school levels, girls obtain better grades in the subject of mathematics.

4.11. Vocation or life project of the students

Among the main professional vocations that educators have identified in their students, medicine stands out (91%) where 64% is represented by girls; engineering (84%), in which boys represent 75% and girls 9%; teaching (83%) where 70% are girls and only 13% are boys; and nursing (80%), mainly associated with girls (77%); in contrast, professions such as physics (70%), mathematics (72%), and mechanics (77%) were positioned with lower vocational representativeness among students (**Figure 8)**. Regarding other vocations, educators mentioned applied sciences to astrophysics, aeronautics, and architecture, in social sciences and economic–administrative referred to law, management, accounting, and also identified that there are students with a vocation for activities or professions related to styling and crafts.

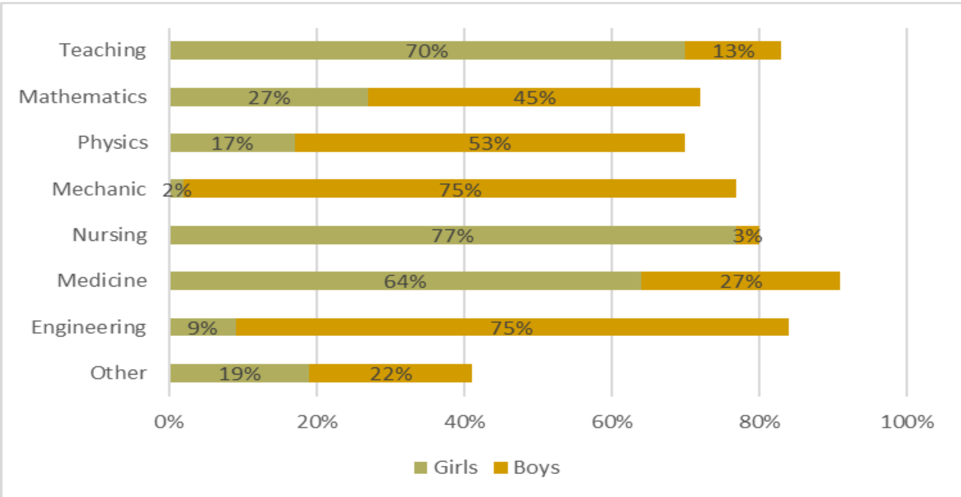

Figure 8. Vocation or life project of the students based on the survey, 2023.
Source: Own elaboration based on the didactic strategies for teaching, 2023.

Therefore, it can be identified that professional vocations related to applied sciences are strongly associated with males, while social sciences and health sciences are associated with females. In this sense, it was substantial to identify by educational level how educators have recognized capacities, aptitudes, and according to their experience, the expectations in the professional field as a life project of their students. Regarding the main vocations identified in the case of girls (**Figure 9**), they refer to health sciences such as nursing and medicine, and social sciences such as teaching.

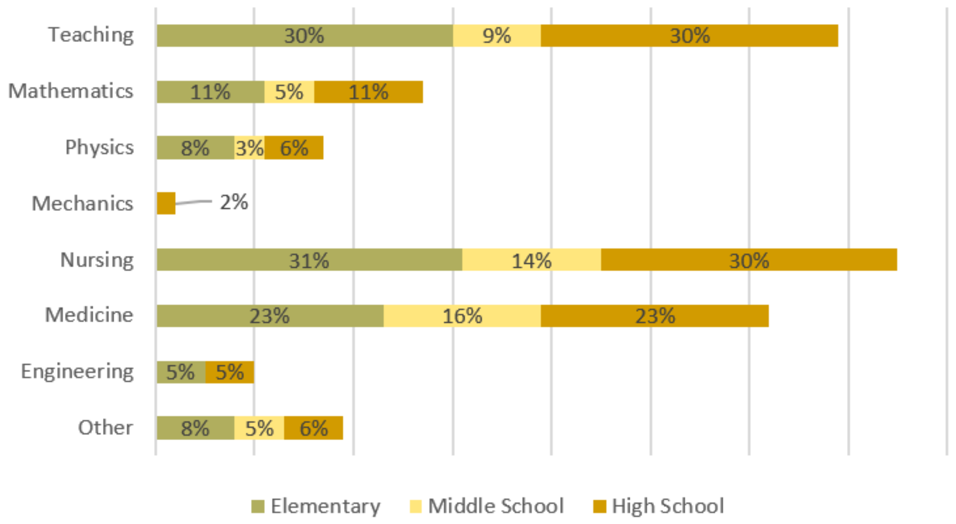

Figure 9. Professional vocation of girls based on the survey, 2023.

