

## A Quantitative Study of Cognitive, Affective, and Instructional Barriers to Learning

### Physics at the College Level

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#### Abstract



*A significant gap exists between desired learning objectives and observed students' learning outcomes in college-level physics. The present study explored the role of cognitive and affective factors on students learning and their attitude towards learning physics. The present study aimed to test the Integrated Physics Learning Difficulty Model (IPLDM) by examining the associations between mathematical preparedness, physics anxiety, learning strategies, perceived difficulty of the subject, and academic performance. The study was a descriptive in nature where data were collected through cross-sectional survey. All college level science students of district Attock constituted the population. Data were collected from 106 college students using a 5-Point Likert type scale. Diagnostic test was conducted for the purpose of triangulation. Data were analysed using one-sample *t*-test, paired-samples *t*-tests and Pearson correlation coefficients. The findings revealed that that students with stronger math skills found physics less challenging. Mismatch was observed between students' self-perceived mathematical preparedness and diagnostic test. Students perceived physics a difficult subject. Although students showed positive approach toward self-regulated learning, they were not self-confident in learning physics and showed low self-efficacy. Low self-efficacy is the indicator of low achievement in cognitive and affective domain. The findings validate core components of the IPLDM, demonstrating that cognitive resources and affective factors are considerable predictors of students' perceived difficulty and strategic approach to learning physics. The study suggests interventions targeting physics anxiety and mathematical skills.*

**Keywords:** Mathematical Preparedness, Perceived Difficulties, Learning Strategies, Physics Anxiety, Physics Learning

#### Introduction

Physics, as an essential STEM discipline, is crucial for technological advancement and scientific literacy. It is a key science subject taught to students at school and college level. It plays the central role in understanding the world of science and technology. Despite its major role and importance, students' performance in the subject of physics is not satisfactory as compared to their performance in other science subjects like biology and chemistry. This difficulty leads to the demotivation of students to learn Physics (Habibi et al., 2019). School administration and physics teachers are concerned about the poor performance of the students and their low results in board classes. Students don't like physics due to its abstract and difficulty level. They fail to develop positive attitude towards physics (Henderson, 2018). As a result, aims and goals set for teaching physics at college level are not achieved. The board results and review of related literature indicate the significant gap between the desired students learning out comes and the student's learning gain. Students lack deep understanding of the content taught at a specific grade. As a result, despite its importance, a persistent gap exists between instructional objectives and student learning outcomes. Many students complete physics courses with a fragile, formulaic understanding that fails to translate into robust conceptual knowledge or practical problem-solving ability (Mestre et al., 2011). Various factors related to cognitive and affective domains are often studied in isolation and a comprehensive, quantitative model that examines their relative contributions and interrelationships is lacking.

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The present study aims to explore the cognitive and affective challenges and difficulties learners face in learning college-level physics. The primary research question is: To what extent do cognitive learning strategies, affective factors, and mathematical preparedness collectively and uniquely predict the perceived difficulty of college-level physics?

The study is significant for all the stakeholders; students, teachers, parents, college administration, curriculum designers to address these challenges to facilitate the learners and learning process. The study was delimited to college students studying during the 2025-26 academic year in Punjab.

