Bridging Motivation and Mastery: The Role of Self-Efficacy in Math Education

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***Abstract* – The main objective of this study was to examine new ways of assessing self-efficacy in learning mathematics that affect students' educational performance through perceived utility and intrinsic motivation. The study's research design was cross-sectional in nature, consisting of 1232 elementary-level students. Data were collected using the Mathematics Motivation Scale (MMS), which was later analyzed using SmartPLS4 and SPSS software. After analysis, the authors concluded that SELPM (Self-Efficacy to Learn and Perform in Mathematics) partially mediates the relationship between the IMLM (Intrinsic Motivation to Learn Mathematics) of the students and their PUM. The researchers suggested that teachers should design effective teaching methodologies that significantly contribute to their (self-efficacy to learn and perform in mathematics) SELPM, (intrinsic motivation to learn mathematics) IMLM, and PUM (Perceived Utility of Mathematics). Future studies might be conducted to replicate the study's result and to explore the causes of the partially mediated effect of students' SEPM between their IMLM and PUM.**

***Keywords* – Elementary students, intrinsic motivation, perceived utility, self-efficacy, mathematics.**

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1. Introduction

The ability to address challenges and complexities is inherent to humans. It forms the foundation of all intellectual disciplines and areas of inquiry [1]. Mathematics is an important area of study that enables a person to tackle various challenges and deal with day-to-day matters [2]. As a result, it is taught to almost everyone worldwide [3], making it an essential component of curricula at different levels of formal education [4], [5]. It has wide-ranging utilities with practical and professional applications [6]. Mathematics education aims to increase students' knowledge and practical application of the subject [7]. According to Ning [8], it is one of the most critical aspects of an educational system, as it could help in higher-level cognitive functions such as problem-solving, creativity, probability, and mathematical reasoning. Mathematics is believed to be one of the disciplines that help push the boundaries of science and technology [9], [10]. Thus, a strong foundation is essential for any nation's technological and economic development [11], [12], [13].

Mathematicians study numbers, shapes, dimensions, and dynamics, making mathematics an essential field of knowledge for learning and enhancing students' analytical skills [14], problem-solving [15], spatial visualization [16] and speculative thinking skills [17]. As a result, it helps them become effective and productive citizens [18].

Mathematics is generally considered a more challenging and complex subject [19]. This difficulty is not limited to classroom performance but also the ability to use it in everyday life. Rodríguez *et al.* [20] said that students often had low self-perceptions about their mathematical skills, which could lead to negative thinking and doubts about their effective use. However, students' active participation, intrinsic motivation, perceptions of utility and importance, and self-efficacy can change their attitude and approach to it [21].

1.1. Intrinsic Motivation of Students and Mathematics Learning

Due to mathematics' significance and unique nature, its teaching-learning process has seized the attention of researchers and educationists [22], [23]. Students are usually driven to study and do well in class due to their intrinsic motivation [24]. They perform better in class when they truly care about their learning and are interested in the process. It is believed that an individual's intrinsic motivation is generally fueled by one's pursuit of and willingness to take on new challenges. Even when no tangible benefits are at stake, people are willing to acquire new knowledge and put their skills to the test if interesting challenges are posed. Intrinsically motivated learners actively pursue knowledge in their studies [25]. They are also more likely to be more regular, set higher goals for themselves, and achieve goals [26].

Mathematics teaching is also most effective when students are motivated and actively participate [21], [26], [27]. Goal setting and IMLM of students are strongly interrelated factors [28]. Interest in the subject and learning are inextricably shaped by the learning environment and motivation [29], [30]. Adamma *et al.* [26] examined the influence of intrinsic motivation on students' school success in different mathematics-related tasks. Data from 200 elementary students were collected, and they found that students' intrinsic motivation correlates with their success and task performance in mathematics.

1.2. Intrinsic Motivation of Students and the Utility of Mathematics

There have been some studies about intrinsic motivation and the utility of mathematics. The findings of those studies are mixed. Some found a positive correlation between those two variables, while others found either a negative or no correlation. A study by Middleton [31] revealed that the utility of mathematics contributed to students' intrinsic motivation. Suárez et al. [32] also found intrinsic motivation to be a significant predictor of students' behavioral engagement and the utility of mathematics. Another study by Rodríguez et al. [33] also supported this. It was found that when students believed their learning would be helpful in their daily lives, they paid more attention to their tasks and completed them better.

Sivrikaya et al. [25] also examined the correlation between intrinsic motivation and performance. After collecting data from 500 students using a questionnaire, they found that students' intrinsic motivation was on the higher side; however, the relationships between intrinsic motivation and the subfactors of the scale were weak.

However, Husman et al. [34] found no correlation between intrinsic motivation and the perceived utility of mathematics (PUM).

1.3. Students' Self-efficacy and Utility of Mathematics

Fan and Williams [35] found that student self-efficacy strongly predicts their academic performance. Positive self-efficacy multiplies academic performance, goal-setting, and work ethic [36]. Lazarides et al. [37] examined the relationship between students' self-efficacy and their eagerness to perform different tasks in mathematics. They found a correlation between students' self-efficacy and their ability to perform different tasks in mathematics. Alves et al. [38] investigated the relationship between students' self-efficacy and mathematics' perceived importance and utility. The findings revealed that mathematics' utility was associated with students' self-efficacy. Similar results were also reported by Tossavainen et al. [39]. On the other hand, students' self-efficacy did not correlate with the utility of mathematics [40]. It was also found that the utility of mathematics was higher among male students than their counterparts.

