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Influence Of Gender Disparities On Learning Outcomes In Mathematics: Mediating Effect Of Students' Academic Performance And Moderating Effect Of Adaptive Platform Environment

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Abstract
Introduction: This study examines the complex relationships between gender disparities, learning outcomes, and educational performance expectancy in Pakistan's academic performance. It goals to offer insights into the dynamics shaping instructional consequences and the function of various factors, such as gender disparities and academic overall performance, in influencing gaining knowledge of effects.
Objectives: This research has 3 objectives. H1 implies gender differences help learning. Gender inequality improves learning, according to research. Educational systems are difficult, especially in Pakistan due to gender discrepancies. Reducing these inequalities could improve education. H2 proposes that academic performance expectancy (APE) moderates gender inequalities in learning. APE does not independently predict learning results, but statistical studies suggest it influences them. This shows how complex elements affect educational success. H3 links gender differences in academic performance to learning outcomes. Academic performance positively impacts gender gaps and learning outcomes. Translating gender inequalities into educational results requires academic performance.
Adaptive Mathematics Platform (PAM) and Learning Outcomes: The look at evaluates the Adaptive Mathematics Platform (PAM) and its impact on mathematical information acquisition amongst number one school youngsters. Longitudinal facts analysis famous extensive improvements in gaining knowledge of effects, suggesting the potential value-effectiveness of the PAM method.
Integration of Educational Technology: The look at additionally highlights the importance of instructor engagement and external elements in maximizing the advantages of educational technology integration. It emphasizes the complementary position of era in augmenting teachers' sports and enhancing educational support for kids.
Conclusion: These findings underscore the complexity of instructional dynamics and spotlight the significance of addressing gender disparities and academic overall performance in tandem to foster more equitable and powerful studying environments. Further studies exploring the underlying mechanisms and implications for instructional regulations and interventions is warranted to narrow instructional gaps and promote inclusive schooling.

Keywords: Gender Disparities, Learning outcomes, Academic Performance, Adaptive platform environment

1. Introduction

The Adaptive Mathematics Platform (PAM), developed by Plan Ceibal, was introduced to elementary school pupils and teachers in 2020. The majority of individuals identify PAM by its abbreviation. This tool enables the examination of subjects and methodologies, as well as the generation of novel knowledge. Intended to simultaneously achieve all of these objectives. The platform offers educators a range of resources to enhance their instructional methods, set educational goals, and allocate both solo and collaborative tasks to students, to foster comprehensive and experiential learning. Customized education is provided by adapting more than 100,000 PAM exercises to match the individual ability level of each learner.
Although there has been a significant increase in the utilization of PAM in primary schools, there are still variations in the preferences and extent of usage among students and instructors (Yaqoob, Tariq, et al. 2023). The PAM has experienced significant growth in primary education since its implementation at the elementary level. The primary objective of the PAM's founders was to cater to secondary schools.
The available evidence about the impact of Information Computerized Technology (ICT) in schools on children's learning is limited. There is limited knowledge of its impact on other aspects, such as the social behavior of adult students and their academic performance. This requires conducting the study. This is particularly accurate in developing nations, where the

importance of education quality is growing, resulting in a greater utilization of ICT in educational settings. This holds particular significance in light of the increasing anxiety regarding the quality of education in developing nations. A comprehensive examination of rigorous studies conducted globally has yielded conflicting results regarding the impact of technology on education. These studies were carried out in various countries. This demonstrates that the efficacy of classroom technology is contingent upon the specific intervention being implemented. In their study, Sidhu, Mehrabi, and colleagues (2023) found that these criteria had an impact on the effectiveness of an intervention in addressing current academic constraints. This supports the idea that the intervention has a crucial role in determining the instructional capability of technology.

This research investigates longitudinal data from a specific subset of third-year primary school pupils in 2020 to assess the potential impact of the PAM on mathematics learning. The present study will rely on data obtained from a sample of third-year elementary school pupils in the year 2020. The data from 2020 third-year students was analyzed in this study. The pupils underwent assessments in reading and mathematics after the academic year, as well as in three subsequent years. Both assessments evaluated the student's comprehension of the subject matter. Based on the statistical data provided by the platform, an analysis was conducted to ascertain the potential correlation between the utilization of the tool and the improvement of children's test scores. The determination was made regarding the impact of the tool on pupils' test scores. This enabled them to ascertain the potential correlation between the tool and the improvement in students' test scores. Consequently, we deduced that the utilization of tools had an impact on profits. The designated project is titled "Takeuchi 2023."

The impact of this intervention on elementary and secondary school children in underdeveloped nations has been demonstrated in experimental research conducted by Banerjee et al. (2007) and Muralidharan et al. These grades were assigned to economically disadvantaged nations. There is a scarcity of studies on technology-assisted learning due to the nascent stage of systematic study. The prevalence of technology-assisted learning is increasing. The recent revelation has engendered a multitude of novel insights regarding the issue at hand. According to the findings of Pande and Moharir (2023), educational programs that are technology-based are demonstrating the highest level of advancement. The study conducted by Muralidharan et al. (2023) examined Mindspark, a software designed for mathematics and language. The efficacy of the interventions is emphasized by the writers. Similar to Plan Ceibal's PAM, this program customizes coaching and training to address specific needs. Algorithms detect error patterns and offer each learner immediate feedback, alternative solutions, and tailored exercises. The survey surveyed a representative sample of secondary school students in Pakistan to assess the extent to which their Mathematics and language skills were enhanced. The influence was identified by the authors. Lower-achieving pupils derive greater advantages compared to their higher-achieving counterparts. The authors assert that the intervention's primary advantage lies in its capacity to individualize schooling. Due to the significant variation in students' talents. According to the authors, the primary benefit of the intervention lies in its ability to individualize education. Authors concur. Considering the influence of this intervention on learning, technology can enhance educational efficiency. Considering the scale of this investment, technology has the potential to enhance educational efficiency. The Adaptive Mathematics Platform (PAM) is an educational platform that utilizes technology to be responsive to the individual knowledge and abilities of students. This enables the system to enhance its ability to cater to the needs of individual students. This analysis provides initial evidence of the effectiveness of the plan in Pakistan. The utilization of the technology in school is determined by both teachers and pupils. It is easily accessible for schooling. Despite its increasing usage, the instructional applications of this technology remain unfamiliar (Ganymede, 2023).