### **Literature Review**

Physics is the study of nature. It is the relation between matter and energy and their mutual interaction. It is one of the major science subjects. Understanding of physics need both mathematical skills and conceptual understanding. Both procedural (mathematical skills) and conceptual knowledge are the main components of learning physics. Uhdén et al. (2012) observed that mathematics hinders the conceptual understanding and comprehension of content of physics. In physics the measurement play a vital role and extensive use of mathematical concepts in teaching physics indicates crucial contribution of mathematics in understanding physics (Burkholder et al., 2021; Redish & Kuo, 2015). Meltzer (2002) found the strong evidence between students' conceptual learning gain in Physics and their mathematical skills. Burkholder et al. (2021) highlighted that mathematical skills are even more important than the initial knowledge about the concepts related to Physics. Students use mathematical skills in solving problems in Physics (Burkholder et al., 2021; Redish, 2009). It means cognitive transition is required to integrate both physics and mathematics. Therefore, developing expertise in learning physics need expertise in mathematics. Students experience college education as stressful as it is critical for their future life (Acharya et al., 2018). At this stage students often exhibit behavior to postpone learning activities. This leads to anxiety. Studies indicate the negative correlation between the anxiety and learning (Choudhury & Chechi, 2022; Rani, 2025). Recent studies have revealed several aspects of anxiety in learning physics. According to Taibu and Ferrari-Bridgers (2020), in the study 'Physics language anxiety', anxiety decreases students' performance in physics and directly affect the perceived difficulty and learning strategies of the students. Similarly, Kalender et al. (2022), Wang et al. (2022a) and Hawes and Arya (2023) relate anxiety to social-psychological factors and it reduces the performance of the students because it consumes cognitive resources. Targeted interventions reduce the anxiety and improve the performance (Molin et al., 2021). Addressing anxiety of the students improve their performance and attitude in physics (Murch, 2023). Findings of various researches show that the teaching methods are also important variables. Implementing student-centered, activity-based teaching-learning improve conceptual understanding and reduce learners' anxiety.

Keeping in view the above empirical evidences Physics anxiety is defined as a multidimensional state, prompted by engagement with physics learning contexts. Anxiety related to Problem-Solving, Physics Language and Stereotype-Threat Anxiety are its various forms. As a result of Anxiety, various types of behavior appear. These include reduced help-seeking, superficial learning approaches, avoidance behaviours and premature problem abandonment etc. Degree of anxiety is affected by classroom teaching methodologies, learning environment and classroom assessment practices.

Learning Strategies are the key mediator. The type of learning strategies is a key factor which determine leaning success (Apedoe & Schunn, 2013). There are two forms of learning approaches and strategies; 'deep-level' learning strategies (like problem solving, critical thinking) and 'surface-level' learning strategies (like rote memorization). Self-regulated learning (SRL) strategies can significantly improve students' performance and their attitude (Bernacki et al., 2011). According to Meltzer (2002), successful learners use coherent conceptual frameworks and monitor their understanding. On the other hand, low-performing students often rely on fragmented knowledge and formula-seeking behaviours. This evidence supports the path from Learning Strategies to Performance. Furthermore, a student's level of anxiety and preparedness directly influences their capacity to deploy these effective strategies.

## Conceptual Framework

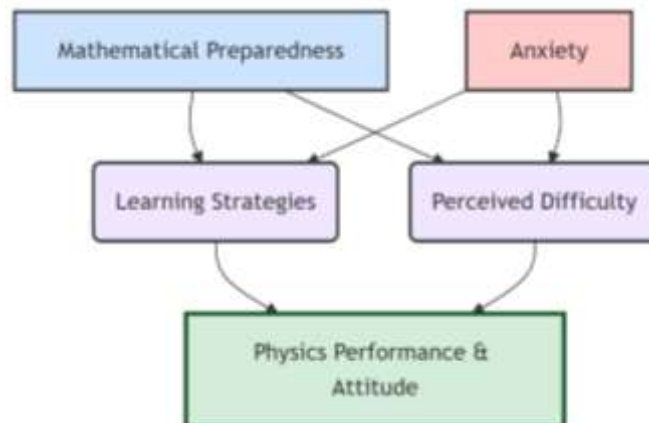


Fig 01. Integrated Physics Learning Difficulty Model (IPLDM)

On the basis of literature review, the present study proposes the Integrated Physics Learning Difficulty Model (IPLDM), as illustrated in Figure 1. The model presents the interrelated constructs. Anxiety and mathematical preparedness two fundamental input variables. Mathematical prerequisite skills are academic foundations which influence the perceived difficulty of the subject and choice of the learning strategies and approaches students adopt. These learning strategies, approaches and tactics and perceived difficulty determine cognitive and affective achievement of the learners. What types of learning strategies student adopt for either surface- level learning or in-depth learning along with perceived difficulty of physics decide the future achievement of the learners in the subject of physics? In other words, learning strategies, perception about the difficulty level of the subject, mathematical preparedness and physics anxiety are the fundamental factors which affect student's attitude towards learning physics and their academic achievement.