Source: Own elaboration based on the survey, 2023.

At the primary level, the main profession identified is nursing (31%), followed by teaching (30%). In middle school, medicine (16%) and nursing (14%) stand out, and in high school, both teaching and medicine are positioned as the main vocations of students at these educational levels.

Regarding applied sciences, the percentages indicate that although not representative, it is significant that from the primary level, future human–professional capital is identified in areas such as mathematics (11%), physics (8%), and engineering (5%). Similarly, at the high school level, there is the same correspondence towards these sciences.

Therefore, it is important to strengthen, motivate, and develop logical–mathematical abilities from an early age so that girls –in this case– are formed and prepared so that when they reach the university stage, they do not give up on careers associated with applied sciences because they do not feel sufficiently apt for their study.

Regarding the vocation of the life project of boys (**Figure 10**), engineering (74%) and mechanics (74%) predominate, followed by physics (52%) and mathematics (43%), in contrast, nursing (4%) and teaching (13%) are the professions with the least identification among males.

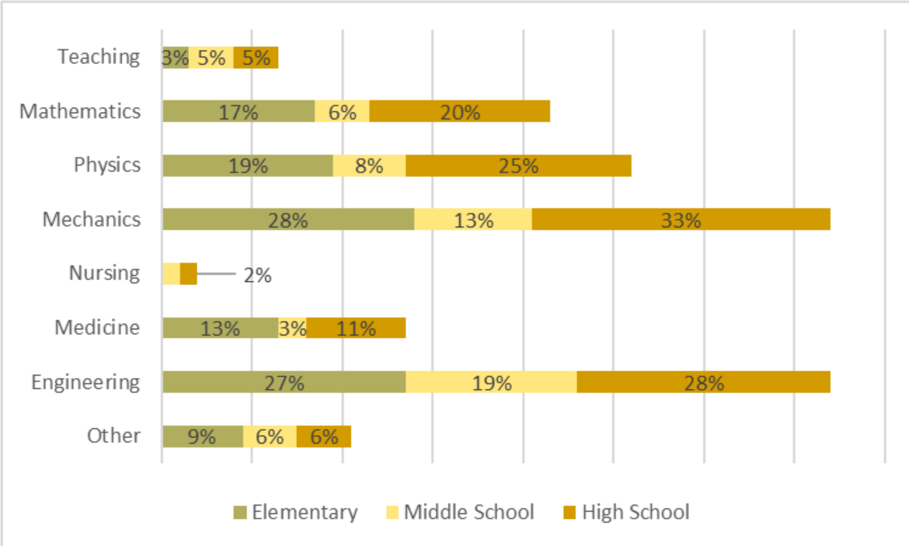

Figure 10. Professional vocation of based on the survey, 20.

Source: Own elaboration based on the survey, 2023.

At the primary level, mechanics (28%) and engineering (27%) stand out as the professions with the highest preference among boys; in middle school and high school, there is also an inclination towards these professions. Similarly, physics and mathematics are highlighted to a lesser extent at the high school level.

4.12. Participation

As shown in **Figure 11**, although educators indicate that girls pay more attention in class (76.6%) and participate more in class (64.10%), it is the boys who participate in mathematics competitions (53.10%) more frequently.