Although assumptions increase the evaluation's internal validity, this method is more flexible to real-world situations than experimental investigations. This is external validity. Although not an experimental study, assumptions improve judgment internal validity. This strategy is more reliable. This method allows nationwide evaluation of an intervention, taking into account larger effects that laboratory research sometimes overlooks. There are several ways to analyze this. This study examines how a national activity affects a population. (Boubakri, 2023).

This study examines how the Adaptive Mathematics Platform affects students' long-term Mathematics learning. This study examines whether PAM, a 2020 elementary school curriculum, improves third-year pupils' Mathematics skills. This study uses student data to illustrate Mathematical knowledge dispersion. This study examines how PAM use affects education at four levels. This longitudinal study uses multivariate regression analysis to explore probable outcomes.

Literature Review and Hypothesis Development

The issue of women's underrepresentation in Science, Technology, Engineering, and Mathematics (STEM) fields has frequently been a subject of concern among researchers and politicians. Based on findings from a survey conducted by UNESCO, it is evident that while 28% of researchers in related fields are women, only approximately 30% of female students in higher education choose to pursue disciplines related to STEM (Chavatzia, 2017, p. 20). The topic of women's underrepresentation in STEM fields is a multifaceted problem that encompasses various underlying factors and potential remedies (Cheryan et al., 2017). According to Schmader (2022), the factors encompassed in this concept are attitude, support, self-confidence, and early experience.

Gender imbalance is detrimental to per capita business income and the various quality-of-life improvements that come with it. There appears to be no consensus that gender disparities in education are more prevalent in low-income countries and among low-income individuals within countries (Baliamoune & Mc Gillivray, 2015; Bank, 2001). Gender disparities in education reduce the benefits of high female education to society. According to the World Bank, the provision of more opportunities to females in terms of education, good health, property ownership, credit, work opportunities, and political empowerment initiates a 'virtuous cycle' for their households and the country (Hamid & Ahmed, 2011).

It can be difficult to distinguish the influence of gender disparities in education, occupation, and wages. Gender differences in one aspect tend to lead to gender differences. Gender disparity in education may automatically lead to a gender gap in the labor market particularly in the formal sector because employers will favor educated applicants and ignore the uneducated ones. Consequently, the gender gap in education and employment is nearly intimately linked (Klasen & Lamanna, 2009).
Moreover, it has been shown that societal attitudes towards girls' education and other manifestations of gender bias exert a substantial influence on the disparity in educational outcomes across genders (Bandyopadhyay & Subrahmanian, 2008). This is a crucial determinant that contributes to the disparity in educational achievements across genders. Consequently, the presence of teachers holding onto generalized convictions fuels the current orientation dissimilarity in schooling. Instructors might need an unbiased nature while teaching issues of gender assuming they hold one-sided convictions about the abilities to learn of young ladies contrasted with young men. The exhibition of females might be unfavorably impacted by this (Glover et al., 2017; Bohren et al., 2019). As indicated by the review directed by Alan et al. (2018), it was seen that female understudies who get guidance from educators who maintain customary orientation mentalities will quite often accomplish lower scores on true mathematics and verbal assessments. This incorporates both oral and quantitative assessments. There is a potential for this impact to turn out to be progressively unmistakable over time. Given the customary relationship of mathematics with guys, the conceivable negative effect on the presentation of young ladies is especially critical in this particular area. Carlana (2019) has shown that the difference in numerical execution between gender disparities is fundamentally heightened when understudies are educated by mathematics teachers who hold more grounded orientation predispositions. Analyzing a teacher's score on the Gender Science Unconscious Association Test can help identify their unconscious biases.
The accomplishment gap may be attributed to gender disparities in personality, as personality is a predictor of academic success in postsecondary education. According to O'Connor and Paunonen (2007), three factors contribute to this association. According to Rothstein et al. (1994), personality traits are predictive of academic performance through their association with behavioral dispositions such as perseverance and talkativeness. The personality traits of women may result in superior academic conduct compared to those of males. Furthermore, cognitive assessments provide insight into a student's abilities, whereas personality factors offer insights into their future behavior, perhaps serving as a predictor of academic performance (Furnham & Chamorro-Preimuzic, 2004). According to Carvalho (2023), men and women possess similar cognitive abilities. However, variations in personality across genders can influence the academic success of students.
One additional rationale for considering personality traits as indicators of academic performance are that cognitive abilities may diminish in their ability to accurately predict outcomes in the context of higher education (Furnham et al., 2003). O'Connor and Paunonen (2007) found that the correlation between cognitive capacity and academic success is weaker among university students compared to elementary and secondary school pupils. College students may overcome obstacles to pursuing higher education and possess restricted intellectual capacity. The study conducted by Furnham et al. (2003) demonstrates that personality variables, namely gender disparities, have an impact on academic achievement at universities. One argument that has generated debate is the notion that women's personalities may be more compatible with higher education compared to men's (Almås et al., 2023). According to Vincent-Lancrin (2008), teachers may have a preference for feminine actions. The lack of clarity in views and the existing literature may account for the gender gap in schooling and the ability of personality to predict achievement.
For many years, the disparity in learning outcomes, particularly in Mathematics class, has been a fascinating topic for educational researchers. Different studies have been directed to choose if males or females perform better mathematically. The researchers revealed that the variety in the presentation could be massive or little, and the explanation might be social presumptions, self-acumen, and speculation risk. Various experts have focused on the normal effect of direction on Mathematics learning results. In specific assessments, for example, male students get additional astonishing scores and perform better compared with female students in state-endorsed tests and assessments of science. Acknowledged practices and speculations that show that it is generally a male practice to perform better contrasted with females have regularly been referred to as the wellspring of this opening.
The impact of orientation on learning results in mathematics has been a subject of discussion and examination for quite a long time. A few examinations have revealed that male understudies will quite often beat female understudies in government-sanctioned tests and evaluations in Mathematics (e.g., Hyde et al., 2008; Else-Journey et al., 2010). These distinctions have frequently been credited to cultural standards and generalizations that depict Mathematics as a subject fitter for guys, prompting contrasts in certainty, inspiration, and commitment between sexual orientations (Nosek et al., 2009).
However, another exploration has tested the thought of inborn distinctions in gender differences in numerical capacity and accomplishment. Concentrates, for example, the ones led by means of Gunderson et al. (2012) and Hyde and Mertz (2009) suggest that while gender disparities may exist, they are now not truly because of natural or intrinsic contrasts in numerical health. All things being identical, these examinations underscore the task of ecological and socio-social elements in forming understudies' mentalities, convictions, and execution in Mathematics.