### Hypotheses

Based on the IPLDM, the following null hypotheses were tested:

- H<sub>01</sub>: There is no statistically significant relationship between a student's Mathematical Preparedness & Resources and their use of effective Learning Strategies.
- H<sub>02</sub>: There is no statistically significant relationship between a student's Anxiety and their use of effective Learning Strategies.
- H<sub>03</sub>: There is no statistically significant relationship between a student's Mathematical Preparedness & Resources and their Perceived Difficulty of Physics Topics.
- H<sub>04</sub>: There is no statistically significant relationship between a student's use of effective Learning Strategies and their Physics Performance & Attitude.
- H<sub>05</sub>: There is no statistically significant relationship between a student's Perceived Difficulty of Physics Topics and their Physics Performance & Attitude.
- H<sub>06</sub>: There is no statistically significant difference between students' self-reported Mathematical Preparedness and their actual performance on the Mathematics Preparedness Test.

### Methodology

The study was descriptive in nature where cross-sectional survey was used to collect data from a sample. The target population was students enrolled in both private and public sectors colleges during the session 2025-26. A sample of 106 students was recruited online using a convenience sampling method. All the data was collected from the students of private and government sector colleges located in district Attock only. The demographic breakdown was: 55% male, 44% female, 20% from urban areas and 50% from rural areas.

### Data Collection Instruments

#### a. Integrated Physics Learning Difficulty Scale (IPLDS):

A structured 5-Point Likert-type scale was developed. It consisted of the following sections, all using Likert scales to ensure quantitative data: demographic information, Perceived Physics Difficulty Scale (PPDS), Physics Learning Strategy Scale (PLSS) (06 statements), Physics Self-Efficacy Scale (PSES) (05 statement), Physics Anxiety Scale (PAS) (05 statements), and Mathematical Preparedness and Resources (03 statements). Both positive and negative statements were developed. The scale was developed and administered via Google form.

**b. Development of Mathematics Preparedness Test (MPT):**

To assess students’ cognitive preparedness for learning college-level physics, a teacher-made multiple-choice test was developed, covering mathematics concepts from grades 8, 9, and 10. Only concepts directly relevant to college physics were included. The instrument was validated by expert college-level physics teachers, ensuring content accuracy and relevance. Initially, 25 items were developed and finally, 20 items were retained for the final version of the test. Following criteria was developed and validated

**Table 1**

*Criteria to judge students’ performance in Diagnostic Test*

Score Range	Performance Level	Description of Student Preparedness
85–100%	Very well Prepared	Demonstrates strong mastery and shows high readiness for college physics. Requires no intervention.
70–84%	Well Prepared	Understands most prerequisite concepts, can follow college physics with normal instruction. Requires minor support.
50–69%	Partially Prepared	Shows significant gaps in prerequisite mathematics. Requires remediation
Below 50%	Not Prepared	Lacks basic mathematical concepts required for understanding of college physics. Immediate remediation required

**Results**

**Table 2**

*Correlations of the factors affecting students’ performance in Physics*

Variable	n	M	S.D	1	2	3	4
1.Perceived Difficulty	106	18.77	4.96	-			
2.Learning Strategies	106	19.82	3.59	-.315*	-		
3.Self-Efficacy	106	18.83	3.34	-.305	.315	-	
4.Anxiety	106	11.47	3.76	.48	-.078	-.41	-
5. Math Preparedness	106	20.42	3.89	-.306	.315	.26	-.28

\* $p < .01$

The analysis clearly reveals the correlation between various variables. Following table show the decision about the first five hypotheses;