1.4. Self-Efficacy and Intrinsic Motivation

Many studies have found positive relationships between intrinsic motivation, self-efficacy, and school success [41], [42], [43]. Furthermore, multiple studies have found a strong relationship between student self-efficacy and their level of intrinsic motivation in mathematics [44], [45], [46]. Siddiqui et al. [42] found a positive correlation between students' intrinsic motivation, self-efficacy, and mathematics performance. Furthermore, it was revealed that intrinsic motivation, self-efficacy, and performance were positively associated with blended learning. In addition, girls were found to have higher motivation levels than boys. Another study found that intrinsic motivation and self-efficacy increased when they actively participated in mathematics learning [28]. Collecting data from elementary-level students through a longitudinal survey, Niehaus et al. [36] found that students' self-efficacy and intrinsic motivation correlated throughout the academic year. Özcan and Eren Gümüş [47] also concluded that students' self-efficacy was a motivational measure alongside external and internal motivators and, therefore, viewed as a tiered construct under motivation in the existing body of knowledge. They revealed that the students' self-efficacy for mathematics had a strong relationship with their IMLM.

1.5. Mediating Role of Student Self-Efficacy in Mathematics

Some studies have investigated the mediating role of students' self-efficacy in mathematics. In one of those studies, You *et al*. [28] found that self-efficacy and motivational behavior were strongly correlated. In addition, it was concluded that self-efficacy mediated the relationship between teacher behavior and students' performance in mathematics. The mediating role of students' self-efficacy in the relationship between their grades and different motivation factors is also evident in the study [48].

Li and Zheng [49] also conducted a study to explore the mediating role of elementary-level students' self-efficacy for mathematics on intrinsic motivation, PUM, and self-regulated learning. The findings revealed that the level of self-efficacy significantly influenced students' self-regulated learning, intrinsic motivation, and perceived utility. Both intrinsic motivation and perceived utility were strong predictors of self-regulated student learning. Furthermore, the direct effect of self-efficacy on self-regulated learning was shown to be significantly mediated by PUM.

Although there have been various studies on the factors contributing to intrinsic motivation and utility (perceived utility) of mathematics and a few studies using self-efficacy as a mediating variable, such studies reveal mixed results. Furthermore, not a significant volume of studies has been conducted on subcontinental students.

It is essential as the teaching-learning style in the subcontinent (mainly focusing on traditional techniques, still a very much teacher-focused approach, etc.) is quite different from western countries.

Realizing this gap, the current study has been carried out in Pakistan to investigate the mediating effect of the SELPM of students between their IMLM and their PUM. To the best of the authors' knowledge, no such study has been carried out in developing countries, including Pakistan. Therefore, it would be a significant effort to fill the knowledge gap and to provide a foundation for future researchers and academia working on students' self-efficacy to learn and perform in mathematics SELPM). Moreover, it mediates the effect on variables that contribute to mathematics learning. The research objective addressed in the current study is the following:

- Investigate the mediating effect of students' self-efficacy in learning and performing mathematics between their intrinsic motivation to learn mathematics and their perceived utility.

1.6. Research Model and Hypotheses

The study's research model was designed based on the literature review on students' self-efficacy to learn and perform in mathematics (SELPM), their intrinsic motivation to learn mathematics (IMLM), and their perceived utility of mathematics (PUM). The model has been developed based on the research objective (Figure 1). It revolves around three variables: students' IMLM (independent variable), their PUM (dependent variable), and students' SELPM (mediating variable).