One vital element that might intervene within the connection between gender disparities and studying effects in mathematics is the understudies' scholarly exhibition. Scholarly execution, as estimated with the aid of grades, test ratings, and homeroom commitment, can act as a mark of understudies' authority over numerical ideas and abilities. Research has shown that distinctions in scholarly execution among male and woman understudies can add to orientation holes in numerical accomplishment (Eccles et al., 1990; Penner & Paret, 2008). For instance, if woman understudies get decreased grades or perform less well on normalized science exams contrasted with their male partners, this will fuel existing orientation variations inside the subject.

Table 1: Studies Reporting Gender Differences in Mathematics Achievement

Study	Findings
Hyde et al. (2008)	Male students tend to outperform female students in standardized tests and assessments in mathematics.
Else-Quest et al. (2010)	Similar findings indicate male students outperforming female students in Mathematics assessments.
Nosek et al. (2009)	Gender disparities are attributed to societal norms and stereotypes portraying mathematics as a subject more suited to males.

Table 2: Studies Challenging Inherent Gender Differences in Mathematics Achievement

Study	Findings
Gunderson et al. (2012)	Gender disparities in Mathematics are not necessarily due to biological or innate differences but are influenced by socio-cultural factors.
Hyde and Mertz (2009)	Environmental and sociocultural factors play a significant role in shaping students' attitudes and performance in mathematics.

Table 3: Studies Highlighting the Mediating Role of Academic Performance

Study	Findings
Eccles et al. (1990)	Differences in academic performance between male and female students contribute to gender gaps in Mathematical achievement.
Penner & Paret (2008)	Lower grades or poorer performance by female students in Mathematics exacerbate existing gender disparities in the subject.

Additionally, the effect that mastering results has on shaping students' Mathematical experiences and achievements can't be overstated. The integration of tutorial generation has lately given upward thrust to adaptive studying environments. These settings cater to the particular desires, options, and learning methods of each student. Such environments offer individualized learning trips, instant remarks, and bendy content transport. This tailor-made approach can lessen the gender gap in arithmetic by imparting equitable aid to all students, no matter their gender (Rosen, 2018).

Hypothesis Development

Based on the literature reviewed, the following hypotheses are proposed:

Hypothesis 1 (H1): There is a positive relationship between gender disparities and learning outcomes in mathematics.

Hypothesis 2 (H2): Academic performance has a mediating effect on the relationship between gender disparities and learning outcomes in mathematics.

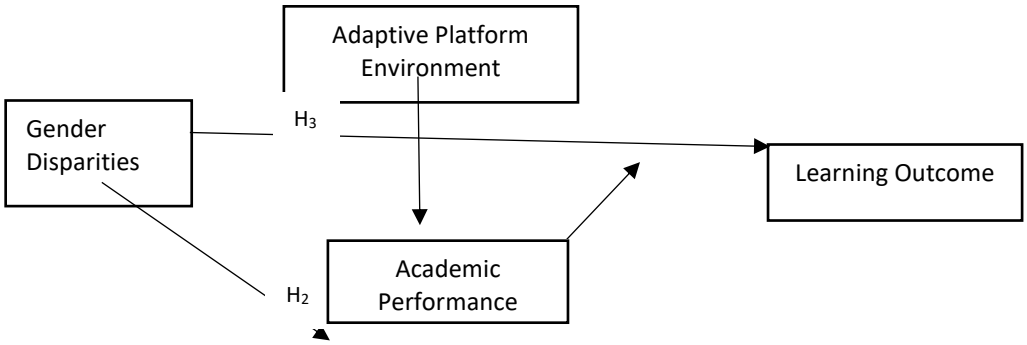
Hypothesis 3 (H3): Adaptive platform environment has a moderating effect on the relationship between gender disparities and learning outcomes in mathematics.

It is hypothesized that the differential effect of gender on mathematics outcomes will be less pronounced in adaptive learning environments, suggesting that such platforms may mitigate the gender-based variations in Mathematics achievement that are observed in more conventional educational settings.

Additionally, the mediating impact of academic overall performance underscores the need for specialized strategies to deal with the educational imbalances among genders. By emphasizing the enhancement of educational overall performance, the ones within the instructional and coverage geographical regions can decrease the effect gender has on instructional effects, accordingly advancing an extra equitable attainment of education. Approaches consisting of the supply of particular guides and sources, the utility of teaching strategies grounded in studies, and the development of an encouraging instructional ecosystem, can contribute to empowering younger women to thrive in historically male-dominated subjects along with Mathematics and assist close the gender gap in instructional performance.

To summarize, the influential role of academic fulfillment is famous for the problematic relationships between gender, scholastic accomplishments, and educational consequences. Identifying and tackling the elements that lead to gender gaps in school performance allows teachers and decision-makers to strive for learning spaces that are fair and supportive, helping every student succeed.

Figure 1: A proposed conceptual model



Methodology:

The students use the software for a cumulative total of ninety minutes outside of the normal classroom hours. The first half of the session is spent engaging in self-directed activities, and the second half of the session is spent getting assistance from an assistant in groups of between 12 and 15 students. The first half of the session is spent engaging in self-directed activities. The amazing efficacy of many therapies that have been established in research that has been published can be explained in another manner by adapting the teaching approach to the student's present level of understanding. This is one of the ways that has been demonstrated in the research that has been published. For an illustration of this, see Banerjee's evaluation of the "Balsakhi" Program in Pakistan. Another example of this would be the practice of classifying students according to the level of their abilities. For an illustration of this, see the evaluation of the influence that "tracking" had in Kenya. (Kumar & Sahu, et al. 2023)

The assessment of the impact of the PAM will be facilitated by the use of longitudinal learning data, the examination of PAM usage fluctuations between 2021 and 2023, and the utilization of reading gain as a measure to mitigate selection bias resulting from unobservable factors that influence student performance (Ganglo, 2023). This approach will assess the influence of the PAM.