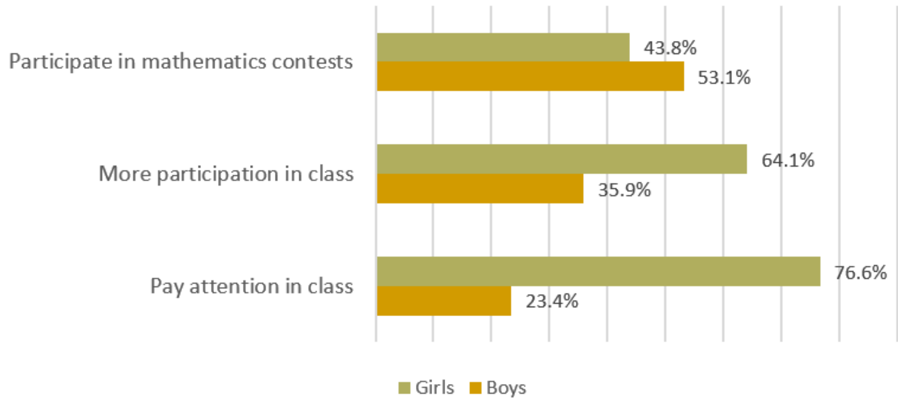

Figure 11. Participation in the learning of mathematics based on the survey, 2023.

For this reason, another of the questions asked of the teachers was to identify what obstacles girls face in learning mathematics, to which they referred to internal and external factors as follows:

Internal factors:

- Paying attention longer than boys
- Insecurities in the classroom
- Bullying

- There is a need to strengthen knowledge about basic operations and solution procedures.
- Mathematical, Critical, and Logical Thinking
- Failure to apply theorems, definitions, or postulates in a given project.
- They are too mechanical or unreasonable.

External factors:

- Little practice of problems and exercises
- The home where it is formed.
- Responsibilities for household chores
- Lack or no help from parents.
- Stereotypes
- Worry about family or relationship problems

Data also showed greater performance, specifically in the case of boys, and constancy in the mathematical training of girls. However, girls are at a disadvantage over boys with respect to solving mathematical problems and participating in competitions in this area.

Although the abilities to develop logical mathematical knowledge have no distinction of gender, it must be recognized that there are external factors experienced in other areas such as the home. Girls are often entrusted with activities of care for boys and the elderly and chores, under the stereotype that they are by nature caregivers and administrators of the home. Therefore, this may imply a correspondence in the teaching–learning process, and they may not be able to potentiate their mathematical knowledge within the classroom.

4.13. Self–esteem

According to the perception of teachers (**Table 8**), it was identified that 53% of girls are more confident in solving mathematical problems, while boys account for 47%. At both the elementary and high school levels, it has been identified that girls show greater confidence.

Table 8. Stimulation of self–esteem by educational level according to gender based on the survey, 2023.

Gender	Educational level[1]			Total
	Primary	Middle school	High school	
Problem resolution security				
Girls	22%	11%	19%	53%
Boys	19%	11%	17%	47%
Total	41%	22%	36%	100%
Occurrence of recognition				
No	5%	5%	19%	53%
Yes	36%	17%	17%	47%
Total	41%	22%	36%	100%

[1]Preschool level was omitted.

Regarding the recognition of students, 47% of teachers reported that there is public recognition of boy's tasks or achievements; in contrast, 53% indicated that they do not. The educational level where students are most recognized is in elementary school (36%), while high school (19%) and middle school (5%) are where they carry out these recognitions less frequently.

Therefore, it is important to mention that in the teaching–learning process, the teacher, as a facilitator and training guide, must look for strategies to motivate meaningful learning, which, to a large extent, is associated with the recognition of their students. In this way, a sense of self–confidence and motivation to continue learning are generated.

Among the main types of recognitions that are carried out within classrooms and institutions, teachers mentioned: public congratulations, certifications, Olympiads and math contests; civic recognition; distinction on campus (honor roll); encouragement within the classroom such as treats, games, surprise gifts and scholarships; motivation to continue improving; and school performance awards such as extra points in exercises or projects or exempting them from some task.

4.14. Leadership

Teachers were asked to identify those who they identify as better at reconciling or mediating a conflict in the classroom, as well as those who better coordinate work teams. Findings show that girls excelled in both tasks related to leadership (**Figure 12**).