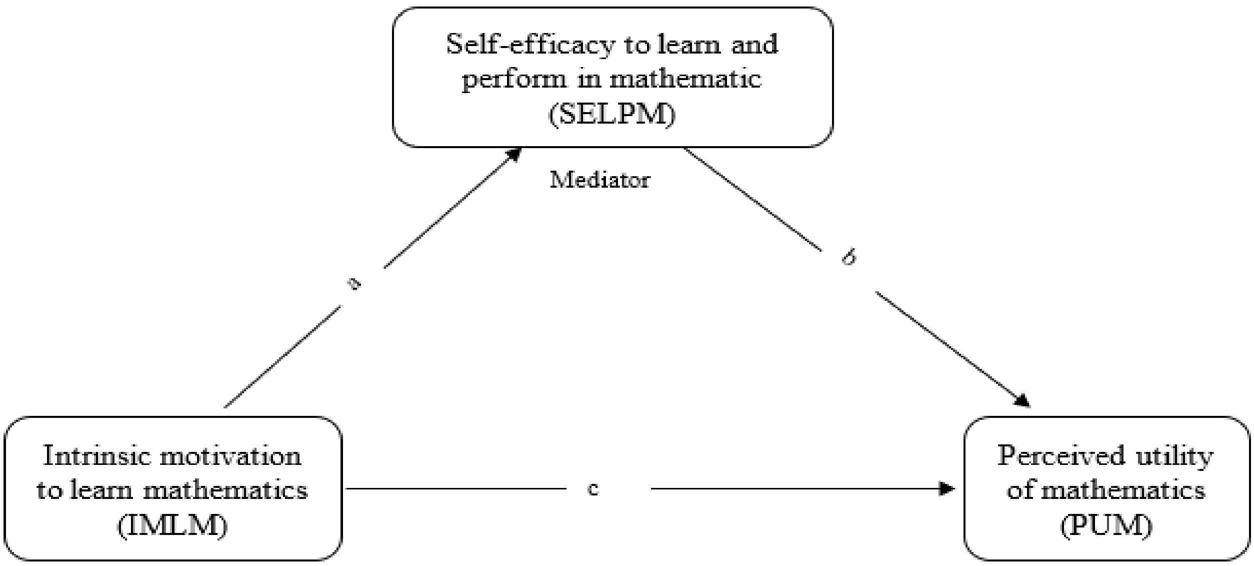

Figure 1. Proposed model

Based on the study model and the research objective, the authors developed the following null hypotheses, which were tested at Alpha level 001.

H_{01}. There is no significant relationship between the IMLM of the students and their SELPM.

H_{02}. There is no significant direct effect of students' IMLM on their PUM.

H_{03}. There is no significant indirect effect of the students' IMLM on their PUM through their SELPM.

2. Methodology

Considering the nature of the study, the current study followed a positivistic research philosophy to examine the mediational role of students' self-efficacy between their intrinsic motivation to learn mathematics and their perceived utility of mathematics learning. A quantitative research approach was used in the present study to understand how self-efficacy mediates the said relationship through direct and indirect pathways.

2.1. Research Design

The current study was carried out to explore the mediating effect of grade eight students' SELPM between their IMLM and their PUM. Following the positivist worldview, the authors used a quantitative research method. The research design of the study was cross-sectional. The researchers collected SELPM, IMLM, and PUM data from grade eight students.

2.2. Participants

The study population consisted of eight grade-level students enrolled in public schools of the Lahore division during the academic year 2022-23. The entire Lahore division, which has four districts (Lahore, Kasur, Nankana, and Sheikhupura), was taken as a geographical unit for the current study. During that academic year 2022-23, 1,40,208 eight grade students were enrolled in the Lahore division: Lahore, 1,40,208; Kasur, 34,728; Nankana, 15,165; and Sheikhupura, 29,858. [50]. Data were collected from intact groups (whole classes) randomly selected from randomly selected schools in those districts. Only one class was selected from every school. A total of 1,232 eighth-grade students were chosen from 20 different schools. The sample was selected from two districts of the Lahore division (Lahore, 47.4%; Kasur, 52.6%). Whereas 46.4% of them were boys and 53.6% were girls. Table 1 provides further details.

Table 1. Demographic information of the participants (N = 1232)

Variables	Category	Number	Percentage
Gender	Boy	572	46
	Girl	660	54
District	Kasur	648	53
	Lahore	584	47

2.3. Research Instrument and Data Collection

To measure students' responses against study variables, the authors adapted the mathematics motivation scale (MMS) developed by Zakariya and Massimiliano [51]. The original MMS consists of five factors (self-efficacy for learning and performance motivation, intrinsic motivation, the utility of mathematics motivation, the importance of mathematics motivation, and extrinsic motivation) and 24 items. The researchers modified MMS and revised it into three factors and 17 items. Factors were renamed, that is, SELPM, IMLM, and PUM, and items were revised accordingly. The authors used the modified scale to measure students' responses against study variables on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Data was collected using a self-administered questionnaire. The researcher personally visited the schools and collected data from elementary-level students. The whole process took three months (December 20223 to February 2023).

2.4. Validation of a Modified Scale

The researchers used Smart PLS software to check the reliability and validity of the scale. Cronbach's Alpha was used to check the reliability of the scale.

Table 2. Reliability of the scale

Constructs	Cronbach's Alpha	rho_A	Composite Reliability	AVE
IMLM	.622	.690	.795	.570
SELPM	.758	.790	.826	.523
PUM	.784	.808	.847	.528

Table 2 shows the results of the Cronbach alpha test. According to Hair *et al*. [52], the scale is excellent, with a Cronbach alpha value exceeding 80. Above .70, it is acceptable, and at 60 or above, it is considered an exploratory scale. For the current scale, the Cronbach alpha value for students' IMLM is .622; for their SELPM, .758; and for PUM, the value is .784, making the modified scale reliable for data collection.

Composite reliability is recommended over Cronbach's alpha to evaluate the convergent validity of a reflective model. Since Cronbach's alpha could overstate or understate reliability, it could be favored as a measure of consistency. An ideal estimate of composite reliability would be 1. Composite reliability values should be greater than .6 for exploratory studies, greater than .7 for confirmatory studies, and more than .8 for strong confirmatory studies [53]. For the current study, the positive reliability values for all subfactors were greater than .7 (IMLM .975, SELPM .826, and PUM .842).

The extracted average variance (AVE) was applied in divergent and convergent ways for the validity testing. AVE reflects the typical degree of group membership shared by individual latent factors in a reflective model. AVE should be greater than .5 [54]. This indicates that the determinants should account for at least 50% of the variance in the dependent variables. An AVE < .50 indicates that the error variance is greater than the explained variance. In this study, the AVE for all subfactors is above .5 (Table 2).

2.5. Discriminant Validity

The Fornell-Larcker criterion was used to examine and test discriminant validity by assessing the degree to which every latent variable differed from other constructs [55]. The results are provided in Table 3.