We provide a breakdown of the empirical model that was utilized, as well as additional estimates to support the validity of the findings that were uncovered. See the commentary provided by Banerjee et al. (Boubakri 2023) for additional information on how to scale up programs that have proven successful in earlier, smaller-scale experimental trials.

Before doing empirical exploration on the hypothesis, evaluating the validity and reliability quality of the data is critical. The persistence of information is assessed utilizing Cronbach's Alpha and composite dependability. On the other hand, Hair et al. (2010) propose that it is fitting for the determined Cronbach's alpha of every variable to outperform 0.7. The authors Feng and Wang (2016) proposed that the composite dependability value of each variable should exceed 0.6. The trustworthiness of the data for further investigation is demonstrated by the estimations presented in Table 4.

The validation of both the concept and content was conducted. Content validity was ensured by the involvement of three researchers, feedback from participants in a pilot study, and an extensive examination of relevant literature. The utilization of principal component analysis with varimax rotation serves to enhance the validity of the construct. The findings of the extraction of four variables with eigenvalues equal to or greater than 1 are presented in Table 4. These variables collectively explain 76.4% of the total variation. According to Beauducel and Wittmann (2005), all items exhibited significant loading on their designated constructs, with factor loadings exceeding 0.60. Furthermore, the presence of cross-loading did not pose any concerns. This observation illustrates the unidimensional nature of items. Based on the results presented in Table 5, it is necessary to conduct additional analysis on the 5-factor model. This illustrates the constructs' ability to differentiate between different groups, as the square root of the average variance retrieved is greater than any correlation between pairs.

All variance inflation factors were found to be below 2, suggesting that multicollinearity is not a concern in this study. The present study utilizes hierarchical regression analysis, and the results of three separate regression models are presented in Table 6. The control variables of Gender disparities, Academic performance, and Adaptive platform environment are used to conduct a regression analysis on the learning outcomes.

Table 4: Reliability and validity estimates

Variable	Item	Standardized item loading	Composite reliability	Cronbach's Alpha
Learning Outcome	LO1	0.75	0.862	0.784
	LO 2	0.81		
	LO 3	0.83		
	LO 4	0.88		
Gender Disparities	GD 1	0.68	0.893	0.823
	GD 2	0.79		
	GD 3	0.82		
	GD 4	0.87		
	GD 5	0.77		
	GD 6	0.82		

Adaptive Platform Environment		APE 1	0.78	0.901	0.844
		APE 2	0.77		
		APE 3	0.79		
		APE 4	0.82		
		APE 5	0.77		
Academic Performance		AP 1	0.632	0.872	0.841
		AP 2	0.762		
		AP 3	0.711		
		AP 4	0.768		

Table 5: Discriminant validity estimates

	Mean	SD	LO	GD	APE	AP
LO	5.121	0.861	**0.783**			
GD	5.726	0.924	0.486***	**0.818**		
APE	4.865	0.796	0.285***	0.176*	**0.732**	
AP	5.289	0.901	0.352***	0.399***	0.501***	**0.810**

Note: the bold numbers in the diagonal show the square root of the average variance extracted.
**α=0.01, ***α=0.001

The data

The current investigation is founded on two separate data sets that were acquired in the past and used as a foundation. A database that includes two national learning evaluations is made available to the general public by the Department of Educational Research and Statistics of the Central Board of Directors of the National Public Education Administration (DIEE/CODICEN/ANEP). Plan Ceibal was solely responsible for developing and maintaining the second database, which was based on the records that were kept up to date by the platform itself. This database was created by Plan Ceibal. The research utilized a database that cataloged various methods students employed when engaging with the PAM. A unique student identifier connected this database to another, facilitating the investigation (Eckardt, Ainsworth, et al. 2023). Consequently, the research could explore the relationship between students' test performance and their use of the academic tool.

In 2020, a select group of third-grade students underwent evaluation through two distinct assessments focused on reading and mathematical skills. These examinations aimed to reflect the broader academic abilities of all students within the school. The initial information set was constructed by compiling the findings of these tests into a single body of data. The first of these examinations was carried out at the end of the year 2020, and the second of these examinations was carried out at the end of the year 2023, at which point the great majority of these youngsters were enrolled in the sixth grade. According to Abbas, Ekowati, and others (2023), the test for the Third Regional Comparative and Explanatory Study, which is more often referred to as TERCE, was carried out in the year 2020. A multinational survey known as TERCE is currently under the supervision of the Latin American Laboratory, which is responsible for its coordination.

The United Nations Educational, Scientific, and Cultural Organization evaluated the quality of education (LLECE), in which Uruguay was one of the 15 countries that took part. The area of the world that is commonly referred to as Latin America (please refer to UNESCO-OREALC, 2023, which has been attached here for your personal use should you require any further information regarding the format of the assessment instruments).8. In 2023, the DIEE/CODICEN/ANEP performed the second learning evaluation with the class of third-grade kids who had previously participated in the TERCE 2020 program. In this evaluation, the students were asked to reflect on what they had learned from the TERCE 2020 program. When the incident in question took place, the vast majority of these students were in the very final year of their elementary school education. Since LLECE/UNESCO always uses the same methodological strategy when conducting evaluations of regional programs, this most current evaluation was carried out in the same fashion as all of the others. The DIEE also carried out a method to equate the results from the third grade to the metric of the sixth grade. This technique enabled the analysis of students' development between the third and sixth grades in absolute terms, both in Reading and mathematics (Boubakri 2023). The method was carried out to make the outcomes of the third grade comparable to those of the sixth-grade metric. This procedure was carried out so that the points obtained in the third metric could be converted into those obtained in the sixth measure.

The information that is provided in the table that is located below applies to the total number of students who were evaluated in reading and mathematics in 2020, and 2023, and in the combined total for both years. The students who participated in this study and were included in the sample were drawn from the second group. These are the pupils to whom an evaluation of the quantity of knowledge gained between the two examinations was feasible. The results presented henceforth originate from an analysis of 2,143 children's assessments in Mathematics and reading conducted in the years 2020 and 2023, as documented by Abbas, Ekowati, and colleagues in 2023. This was done so that the findings could be more accurately presented. The conclusions that are shown below were compiled using this information, which may be

found below. These individuals received their education at one of the nation's 237 public or private schools, which are dispersed over a wide range of states and geographic areas.