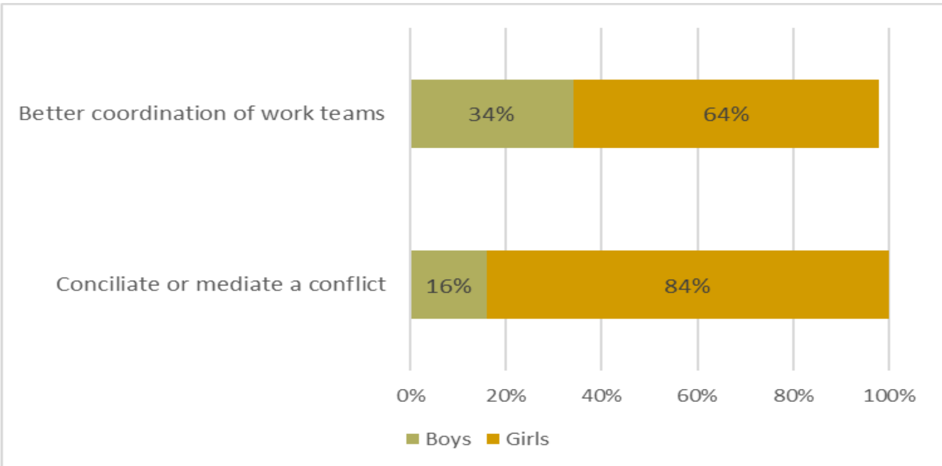

Figure 12. Leadership in the classroom based on the survey, 2023.

Source: Own elaboration based on the didactic strategies for teaching, 2023.

4.15. Teaching strategy

To measure the work that teachers have done, it was necessary to identify whether strategies designed within the planning of the subject (mathematics) highlighted the abilities of girls (**Table 9**). As a result, 80% of teachers said they do plan, taking into account their students' gender (being boys or girls), while 20% said they do not.

In general terms, only one strategy specifically designed for girls was identified, which involved tasks related to coordinating teamwork, while the other strategies listed refer to a very generalized group didactic approach. Regarding those who indicated that they do not carry it out, educators considered it unnecessary because "all strategies are designed without [gender] distinction, but to develop and showcase abilities" (García et al., 2021), in that sense, it is not recognized as relevant in the subject planning process.

Table 9. Design of teaching strategies for girls based on the survey, 2023.

Yes	No
• Mathematics fair • Acting and public speaking • Develop creativity • Teamwork where girls are coordinators to promote leadership. • Didactic mathematical games • Competitiveness strategies • Overview of the topic covered • Problem solving • Motivation to participate in class	• No gender distinction in lesson planning • Not considered important • Not a priority • Due to the time and subject matter • All strategies are designed without distinction, but to develop and show capabilities. • Everyone has the same ability

Educators were also asked if they design tasks or exercises that encourage girls' participation. Sixty–nine percent of educators indicated that they do, such as: collaborative work where girls are coordinators, solving real–life problems, workshops in class, educational games and material design, presentations in class and to other groups, and peer support. In contrast, 31% mentioned that teaching design is carried out without gender distinction since the objective is the development of capacities in mathematical thinking.

Finally, in this section, it was asked whether activities promoting a sense of achievement are encouraged, with 53% indicating that they do design such activities: 41% were in primary where they conduct contests and talent shows; 22% in middle school, where activities are aimed at boosting self–esteem and competition, competition between men and women, tournaments, and math fairs; finally, 36% in high schools, where activities stand out that allow students to earn extra points, self–assessment, recognition of performance, and science fair.

4.16. Family environment

According to Varela (2017), "the family nucleus is fundamental in the comprehensive development of boys and girls, since from the earliest educational stages (preschool and primary) to the extent that there is effective accompaniment by the parents or guardians of the students regarding their school performance, attention inside and outside the classroom, and follow–up in situations that imply a positive or negative factor in the cognitive development of the students, it has implications on how they perform academically" (p. 224).

For example, if there is no support from parents or guardians to address doubts on how to solve a mathematical exercise because they are tired, have other activities, or simply do not want to do it, the student probably will not have the confidence to solve it by themselves, or their learning will be less significant since there are learning barriers that if not addressed can affect school performance, motivate school dropout, or not continue with studies in middle school, high school, or university due to the bad experience of how to appropriate such knowledge. Therefore, educators were asked to identify who receives more support at home (**Table 10**). Of these, 69% indicated that girls receive more support in relation to boys (31%).