Table 3. Fornell-Larcker criterion

Constructs	IMLM	SELPM	PUM
IMLM	**.755**		
SELPM	.443	**.641**	
PUM	.434	.584	**.667**

To ensure the scale's discriminant validity, the researchers calculated the square root of the AVE and correlated it with the constructs measured by the scale. The diagonal entries showed values for the analysis.

The analysis revealed that the model's discriminant validity is acceptable, as all diagonal entries are higher than non-diagonal ones (Table 3).

2.6. Collinearity Assessment

Multicollinearity is the eminent assumption to be tested for the mediation model. To test multicollinearity, the researchers computed the values of the inner variation inflation factor (VIF) and the outer VIF, presented in Tables 4 and 5.

Table 4. Outer VIF values

Latent Variables	Constructs	Factor Loading
IMLM	IM1	1.338
	IM2	1.452
	IM3	1.413
	IM4	1.130
SELPM	SE1	1.393
	SE2	1.315
	SE3	1.375
	SE4	1.201
	SE5	1.616
	SE6	1.652
	SE7	1.661
PUM	UoM1	1.126
	UoM2	2.124
	UoM3	2.039
	UoM4	1.296
	UoM5	1.624
	UoM6	1.495
	UoM7	2.037

Table 5. Inner VIF values

	IMLM	SELPM	PUM
IMLM		1.000	1.244
SELPM			1.244
PUM			

The findings in Tables 4 and 5 show that the outer and internal VIF values are much lower than 5, suggesting multicollinearity is not an issue with these data [56].

2.7. Ethical Considerations

The study respondents were elementary-level students (adolescents) enrolled in the public schools of the Kasur and Lahore districts. The authors recruited study participants by taking a signed consent form from school administrators and class teachers. Before collecting data, the researchers briefed students about the study's aim. No physical or psychological harm was involved, as the data was collected in school settings. The students could withdraw from the study if they felt any potential harm. They were also assured of their anonymity and confidentiality.

3. Results

After collecting data, the authors applied data screening to identify missing values and exclude them from the data analysis file.

A software like SmartPLS4 and Statistical Package for Social Sciences (version 26) was used for data analysis. The null hypotheses were tested at 0.01, using the SEM model based on the bootstrapping method. The results are provided below under the relevant headings.

3.1. Relationship between Students IMLM and Their SELMP

The researchers collected data to measure students' IMLM and SELPM to test collinearity. They designed the first null hypothesis to test one of the assumptions of mediation analysis, which is that the independent and mediator variables should have a relationship but not be higher than .80 to avoid multicollinearity. The authors determined the bivariate relationship by applying Pearson's correlation, and the results are presented in Table 6.

Table 6. Relationship between IMLM and SELPM

		IMLM	SELPM
IMLM	Pearson Correlation	1	.402**
	Sig. (2-tailed)		.000
	N	1232	1232
SELPM	Pearson Correlation	.402**	1
	Sig. (2-tailed)	.000	
	N	1232	1232

***. The correlation is significant at this level: 01 (2-tailed).*

In Table 6, the authors presented the collinearity analysis and found that the mediator variable (SELPM) and the independent variable (IMLM) had a linear, positive and moderate correlation (r = .402, n = 1232) and statistically significant at p < .01. It was found that the data did not support H_{01}. There was a moderate relationship between IMLM and SELPM, and the multicollinearity assumption was not violated.

3.2. Direct Effect of Students' IMLM on PUM

The second null hypothesis was designed to measure the direct effect of students' IMLM on their PUM. The authors deployed SEM using the bootstrapping method at a confidence interval of 95 and bootstrapping samples of 5000.

The results of the direct effect of IMLM on PUM are provided in Table 7.

Table 7. Total direct effect

	Effect	*SE*	*t*-statistics	*p*-value	*LLCI*	*ULCI*
IMLM -> PUM	.250	.022	11.288	.000	.207	.293

In Table 7, the authors revealed that the IMLM of students had directly affected their PUM (β = .250, SE = .022).

The analysis did not support the second null hypothesis, and it was found that the direct effect of IMLM of students on their PUM is significant at t = 11.288, p = .000 < .001.

3.3. Mediating Effect of Student's SELPM between Their IMLM and PUM

To test the third null hypothesis, the researchers used SEM with the help of SmartPLS4 at a confidence interval of 95 and a bootstrapping sample of 5000.

Bootstrapping is a technique for validating and testing a model's significance, and t-statistics indicate how significant path coefficients are [52]. Table 8 provides the results for the mediating effect of students' SELPM between their IMLM and PUM.

Table 8. Summary of the mediation analysis

Relationship	**Total effect**	**Direct effect**	**Indirect effect**	**Confidence interval**		***t*-statistics**	**Conclusion**
				Lower bond	Upper bond		
IMLM -> SELPM -> PUM	.398 (.000)	.250 (.000)	.148	.118	.179	17.74	Partial mediation

Confidence interval = 95 %, bootstrap samples = 5000

In Table 8, the researchers presented an analysis of the mediation effect of the SELPM of the students between their IMLM and PUM. It was found that there is a significant indirect effect of

IMLM on PUM (β = .148, t = 17.74), rejecting the third null hypothesis for the mediational effect of SELPM of students between their IMLM and PUM.