Table 6. Number of students evaluated in mathematics and reading and number of schools involved according to the year of the evaluation.

	Students	**Schools**
Evaluation 2020	3761	242
Evaluation 2023	2349	237
Evaluation 2020y2023	**2143**	**237**

PAM usage metrics for the years 2020, 2021, 2022, and 2023 were gathered from the platform and are included in this set of data. These metrics are part of the second group of data. To be more exact, the number of exercises that were completed by the students in each of these years was tallied and retrieved as part of the data collection. This was done to present an accurate image of the activity that they were engaging in. Who among these children participated in the assessments of their learning that were conducted in year 10? In the year 2023, there was a statistic that reflected the student's participation in the Mathematics Championship as well as the number of exercises they finished. This statistic also included the total number of problems they solved. In addition, the total number of issues that were resolved was included in this metric. Because of this, it was feasible to reassemble a measurement of the total amount of workouts that were accomplished outside of the context of the competition. This latter variable was the one that was ultimately employed to arrive at an estimate of the entire amount of time that was spent making use of the PAM in 2023 (Yaqoob, Tariq, & Ahmad 2023). This estimate was used to determine the total amount of time that was spent making use of the PAM in 2023.

Within the context of this scenario, there are going to be three distinct user groups that are put to use. A user will be regarded to be a student in a given year (or period) if they have done at least one exercise, at least 10 exercises, or at least 20 exercises in that given year or the (annual) average of a period within that given year. This requirement can also be met by completing the period's average of period within that given year. The percentage of users who may be classified into each of these three categories based on the amount of time they spend on the site is presented in Table 7. Let's say we're going to zero down on 2023, and we're going to take into consideration the activities that the students engaged in that were unrelated to the contest. In that situation, 33% of the students utilized the platform for 10 or more activities, 39% of the students used the platform for 10 or more activities, and 44% of the students used the platform for 20 or more activities. Putting in some time at the gym. The results of our study indicate that over the period under consideration, there was a visible growth in the application of the term "platform," regardless of whose interpretation of the term "platform" we choose to go with. For example, between the years 2020 and 2023, the percentage of students who completed 20 or more exercises increased from 11% to 39% (Takeuchi 2023). In the equation for multiplication, this would translate to a factor of 3.5.

Because there was not a significant difference in the contrasts between the sample that was initially collected for TERCE and the sample that was ultimately evaluated, a bias caused by the loss of the sample cannot be anticipated even though it occurred.10 There is an indication for participation in the year 2023 that takes into account both the total number of questions that a student answered correctly while participating in the Mathematics Championship and whether or not the student participated in the competition. Because of this, it was feasible to reassemble a measurement of the total amount of workouts that were accomplished outside of the context of the competition. This second variable ended up being picked as the foundation for approximating the educational application of the PAM in 2023 (Sidhu, Mehrabi, 2023) since it was regarded to be the most appropriate variable to use in this capacity.

Table 7. Percentage of PAM user students who performed at least 1, 10, or

Year	**G1**	**G2**	**G3**
2023	44.4	39.0	33.8
2023	48.2	42.7	39.0
2022	42.9	37.9	28.8
2021	36.4	20.7	14.1
2020	20.7	13.4	11.3
2021 -2023	67.5	51.8	42.7

It is important to keep in mind that the percentage of users for the years 2021-2023 refers to the proportion of students who completed at least "N" exercises annually on average across those three years. The information is laid down in the table that follows this paragraph.

The accompanying table (Table 8) gives some measures of the various numbers of exercises that were carried out by students while using the platform. These measurements were taken for three weeks. Take into account not only the year 2023 but also the events that emerged outside of the scope of the competition. According to the data that we compiled, one-fourth of the users completed as many as 22 activities, one-half of the users finished as many as 84 activities, and 75% of the users finished as many as 274 activities. For several years, particularly in 2023, students who utilized the PAM increased the quantity of physical activity they conducted (Pande & Moharir 2023). The most noteworthy expansion took place during this particular year.

We are therefore in a position to assert with absolute certainty that, throughout the time that is being taken into account, there was an increase in the use of the platform both in terms of its extensive margin (the number of users) and its intensive

margin (the number of exercises per user). This is because we are in a position to say for certain that there was an increase in the use of the platform throughout the period that is being taken into consideration.

Table 8. Percentiles of the number of exercises performed by the students who used PAM according to period. A sample of 2143 students from 237 schools

Year	Percentage 25	median	percentage 75	percentage 90
2023 (Total exercises)	22	84	274	402
2023 (total exercises)	25	102	461	931
2022 (total exercises	17	39	140	546
2021 (total exercises)	5	12	39	67
2020 (total exercises)	7	24	61	89
2021-2023 (total exercises)	11	43	167	329

Empirical strategy

When attempting to discover the direct cause-and-effect link that is linked with an intervention in an educational setting, one encounters a wide array of tough problems. The necessity for accurate measurements of the variables of interest, the academic success of pupils being the most important of them, is the first issue that needs to be addressed as part of this project. This is the first issue that needs to be addressed. This assessment of the impact of the PAM was carried out using data that can be relied upon to be correct. Examinations that are patterned after those that are used in other countries give the yardstick that can be used to gauge the level of success attained by students. The pupils who took part in these examinations come from around the country and are drawn from a sample that is meant to be representative of the population of elementary school children who, in 2020, were in the midst of their third year of instruction. On the other hand, the measurement that is acquired through the utilization of the PAM is information that is objective and is compiled from the records of the platform (Kumar, Sahu et al. 2023).