As can be seen in **Table 10**, the percentages are very deep in how teachers perceive the support at home of girls compared to boys; the baccalaureate level is where 18 percent–age points of difference between girls (27%) and boys (9%) were obtained, followed by middle school with a difference of ten percentage points.

Table 10. Home support for students by educational level based on the survey, 2023.

Educational level					**Total**
	Preschool	**Elementary**	**Middle school**	**High school**	
Home Support					
Girls	2%	25%	16%	27%	69%
Boys	0%	16%	6%	9%	31%
Total	2%	41%	22%	36%	100%
Meeting Attendance					
Mom	2%	39%	22%	30%	92%
Dad	0%	0%	0%	5%	5%
Other family member	0%	2%	0%	2%	3%
Total	36%	2%	22%	41%	100%

Regarding attendance at parent meetings, 92% of teachers indicated that mothers attend quarterly meetings more frequently, 5% fathers, and 3% other relatives. In this sense, women continue to predominate in the exercise of the role of caregiver and are responsible for the educational lives of their children.

4.17. Pre and post–training performance

The last section of the questionnaire aimed to identify the performance before and after the mathematics teaching training that teachers took to follow up and influence the improvement of students' academic performance. Two control questions were asked to indicate the percentage of approval in mathematics of their group before and after taking the diploma.

14, 31.75% of the groups had a basic and satisfactory pass percentage, respectively, in the subject of mathematics before the teachers took the diploma; only 4.76% of the groups had excellent passing grades, and 26.98% had outstanding passing grades.

After the diploma course, the teachers reported that there was a significant change in group approval, since from the outstanding approval that was previously 26.98% and changed to 45.3%, the excellent (4.76%) meant 26.6%. In contrast, 4.7% had a basic approval rating, while 3.1% of groups showed no change.

The evolution of unsatisfactory approval (4.7%) improved significantly to more advanced levels; 15.6% of the groups with basic approval improved to satisfactory; 29.7% of groups with satisfactory approval changed to outstanding; and groups with excellence (4.7%) remained in the same approval status (**Table 11**).

In general, according to the percentages provided in the table, there is a significant improvement in the percentage of passing in mathematics after completing the training program of sub–competencies. Math pass rate ranges at the satisfactory, outstanding, and excellent levels increased, while the ranks of unsatisfactory and basic decreased.

Table 11. Percentage of approval of mathematics subjects before and after the diploma course based on the survey, 2023. (TEACHERS).

		After completing the diploma course					**Total**
		Unspecified	**21 to 40 (basic)**	**41 to 60 (satisfactory)**	**61 to 80 (outstanding)**	**81 to 100 (excellent)**	
Before taking the diploma course	Unspecified	1.6%	0.0%	0.0%	0.0%	0.0%	1.6%
	0 to 20 (unsatisfactory)	0.0%	1.6%	1.6%	1.6%	0.0%	4.7%
	21 to 40 (basic)	0.0%	3.1%	15.6%	4.7%	7.8%	31.3%
	41 to 60 (satisfactory)	0.0%	0.0%	1.6%	29.7%	0.0%	31.3%
	61 to 80 (outstanding)	1.6%	0.0%	1.6%	9.4%	14.1%	26.6%
	81 to 100 (excellent)	0.0%	0.0%	0.0%	0.0%	4.7%	4.7%
	Total	3.1%	4.7%	20.3%	45.3%	26.6%	100.0%

Regarding the performance of boys' grades (**Figure 13**), it was observed that within the range of grades from 21 to 40 (basic), 10.90% of boys are rated within this range, as well as 9.40% of girls. In the 40 to 60 (satisfactory) range, the percentage of boys exceeds that of girls, representing 45.30% and 26.60% respectively. Finally, within the range of grades from 61 to 80 (outstanding) is the highest percentage of girls with 40.60% and that of boys 32.80%.