Furthermore, the direct effect of the IMLM of the students on their PUM in the presence of the mediator is also significant (β = .250, p < .001).

Therefore, the SELPM of the students partially mediates the relationship between their IMLM and PUM. Figure 2 further explains the results of the mediation analysis.

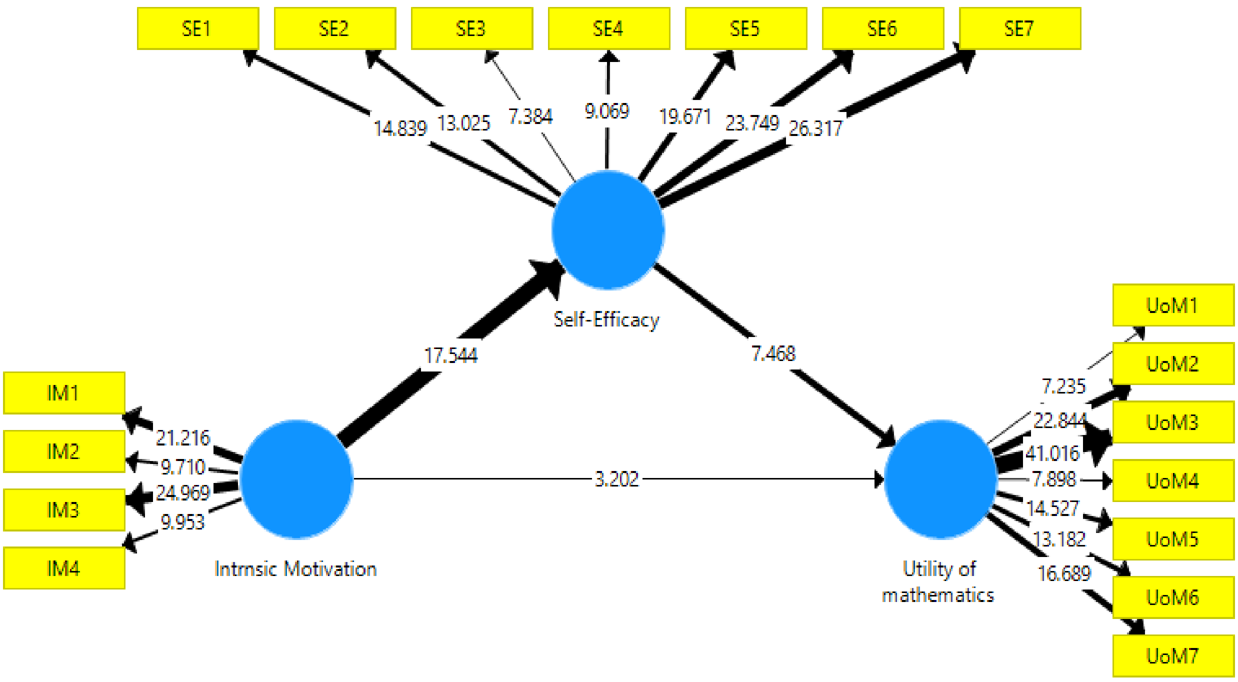

Figure 2. Structural equation model (bootstrapping)

In Figure 2, the researchers presented the highlighted routes focusing on relative values.

Relative values help show the magnitude of the constructs; higher values have heavier (wider/ thicker) paths.

4. Discussion

The present quantitative study investigated the mediating effect of students' SELPM between their IMLM and PUM. After analysis, it was found that the IMLM of the students has a moderate relationship with their SELPM. It was an important finding. First, it supported the collinearity by indicating the relationship; second, its lower value nullified the multicollinearity assumption of the mediation. Although it was a moderate-level relationship, it was linear and positive, which supported several findings of previous studies that revealed a positive relationship between SELPM and IMLM [41], [42], [43]. The authors found a moderate-level relationship that differed from various studies, which revealed that SELPM and IMLM have a strong relationship [28], [42]. This conflict of results will open new opportunities for future researchers to find the reasons for this conflict, ranging from moderate to high relationships.

Mathematics is among the most important subjects for bringing scientific, digital, and technological innovation [9]. It is essential in higher-order scientific developments and learning and plays a vital role in the day-to-day affairs of a typical person [2]. As a result, mathematics teaching and learning have gained much attention from researchers worldwide [22], [23]. However, few studies have been carried out in the subcontinent about the relationship of students' IMLM with their PUM and SELPM separately. This study bridges some of this research gap. Furthermore, it finds out the mediating role of students' SELPM between their IMLM and PUM.

The findings revealed a significant effect and a positive and linear correlation between the students' IMLM and their PUM. It reinforces the results of previous studies, which found a strong relationship between intrinsic motivation and the utility of mathematics [26]. PUM and IMLM have also contributed to a conducive and positive learning environment [29]. However, the current study does not align with the findings of Wang and Berlin [57], who found no significant relationship between the students' IMLM and PUM. This conflict can arise because the two studies were conducted in different contexts, education systems, and times. PUM depends significantly on how mathematics is taught in the classroom and how the participants define utility. In two different contexts, an effective utility may be defined differently (in underdeveloped countries, it is more related to basic mathematical calculations about daily life; in developed countries, it may be more about higher-order utility). As a result, those from relatively developing countries may find their mathematics more effective than those from relatively more advanced countries.