Let's put ourselves in the following situation in our heads so that we may get a better grasp on this significant matter. Assume, for the sake of the argument, that the utilization of the PAM does not alter the amount of knowledge that is obtained, but that students who have a strong desire to learn are more likely to employ it (for reasons that are not connected to the PAM). Along the same lines, the extent to which a student is motivated to learn is one of the traits that contribute to an explanation of how much progress they make in reading and mathematics throughout the academic year. If we were to proceed to compare the degrees of Mathematical growth of students who use PAM to the degrees of Mathematical growth of students who do not use PAM, we would find that students who use PAM have a higher degree of Mathematical growth than students who do not use PAM. This would be the case if we were to compare the levels of Mathematical growth of students who use PAM to the levels of Mathematical growth of students who do not use PAM. In this situation, we would incorrectly attribute MAP as the cause factor of said difference; however, in reality, this finding is due to an omission bias of the underlying causation element, which is motivation. MAP is not the cause of said difference. In other words, we would be incorrectly attributing the cause component of the difference to MAP, which would be the case if we did this. To put it another way, if we did that, we would be wrong. Supposing we tested PAM users and non-users in a slightly different way and compared them based on their Mathematical gain minus their reading gain (Ganglo, 2023). we would find that there is a significant difference between the two groups.

It is recommended that a separate conversation be made on the subject of precisely what it means to be a PAM user. As was just detailed, the results that will be shown will be based on the concept that a PAM user is a student who completes a predetermined minimum number of exercises in a given year (at least one, at least ten, or at least 20 exercises in the year). This premise will serve as the foundation for the data that will be presented. This assumption is going to be put to the test when we compare the findings that are going to be provided with the findings that were acquired in the research that we have just finished going over. A second aspect that must be taken into consideration is the question of whether or not the viewpoints of the instructors or those of the students should be given more weight during the decision-making process. The information that is provided correlates with the use that is made by the student, and it demonstrates a significant intra-group correlation, which suggests that the decision that the instructor makes regarding the incorporation of the PAM is a factor that determines the use that is made by the student. The intra-group correlation also displays a significant correlation, which suggests that the information that is provided correlates with the use that is made by the student. The information that is presented has a direct bearing on the application that the learner makes of it. In the ongoing issue about whether or not to include a measurement of student use or group use (as a proxy for teacher use), the mechanism by which PAM can affect student learning is a key consideration that should be taken into account. The last function, on the other hand, is dependent on how the instructor makes use of this tool inside the constraints of the classroom. This feature can be enabled or disabled at the discretion of the instructor. In this investigation, we will limit ourselves to providing statistics that, in addition to the total score for the class, take into account metrics of student use (Eckardt, Ainsworth, et al. 2023).

Results

In hypothesis H1, we posited that Gender disparities (GD) exert a positive influence on learning outcomes (LO) in Pakistan. The data of Table 9 M1 support hypothesis H1, suggesting that a slight rise in GD is associated with a 0.236 increase in learning outcomes in Pakistan.

Table 9: Hierarchical Regression Estimates

Variable	M1	M2	M3
LO	0.236***	0.226**	0.228***
GD	0.142*	0.084	0.102
APE			0.211*
AP		0.167*	
Constant	2.122***	1.925***	0.992***
N	511	511	511
R^2	0.415	0.472	0.522
F	15.521***	11.881***	14.544***
ΔR^2	0.415	0.046	0.107
ΔF	15.521***	7.313**	5.855***

Note: standardized coefficients are used
***α=0.10, **α=0.05, ***α=0.01**

In H2, we posited that the relationship between GD and LO is influenced by APE, which serves as a moderating factor. The data presented in Table 9, M2, indicates that APE does not have a significant influence on LO when considered as an independent variable. It is accurate to assert that H2 suggests that APE has a moderating role in the association between GD and LO. The conclusions are supported by the results of the F-test and R2 statistics.

The inclusion of a mediating variable (β=0.228***) in the analysis of the independent variables in M3 demonstrates a significant positive relationship between GD and LO. These estimations provide support for H3, suggesting that AP acts as a mediator in the connection between GD and LO.

Each estimate is derived using the standardized values of the test results. Hence, the utilization of standard deviations (SD) is employed to quantify improvements in Mathematics and reading. During their three-year instruction, the pupils in the sample achieved an average improvement of 2.6 standard deviations in mathematics and 1.9 standard deviations in reading (Boubakri, 2023).

The graph presented below illustrates the density function of the reading gain (lower graph) and the mathematics gain (upper graph), with the red line representing PAM users and the green line representing non-users. According to Abbas, Ekowati et al. (2023), the individuals who utilize this visual representation are students who completed tasks from 2021 to 2023. The graph demonstrates that the PAM user condition does not have any impact on reading gain, but it significantly disrupts Mathematics gain. The allocation of Mathematical advantages varies significantly between users and non-users. The density function of students who made use of the platform exhibits a rightward shift, indicating a tendency towards higher marks. According to Yaqoob, Tariq et al. (2023), reading does not demonstrate this.

Graph 1. Distribution of the gain in Mathematics (upper panel) and reading (lower panel) between users (red line) and non-users of the PAM (green line)

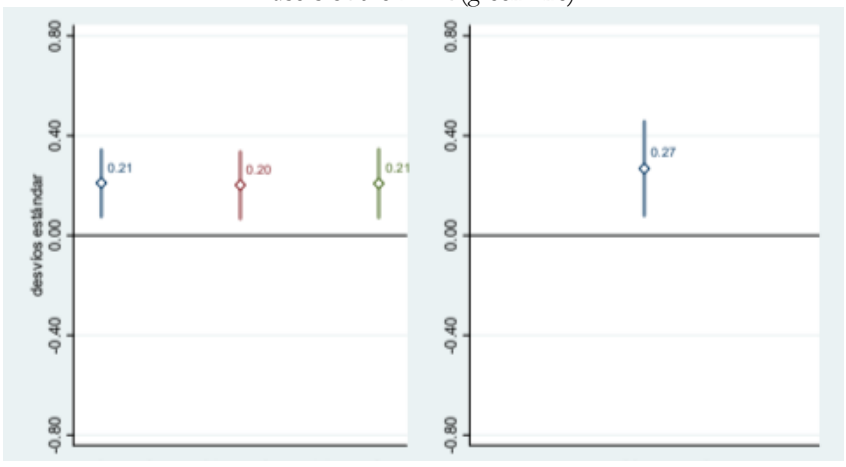
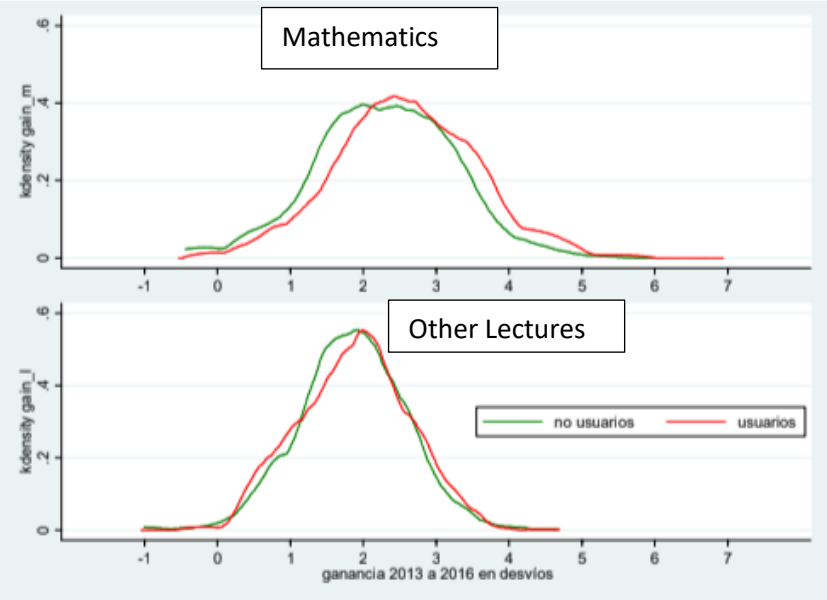