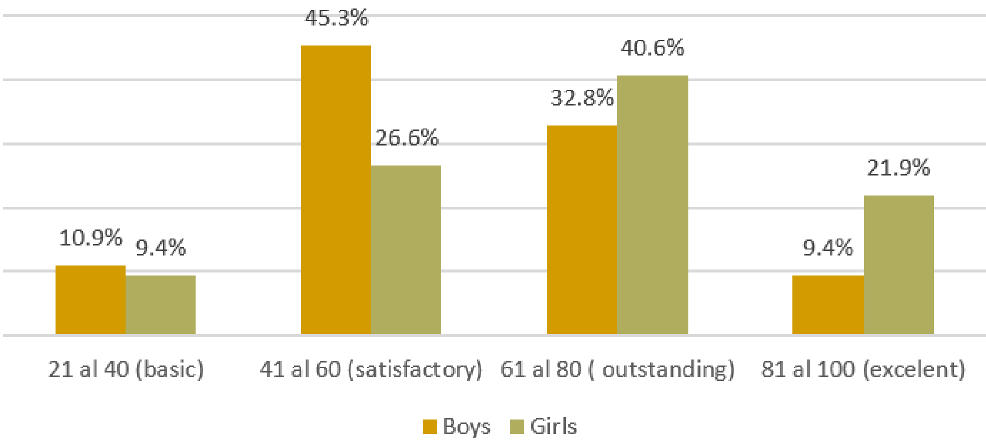

Figure 13. Students' grades performance based on the survey, 2023.

Source: Own elaboration based on the survey, 2023.

5. Conclusions

This article is part of a study conducted in the teacher training context, highlighting the need to strengthen educators' mathematical knowledge, competencies, and ability to analyze and intervene didactically. These deficiencies are linked to a low curricular load in degree programs and a lack of technological and playful strategies to engage students in mathematics. The majority of participants were female teachers, with the largest group (13%) being between 26 and 33 years old and with 0 to 4 years of experience, followed by another significant group (9%) aged between 34 and 41 with 10 to 14 years of experience. Despite limited teacher participation in some regions, the data provides valuable insight into teaching competencies in densely populated areas of Panama, emphasizing the importance of gender equality in teaching mathematics.

The research led to the development of strategies to strengthen mathematical knowledge and teaching competencies, aiming to influence public policy in teacher training and mathematical didactics. The training modules achieved the goal of encouraging teachers to reflect on their practice, integrating didactic appropriateness with the Sustainable Development Goals (SDGs) and playful techniques. The study also included family involvement, particularly from mothers, in supporting their children's mathematical education, highlighting the need to redefine mathematical competence in teachers, considering pedagogical activities and assessment techniques with a gender-specific approach.

Although the survey was designed to collect information about the knowledge and competencies of teachers and parents in hybrid mathematics education, significant patterns emerged in the responses that revealed unexpected differences in the participation and perceptions of boys and girls in this modality. This discovery, which was not part of the initial objectives, sheds light on gender-differentiated behaviors, such as motivation and specific challenges faced by girls in mathematics education. The serendipitous findings, supported by funding agents SENACYT and UNDP, emphasize the importance of examining the social, family, and environmental factors influencing girls' participation in mathematics education, potentially guiding future interventions and improving educational strategies. In conclusion, the use of innovative and playful strategies in mathematics teaching enhances student engagement and supports gender equality, promoting a comprehensive understanding of mathematics and integrating technology into teaching practices. This study contributes to the broader goal of promoting high-quality, equitable education that benefits students, teachers, and the community at large.

Author contributions: Conceptualization, LMM, REDG, AVV and JG; methodology, LMM and EGV; software, EGV; validation, REDG, JG and GBA; formal analysis, AVV; investigation, BAP and GBA; resources: EGV; data curation, AVV; writing—original draft preparation, LMM and BAP; writing—review and editing, REDG and JG; visualization, GBA; supervision, LMM and JG; project administration, LMM; funding acquisition, LMM and REDG. All authors have read and agreed to the published version of the manuscript.

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Ethical approval: The study was conducted in accordance with the Declaration of Helsinki and approved by the Comitee de Bioetica de la Universidad de Panama (ref. CBUP/448/2021 on 17 September 2021).

Data sharing statement: The data supporting the findings and conclusions of this study are available upon request from the corresponding author, as well as from SENACYT and the University of Panama.

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