Regarding the third hypothesis, the study finds that students' SELPM strongly mediates the relationship between their IMLM and PUM. The literature has also supported these findings [28]. Although You et al. [28] collected data from both teachers and students, the crucial finding that self-efficacy is the eminent mediator is the same in both studies. The results of the current study also corroborate those of Tossavainen et al. [39], who identified a relationship between student self-efficacy, motivation, and usefulness in performing different mathematical tasks. It is also logical since self-efficacy (a person's belief in their ability to complete a task or achieve a goal) is likely to affect intrinsic motivation (doing an activity for its inherent satisfaction rather than some separable consequence) and the PUM. Self-efficacy has also been shown to mediate other variables and relationships in mathematics strongly [48], [58].

5. Conclusion

The present study was designed to examine the mediating role of SELPM in students' IMLM and PUM. Data in this quantitative study were collected using random sampling techniques. As a result, the findings can be generalized to the target population. However, as discussed earlier, the literature presents mixed results on the mediating role of SELPM between students' IMLM and their PUM. As a result, the findings may not be generalized beyond similar contexts. Apart from context, other variables, such as academic culture, perceived role and importance of science and technology in society, teaching strategies, and the level and type of actual utility of mathematics in society, may influence the findings.

Despite those concerns, this study's findings indicate that strategies to increase intrinsic motivation and self-efficacy should be employed. These strategies would improve students' interest in mathematics and also help improve their understanding, performance, and utility in practical life.

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References:

[1]. Sun, M., et al. (2014). Exploring colleagues' professional influence on mathematics teachers' learning. *Teachers College Record*, *116*(6), 1-30. Doi: 10.1177/016146811411600604.

[2]. Rossi, M. (2015). Mathematics can be meaningful, easy and fun. *LUMAT: International Journal on Math, Science and Technology Education*, *3*(7), 984-991. Doi: 10.31129/LUMAT.V3I7.981.

[3]. Luitel, L., & Pant, B. P. (2019). Images of the mathematics curriculum held by school mathematics teachers: Mapping the road for transformative pedagogies. *Empowering Science and Mathematics for Global Competitiveness*, 510–516. Doi: 10.1201/9780429461903-69.

[4]. Thoma, A., & Nardi, E. (2018). Transition from school to university mathematics: Manifestations of unresolved commognitive conflict in first year students' examination scripts. *International Journal of Research in Undergraduate Mathematics Education*, *4*, 161-180. Doi: 10.1007/S40753-017-0064-3.

[5]. Halai, A. (2010). Gender and mathematics education in Pakistan: A situation analysis. *The Mathematics Enthusiast*, *7*(1), 47-62. Doi: 10.54870/1551-3440.1174.

[6]. Yang, W., Ng, D. T. K., & Gao, H. (2022). Robot programming versus block play in early childhood education: Effects on computational thinking, sequencing ability, and self-regulation. *British Journal of Educational Technology*, *53*(6), 1817-1841. Doi: 10.1111/BJET.13215.

[7]. Noreen, R., & Rana, A. M. K. (2019). Activity-Based Teaching versus Traditional Method of Teaching in Mathematics at Elementary Level. *Bulletin of Education and Research*, *41*(2), 145-159.

[8]. Ning, B. (2020). Discipline, motivation, and achievement in mathematics learning: An exploration in Shanghai. *School Psychology International*, *41*(6), 595-611. Doi: 10.1177/0143034320961465.

[9]. Ring-Whalen, E., et al. (2018). From conception to curricula: The role of science, technology, engineering, and mathematics in integrated STEM units. *International Journal of Education in Mathematics, Science and Technology*, *6*(4), 343-362. Doi: 10.18404/IJEMST.440338.

[10]. Lai, C., Wang, Q., & Huang, X. (2022). The differential interplay of TPACK, teacher beliefs, school culture and professional development with the nature of in-service EFL teachers' technology adoption. *British Journal of Educational Technology*, *53*(5), 1389-1411. Doi: 10.1111/BJET.13200.

[11]. Wang, Z., et al. (2017). Pedagogical readiness of mathematics teachers to implement innovative forms of educational activities. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(1), 543-552. Doi: 10.12973/EJMSTE/80613.

[12]. Yigit, M. (2014). A Review of the Literature: How Pre-Service Mathematics Teachers Develop Their Technological, Pedagogical, and Content Knowledge. *International Journal of Education in Mathematics, Science and Technology*, *2*(1), 26-35. Doi: 10.18404/ijemst.96390.

[13]. Deho, O. B., et al. (2022). How do the existing fairness metrics and unfairness mitigation algorithms contribute to ethical learning analytics?. *British Journal of Educational Technology*, *53*(4), 822-843. Doi: 10.1111/BJET.13217.

[14]. Mulyatna, F., Imswatama, A., & Rahmawati, N. D. (2021). Design Ethnic-Math HOTS: Mathematics higher order thinking skill questions based on culture and local wisdom. *Malikussaleh Journal of Mathematics Learning (MJML)*, *4*(1), 48-51. Doi: 10.29103/MJML.V4I1.3059.

[15]. Osman, S., et al. (2018). Enhancing students' mathematical problem-solving skills through bar model visualisation technique. *International Electronic Journal of Mathematics Education*, *13*(3), 273-279. Doi: 10.12973/IEJME/3919.