Figure 1. Distribution of the gain in Mathematics



Now, let us analyze and contrast the mean incomes in each region for individuals who utilize and those who do not. Instead of analyzing the distribution of incomes, we will instead compare the central tendency of each distribution between individuals who use the product and those who do
not. This comparison serves to quantify the alteration in density functions that have been previously observed. The statistical significance of the displacement is assessed by conducting a statistical contrast. The information presented in Table 4 is derived from several user definitions of the platform, as outlined by Pande and Moharir (2023).
Table 10 presents the information it uncovers. Firstly, platform users constantly exhibit a greater average Mathematical advantage in comparison to non-users. Furthermore, except for one of the user definitions where the disparity is less than half of the observed difference in Mathematics, there is a lack of statistically significant disparities in reading proficiency between individuals who used the application and those who do not. Currently, the available evidence substantiates the hypothesis that this instructional tool is associated with Mathematical learning but not with reading (Kumar, Sahu, et al. 2023).

Table 10. Average gain 2020-2023 in Mathematics and Reading between PAM users and non-users according to different user definitions

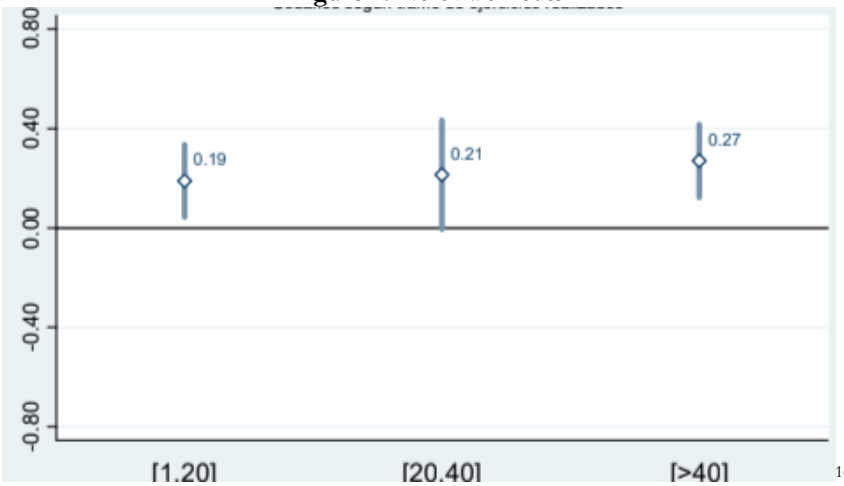
User definition	**users**	**no users**	**difference**	**users**	**no users**	**difference**
Ejercicios en 2023						
1 or more	2.63	2.33	0.30***	1.91	1.86	0.05
10 or more	2.59	2.37	0.22***	1.94	1.85	0.09***
20 or more	2.57	2.40	0.17***	1.90	1.87	0.03
Ejercicios entre 2014 y 2023 (*)						
1 or more	2.56	2.24	0.32***	1.88	1.88	0.00
10 or more	2.60	2.31	0.30***	1.90	1.86	0.05
20 or more	2.56	2.38	0.18***	1.90	1.87	0.03

Here, we provide a more comprehensive examination of the distinctions between individuals who use and those who do not. This suggests the need to assess the Mathematical progress of the students while considering potential disparities between the two groups across many measurable factors such as initial score, gender, socioeconomic position, geographical location, and kind of educational institution. In addition, it is imperative to consider reading proficiency, as elucidated in section 3. Utilizing a regression model facilitates this. The data collected are presented in Table 10. The first three columns of the webpage display the Mathematical benefits that pupils gain, as defined by the three users. The three estimations are depicted in the left panel of Graph 2. The disparities are substantial and beneficial. According to Ganglo (2023), the coefficients obtained from the calculations suggest that the PAM has a standard deviation influence of 0.20 on Mathematical improvement.
Column 4 of Table 10 modifies the user condition by changing it from a student attribute to a group attribute. The modification of the variable of interest in the regression model is indicated from a methodological standpoint. Specifically, the variable representing the proportion of student users within the group is substituted for the user indicator variable. This type of measurement of platform utilization can function as an indicator of teachers' competence in utilizing it within the educational setting. The variable's coefficient is illustrated in the right panel of Graph 2. The observation is noteworthy and motivating, as it demonstrates that students experience enhanced benefits in Mathematics when they utilize it within

collaborative environments. The findings of this research enable us to deduce the significance of employing collaborative resources implemented by educators, along with the presence of external variables at the classroom level (Eckardt, Ainsworth, et al., 2023).