**Table 3**

**Hypotheses Testing Summary**

Hypothesis	Correlation (r)	p-value	Decision
<b>H<sub>01</sub></b> : No statistically significant relationship between Mathematical Preparedness & Learning Strategies	.315	.001	H <sub>01</sub> rejected
<b>H<sub>02</sub></b> : No statistically significant relationship between Anxiety & Learning Strategies	-.078	.425	H <sub>02</sub> accepted
<b>H<sub>03</sub></b> : No relationship between Mathematical Preparedness & Perceived Difficulty	-.306	.001	H <sub>03</sub> rejected
<b>H<sub>04</sub></b> : No relationship between Learning Strategies & Physics Self-efficacy	.315	.001	H <sub>04</sub> rejected
<b>H<sub>05</sub></b> : No relationship between Perceived Difficulty & Physics self-efficacy	-.306	.001	H <sub>05</sub> accepted

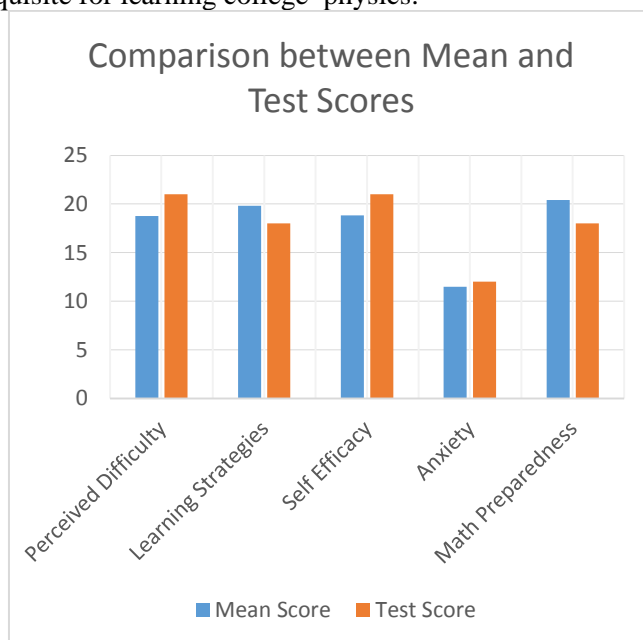
Table 3 reveals that H<sub>01</sub> is rejected: There is a statistical significant positive relationship. This means students with stronger mathematical skills tend to use more effective physics learning strategies at college level. Math Preparedness and resources and strategic learning are interlinked. H<sub>02</sub> is accepted: There is no statistical significant relationship. A student's level of math anxiety does not predict whether they will use effective learning strategies or not. Physics learning Anxiety affects other dimensions but not the reported use of learning strategies. H<sub>03</sub> Rejected: There is a statistical significant negative relationship between both variables. Students with higher math preparedness find physics topics significantly less difficult. Strong math skills buffer against the perception of difficulty in physics. H<sub>04</sub> Rejected: There is a statistical significant positive relationship. The use of effective learning strategies is associated with higher physics performance and attitude. H<sub>05</sub> Rejected: There is a significant negative relationship. Students who perceive physics topics as more difficult perform worse and has negative attitude towards physics. Perceived difficulty is a key obstacle to academic success.

**Table 4**  
**Comparison of mean scores of variables with test score**  
**One-Sample Test**

	Test value	t	df	Sig. (2-tailed)	(2-Mean Difference of the Difference)	95% Confidence Interval	
						Lower	Upper
Perceived Difficulty (n=106)	21	4.63	105	.000	2.22	-3.18	-1.27
Learning strategies (n=106)	18	5.22	105	.000	1.82	1.13	2.51
Self-efficacy (n=106)	21	-6.06	105	.000	-2.30	-3.05	-1.54
Anxiety(n=106)	12	-.78	105	.40	-.39	-1.38	.60
Math preparedness	18	6.40	105	.000	2.42	1.67	3.18

Table 4 indicates the series of one-sample t-tests conducted to compare the sample mean of each construct with the test values. The findings based on the one-sample t-test reveal significant meaning full differences across most variables.