[16]. Lowrie, T., Logan, T., & Hegarty, M. (2019). The influence of spatial visualization training on students' spatial reasoning and mathematics performance. *Journal of Cognition and Development*, *20*(5), 729-751. Doi: 10.1080/15248372.2019.1653298.

[17]. Alfayez, A. A., & Lambert, J. (2019). Exploring Saudi computer science teachers' conceptual mastery level of computational thinking skills. *Computers in the Schools*, *36*(3), 143-166. Doi: 10.1080/07380569.2019.1639593.

[18]. Young, S. N., et al. (2019). Factors affecting PhD student success. *International journal of exercise science*, *12*(1), 34.

[19]. Irfan, M., Kusumaningrum, B., Yulia, Y., & Widodo, S. A. (2020). Challenges during the pandemic: use of e-learning in mathematics learning in higher education. *Infinity Journal*, *9*(2), 147-158. Doi: 10.22460/INFINITY.V9I2.P147-158.

[20]. Rodríguez, S., Estévez, I., Piñeiro, I., Valle, A., Vieites, T., & Regueiro, B. (2021). Perceived competence and intrinsic motivation in mathematics: Exploring latent profiles. *Sustainability*, *13*(16), 8707. Doi: 10.3390/SU13168707.

[21]. Yerizon, Triwani, & Musdi, E. (2022). Effectiveness of Mathematics Learning Devices Based on Flipped Classroom to Improve Mathematical Critical Thinking Ability Students. *International Journal of Education and Management Engineering*. . Doi: 10.5815/ijeme.2022.03.05

[22]. Reynolds, D., & Muijs, D. (1999). The effective teaching of mathematics: A review of research. *School Leadership & Management*, *19*(3), 273-288. Doi: 10.1080/13632439969032.

[23]. Lester, F. K. (2007). *Second handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics*. Information Age Publishing.

[24]. Malik, M. A., & Akkaya, B. (2021). Comparing the academic motivation of conventional and distance education students: A study about a Turkish university. *sjesr*, *4*(2), 341-351. Doi: 10.36902/SJESR-VOL4-ISS2-2021(341-351).

[25]. Sivrikaya, A. H. (2019). The Relationship between Academic Motivation and Academic Achievement of the Students. *Asian Journal of Education and Training*, *5*(2), 309-315.

[26]. Adamma, O. N., Ekwutosim, O. P., & Unamba, E. C. (2018). Influence of extrinsic and intrinsic motivation on pupils academic performance in mathematics. *Online Submission*, *2*(2), 52-59.

[27]. Schöber, C., et al. (2018). Reciprocal effects between self-efficacy and achievement in mathematics and reading. *Learning and Individual Differences*, *63*, 1-11. Doi: 10.1016/J.LINDIF.2018.01.008.

[28]. You, S., Dang, M., & Lim, S. A. (2016). Effects of student perceptions of teachers' motivational behavior on reading, English, and mathematics achievement: The mediating role of domain specific self-efficacy and intrinsic motivation. *Child & Youth Care Forum*, 45, 221-240.

[29]. Middleton, J. A. (2013). More than motivation: the combined effects of critical motivational variables on middle school mathematics achievement. *Middle Grades Research Journal*, *8*(1), 77–96.

[30]. Algarni, B., & Lortie-Forgues, H. (2023). An evaluation of the impact of flipped-classroom teaching on mathematics proficiency and self-efficacy in Saudi Arabia. *British Journal of Educational Technology*, *54*(1), 414-435. Doi: 10.1111/BJET.13250.

[31]. Middleton, J. A. (1995). A study of intrinsic motivation in the mathematics classroom: A personal constructs approach. *Journal for research in mathematics education*, *26*(3), 254-279. Doi: 10.5951/JRESEMATHEDUC.26.3.0254.

[32]. Suárez, N., et al. (2019). Individual precursors of student homework behavioral engagement: The role of intrinsic motivation, perceived homework utility and homework attitude. *Frontiers in Psychology*, *10*, 941.

[33]. Rodríguez, S., Pineiro, I., Regueiro, B., & Estévez, I. (2020). Intrinsic motivation and perceived utility as predictors of student homework engagement. *Revista de Psicodidáctica (English ed.)*, *25*(2), 93-99. Doi: 10.1016/J.PSICOE.2019.11.001.

[34]. Husman, J., et al. (2004). Instrumentality, task value, and intrinsic motivation: Making sense of their independent interdependence. *Contemporary educational psychology*, *29*(1), 63-76. Doi: 10.1016/S0361-476X(03)00019-5.

[35]. Fan, W., & Williams, C. M. (2010). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational psychology*, *30*(1), 53-74. Doi: 10.1080/01443410903353302.

[36]. Niehaus, K., Rudasill, K. M., & Adelson, J. L. (2012). Self-efficacy, intrinsic motivation, and academic outcomes among Latino middle school students participating in an after-school program. *Hispanic Journal of Behavioral Sciences*, *34*(1), 118-136. Doi: 10.1177/0739986311424275

[37]. Lazarides, R., Buchholz, J., & Rubach, C. (2018). Teacher enthusiasm and self-efficacy, student-perceived mastery goal orientation, and student motivation in mathematics classrooms. *Teaching and Teacher Education*, *69*, 1-10. Doi: 10.1016/J.TATE.2017.08.017.