The recent study examines the correlation between the number of exercises performed on the platform, which serves as an indicator of users' level of engagement, and the extent of progress in Mathematics skills. This analysis is comparable to its predecessor, but it categorizes users according to the number of workouts they engage in within a specific year (column 5 of Table 10 and Graph 3). Similarly, the group's level of usage can be described by categorizing it into four segments according to the median number of exercises completed by the students in the group (column 6 of Table 10 and Graph 4). It is imperative to acknowledge that the available information does not substantiate the hypothesis positing a correlation between the frequency of exercise sessions and the development of Mathematical abilities (Boubakri, 2023).

Figure 2: No of workouts



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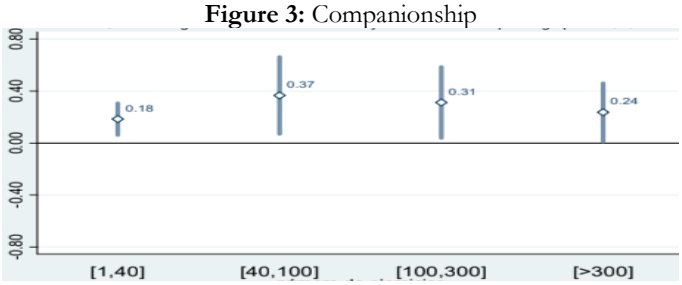
The presence of championships introduces a potential bias in the assessment of usage intensity, particularly when this differentiation has substantial importance. Although this statistic was applied to the 2023 data using the number of exercises completed outside of the tournament, it may not completely account for the number of workouts produced by the competition. Based on the modified metric employed, it becomes apparent that the participants of the championship exhibit a higher average number of workouts compared to the other groups (Abbas, Ekowati et al., 2023).

Figure 3: Companionship



Discussion and Conclusions

The findings presented in Table 9 M1 offer compelling aid for speculation H1, which proposes that gender disparities exert a fine have an impact on on learning effects in Pakistan. According to the records, even a moderate boom in gender disparities correlates with a fantastic improvement in gaining knowledge of consequences, indicated by way of a 0.236 growth. This result underscores the complex dynamics at play in instructional structures, particularly in contexts like Pakistan where gender inequalities persist. The implication is that efforts to deal with and mitigate gender disparities may want to potentially yield sizeable blessings in phrases of improving educational outcomes. However, it's essential to apprehend the multifaceted nature of this relationship and to delve deeper into the underlying mechanisms driving these results. Further studies exploring the nuanced interaction between gender dynamics and learning consequences is warranted to inform extra centered interventions and rules aimed at fostering equitable and effective educational environments.

The results presented in Table 9, M2 shed mild at the nuanced dating between gender disparities (GD), studying outcomes (LO), and academic overall performance expectancy (APE), as hypothesized in H2. Initially, H2 posited that the affiliation between GD and LO is stimulated with the aid of APE, suggesting a moderating position for APE in this courting. However, the information implies that once considered as an unbiased variable, APE no longer exerts a large effect LO. This locating may additionally appear contradictory at the start glance, however upon nearer examination, it underscores the complexity of the relationships at play. Despite the shortage of direct impact, H2 nevertheless holds weight, suggesting that APE may indeed play a moderating position within the association among GD and LO. This interpretation is reinforced

with the aid of the outcomes of the F-take a look at and R2 facts, which assist the perception that APE influences the electricity or path of the relationship among GD and LO, although it does not independently predict LO. These findings spotlight the need for further research to elucidate the mechanisms via which APE operates as a moderator, in addition to its implications for instructional guidelines and interventions aimed at addressing gender disparities and improving learning outcomes.

The integration of a mediating variable, denoted by β=0.228***, into the analysis of independent variables in Model 3 (M3) unveils a compelling insight into the dynamics between gender disparities (GD), academic performance (AP), and learning outcomes (LO). The results indicate a significant positive relationship between GD and LO, bolstering the support for hypothesis H3. This finding suggests that academic performance indeed acts as a mediator in the connection between gender disparities and learning outcomes. By establishing this mediation pathway, the study sheds light on the intricate mechanisms through which gender inequalities impact educational outcomes. Specifically, it underscores the role of academic performance as a crucial factor that mediates the effects of gender disparities on learning outcomes. These findings hold important implications for educational policies and interventions, emphasizing the need to address both gender disparities and academic performance in tandem to foster more equitable and effective learning environments. Further research exploring the underlying mechanisms and potential interventions stemming from these findings could contribute significantly to efforts aimed at narrowing educational gaps and promoting inclusive education.

The objective of this study was to examine the correlation between the implementation of the PAM and the amount of Mathematical knowledge acquired by a group of primary school children based on longitudinal data. We employed an empirical methodology that relied on the available facts but with certain predetermined assumptions. To achieve this objective, the acquisition of longitudinal data on learning was deemed essential. The data allowed for the observation of substantial diversity in how pupils employed the PAM. Furthermore, it provided the opportunity to employ improvements in reading skills as a means to mitigate the inherent selection bias in this type of analysis (Pande & Moharir, 2023).

The mean advancement attained by the same students after three years of study is calculated to be 2.6 standard deviations, serving as a benchmark for this outcome. The practical evaluation of this outcome can be conducted by employing cost-effectiveness analysis, a method that compares the outcomes of the intervention under investigation with the associated costs. While the current analysis does not specifically focus on the PAM strategy, it is plausible to assume that it is a very cost-effective approach (Sidhu, Mehrabi, et al., 2023).

During the evaluation of the platform's impact, we have observed that students derive greater benefits in direct proportion to their level of engagement with the platform inside the classroom setting. Based on this outcome, we may acknowledge the importance of the teacher's impact on the group's usage of the tool, as well as the existence of external factors at the class level (Takeuchi: 2023).

Given the findings of Muralidharan et al. (2023), it is crucial to underscore that the integration of technology in educational environments should not be perceived as diminishing the importance of the instructor in delivering teaching. Concerning this specific issue, it is crucial to consider it. Conversely, when technology is employed to perform mundane tasks (such as skill categorization) and tasks that necessitate extensive data analysis (such as recognizing patterns in student responses and offering tailored feedback and guidance), it can complement the instructor's activities. To provide an example, educators can allocate additional time toward educational domains in which they possess a competitive edge over technological advancements. This enables educators to enhance their academic support for children. For example, individuals may allocate additional time towards the facilitation of collaborative learning methodologies, which can contribute to the enhancement of social and non-cognitive skills (Yaqoob, Tariq, et al., 2023).

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