- (i)  $t(105) = 4.63, p < .001$ . Students’ perceived difficulty of physics topics was significantly higher than the test value. The positive mean difference (2.22) indicates that students, on average, experience greater difficulty with physics topics than the benchmark level.
- (ii) Students scored significantly above the test value in the use of effective learning strategies.  $t(105) = 5.22, p < .001$ . The mean difference (1.82) shows they report actively using more strategic approaches to learning than expected. This indicates a generally positive approach toward self-regulated learning.
- (iii) Self-efficacy and self-belief affect learning scores. Table 3 indicates lower score of self-efficacy as compare to the reference value.  $t(105) = -6.06, p < .001$ . It indicates that students are not self-confident in learning physics. Students had low self- efficacy. Low self-efficacy is the indicator of low achievement in cognitive and affective domain.
- (iv) There is no statistical significant difference between the anxiety scores and the test value.  $t(105) = -0.78, p = .40$ . It means students have anxiety at average level.
- (v) There was a statistical significant difference between students’ self-perceived mathematical preparedness scores and the test value.  $t(105) = 6.40, p < .001$ . The results point out that college students perceive that they are have the required level of proficiency in mathematics which is prerequisite for learning college physics.



To check the students’ preparedness of mathematics to learn physics at college level, a teacher-made diagnostic test was prepared and conducted.

**Diagnostic Test Performance**

Performance of the students in diagnostic test was recorded. The performance was compared with the criteria developed. The single score set from criteria was 70% (lower limit of well-prepared).

**Table 5.**  
**Mean and Std. Deviation of students in diagnostic test performance.**

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Diagnostic. Test	106	52.59	15.53	1.50

**Table 6.**  
**Mean and Std. Deviation of students in diagnostic test performance.**

One-Sample Test						
Test Value = 70						
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Diagnostic. Test	-11.54	105	.000	-17.40	-20.40	-14.42

A one-sample t-test was conducted to determine whether the students' score on the diagnostic test differed significantly from the proficiency benchmark of 70%. The results indicated that the mean test score ( $M = 52.59$ ,  $SD = 15.53$ ) was statistically significantly lower than the benchmark value of 70,  $t(105) = -11.54$ ,  $p < .001$ . The mean difference and t-value suggests that the students' performance was below the established proficiency criterion indicating inadequate mastery of the basic skills and concepts required for learning of college physics.

Now compare the perceived preparedness and actual performance.

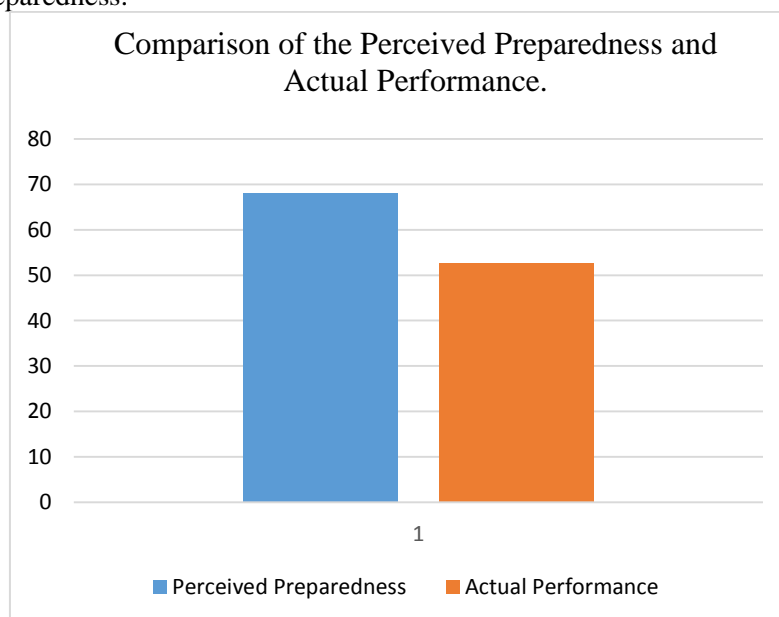
**Table 7**  
**Mean and Std. Deviation with Paired Samples Correlations**