[38]. Alves, M., et al. (2016). Self-efficacy, mathematics' anxiety and perceived importance: an empirical study with Portuguese engineering students. *European Journal of Engineering Education*, *41*(1), 105-121. Doi: 10.1080/03043797.2015.1095159.

[39]. Tossavainen, T., Rensaa, R. J., & Johansson, M. (2021). Swedish first-year engineering students' views of mathematics, self-efficacy and motivation and their effect on task performance. *International Journal of Mathematical Education in Science and Technology*, *52*(1), 23–38. Doi: 10.1080/0020739X.2019.1656827.

[40]. Riegle-Crumb, C., et al. (2019). Inquiry-based instruction in science and mathematics in middle school classrooms: Examining its association with students' attitudes by gender and race/ethnicity. *AERA open*, *5*(3), 2332858419867653.

[41]. Pečiuliauskienė, P. (2020). School students' self-confidence in science and intrinsic motivation for learning science: self-concept and self-efficacy approach. *Pedagogika*, *137*(1), 138-155.

[42]. Siddiqui, S., Thomas, M., & Soomro, N. N. (2020). Technology integration in education: Source of intrinsic motivation, self-efficacy and performance. *Journal of E-learning and Knowledge Society*, *16*(1), 11-22. Doi: 10.20368/1971-8829/1135188.

[43]. Augustyniak, R. A., et al. (2016). Intrinsic motivation: an overlooked component for student success. *Advances in Physiology Education*, *40*(4), 465-466.

[44]. Wan, Z. H. (2021). Exploring the effects of intrinsic motive, utilitarian motive, and self-efficacy on students' science learning in the classroom using the expectancy-value theory. *Research in Science Education*, *51*(3), 647-659. Doi: 10.1007/s11165-018-9811-y

[45]. Tian, Y., Fang, Y., & Li, J. (2018). The effect of metacognitive knowledge on mathematics performance in self-regulated learning framework—multiple mediation of self-efficacy and motivation. *Frontiers in psychology*, *9*, 2518.

[46]. El-Adl, A., & Alkharusi, H. (2020). Relationships between self-regulated learning strategies, learning motivation and mathematics achievement. *Cypriot Journal of Educational Sciences*, *15*(1), 104-111. Doi: 10.18844/CJES.V15I1.4461.

[47]. Özcan, Z. Ç., & Eren Gümüş, A. (2019). A modeling study to explain mathematical problem-solving performance through metacognition, self-efficacy, motivation, and anxiety. *Australian Journal of Education*, *63*(1), 116-134. Doi: 10.1177/0004944119840073.

[48]. Skaalvik, E. M., Federici, R. A., & Klassen, R. M. (2015). Mathematics achievement and self-efficacy: Relations with motivation for mathematics. *International Journal of Educational Research*, *72*, 129-136. Doi: 10.1016/J.IJER.2015.06.008.

[49]. Li, S., & Zheng, J. (2018). The relationship between self-efficacy and self-regulated learning in one-to-one computing environment: The mediated role of task values. *The Asia-Pacific Education Researcher*, *27*(6), 455-463. Doi: 10.1007/s40299-018-0405-2

[50]. Government of the Punjab. (n.d.). *School Information System*. School Education Department. Retrieved from: https://sis.pesrp.edu.pk/ [accesed: 10 August 2024]

[51]. Zakariya, Y. F., & Massimiliano, B. (2021). Development of mathematics motivation scale: A preliminary exploratory study with a focus on secondary school students. *International Journal of Progressive Education*, *17*(1), 314-324. Doi: 10.29329/IJPE.2021.329.20.

[52]. Hair Jr, J. F., et al. (2021). *Partial least squares structural equation modeling (PLS-SEM) using R: A workbook*, 197. Springer Nature. Doi: 10.1007/978-3-030-80519-7.

[53]. Rouf, M. A., & Akhtaruddin, M. (2018). Factors affecting the voluntary disclosure: a study by using smart PLS-SEM approach. *International Journal of Law and Management*, *60*(6), 1498-1508.

[54]. Hock, M., & Ringle, C. M. (2010). Local strategic networks in the software industry: An empirical analysis of the value continuum. *International Journal of Knowledge Management Studies*, *4*(2), 132-151. Doi: 10.1504/IJKMS.2010.030789.

[55]. Hair, J. F., et al. (2017). Mirror, mirror on the wall: a comparative evaluation of composite-based structural equation modeling methods. *Journal of the academy of marketing science*, *45*, 616-632.

[56]. Bhutta, E., Kausar, S., & Rehman, A. (2019). Factors affecting the performance of market committees in Punjab, Pakistan: an empirical assessment of performance through smart PLS mediation analysis. *Journal of Agricultural Research, 57*(3).

[57]. Wang, T. L., & Berlin, D. (2010). Construction and validation of an instrument to measure Taiwanese elementary students' attitudes toward their science class. *International Journal of Science Education*, *32*(18), 2413-2428. Doi: 10.1080/09500690903431561.

[58]. Doménech-Betoret, F., Abellán-Roselló, L., & Gómez-Artiga, A. (2017). Self-efficacy, satisfaction, and academic achievement: the mediator role of Students' expectancy-value beliefs. *Frontiers in psychology*, *8*. Doi: 10.3389/fpsyg.2017.01193.