	Mean	N	Std. Deviation	Std. Error Mean	Correlation	Sig.
Math	68.08	106	12.99	1.26		
Diagnostic. Test	52.59	106	15.53	1.51	-.222	.022

**Table 8**  
**Comparison of the Perceived Preparedness and Actual Performance.**

Paired Differences							
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
15.49	22.35	2.17	11.18	19.79	7.13	105	.000

Table 8 indicates the results of paired-samples t-test to compare students' perceived math preparedness to their actual performance on a diagnostic test. Students' self-reported math preparedness score was statistically significant different from the performance of the students in diagnostic test.  $t(105) = 7.13$ ,  $p < .001$ . The t-value indicated that both the scores were statistically significantly different. It means students' actual performance is lower than their overestimated mathematical preparedness.



## Discussion

The present study explored the relationship among the various variables that influence the cognitive and affective domain of learning physics at college level. Although students claimed that they were well prepared in mathematical skills to study physics at college level, their claim was not confirmed through their performance in diagnostic test. Students' performance in mathematics test was below the required level. This mismatch indicate that weak mathematical concepts are the potential barrier for students to be a successful learner. Various studies claim that mathematics competency is a strong predictor of physics achievement (Pasigon, 2024; Pongsophon, 2025; Tong et al., 2025). Meltzer (2002) indicated that role of mathematics is more crucial than students previous gain in physic. There is a strong positive correlation between students gain in physics and their mathematical skills (Chen et al., 2021; Tong et al., 2025) Insufficient mathematical foundations may limit students' ability to fully engage with physics concepts, especially those concepts that need problem-solving, algebraic manipulation, or reasoning with formulas. Tong et al. (2025) recommend the inclusion of algebraic skills in physics education for significant improvement in students' learning outcomes.

Anxiety is another construct that influence the selection of learning strategies and approaches and perceived difficulty of the subject. Students reported higher level of perceived difficulty in learning physics. The Role of anxiety and learning strategies is highly acknowledged in the literature (Wang et al., 2022b; Xu et al., 2022) The findings of the present study are in consistent with the findings of the previous studies. Hansson (2024) and Tenzin et al. (2022) highlighted the same results. This suggests that low mathematical preparedness may contribute to heightened difficulty perceptions, compounding the challenges students face in mastering physics content. Wang et al. (2024) observed that due to self-perceived difficulty students avoid difficulty tasks. Students self-perception regarding the subject difficulty result their poor performance in the subject.

Anxiety level, according to the findings of the present study did not differ from the established benchmark significantly. It means even high level of perceived difficulty of the subject do not necessarily generate the elevated anxiety.

Despite the challenges of anxiety and perceived difficulty, students reported they are actively engaged in self-regulated learning. Students claimed they use various learning strategies. However, these learning approaches are only effective if students are good at mathematical skills and positive high level of self-efficacy. Studies demonstrate that self-efficacy is required in physics (Catena & Testa, 2024; Dou et al., 2018; Sawtelle et al., 2012).

These findings demands the need for interventions that strengthen foundational mathematics skills, enhance conceptual understanding, and boost students' confidence, allowing them to better apply learning strategies and achieve higher performance in physics.

## Recommendations

1. Mathematical preparedness is the necessary prerequisite for effective learning of physics. It is, therefore, necessary to plan interventions for remediation. Inclusion of algebraic skills in physics education will improve students' learning outcomes significantly.
2. In teaching-learning process teachers usually ignore students' affective domain. Students' motivation and physics anxiety of the subject along with their perceived difficulty of the subject should be addressed during the instruction.
3. Learning by doing improves the perceived difficulty level. Therefore, student –centered approaches should be adopted to lower their perceived difficulty of the subject.
4. In traditional assessment system, only cognitive assessment is addressed. There is a need to assess students' motivation, anxiety and perceived difficulty periodically to monitor students' overall learning progression.

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