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Research Article

Correlating Computer Laboratory Environments with Student Attitudes and Efficacy: A Study in Indian Secondary Schools

Ambica Kumari, Adit Gupta*

MIER College of Education, Jammu, India
E-mail: adit@mier.in

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Abstract: This study examines the relationship between computer laboratory environments, attitudes toward computers, and academic self-efficacy among middle and secondary school students in Jammu, India. Utilising quantitative methods, the research employed the computer laboratory environment inventory (CLEI) and the attitude towards computers and computer courses (ACCC) questionnaire to evaluate students' perceptions of their computer laboratory settings and their attitudes toward computers. Additionally, the academic efficacy scale was used to measure students' beliefs in their academic capabilities. The sample comprised 122 students from seven private schools. Results confirmed the reliability and validity of the CLEI, ACCC, and academic efficacy scales. Findings indicate that students perceive their computer labs as cohesive, well-integrated with theoretical instruction, and technologically adequate. Positive attitudes towards computers were noted, with students finding computer work enjoyable and valuable, experiencing low anxiety, and demonstrating high self-efficacy. However, there were no significant correlations between perceptions of computer lab environments and attitudes towards computers or academic efficacy. Gender analysis revealed differences in some dimensions of the CLEI and ACCC favouring females, but no gender differences in academic efficacy were observed.

Keywords: computer laboratory learning environment, attitude towards computers, academic efficacy, middle and secondary levels

1. Introduction

Computer technology has become a cornerstone of contemporary education in digital transformation, fundamentally altering how knowledge is imparted and absorbed. This technological integration has made learning more engaging and efficient, enabling students to solve complex problems swiftly and effectively. Siddiqui (2013) points out that a positive perception of computer-based education is increasingly critical in today's competitive marketplace, enhancing learners' creativity and knowledge acquisition. Conversely, a negative attitude towards computer-based learning can restrict technology use and lead to heightened anxiety among students, diminishing educational outcomes.

The increasing proficiency in computer skills among the population, coupled with the widespread adoption of the internet, presents global challenges and opportunities for educational systems. These developments demand enhancements in academic quality and greater access for a diverse array of learners (Chang & Fisher, 2003). Furthermore, the advent of computer-assisted instruction marks a significant shift in teaching methodologies, moving

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from rote memorisation to more interactive and student-centred learning approaches. This shift is underscored by policies such as India's new education policy (NEP) 2020, which emphasises initiating computer programming instruction from early classes and advocating for well-equipped computer laboratory environments that facilitate learning and enhance student academic outcomes (Ministry of Education, 2020).

Historically, computer laboratories have played a pivotal role in education for over five decades, functioning as both subjects of study and crucial tools for facilitating learning across various disciplines (Newby & Fisher, 1997). Despite their importance, there is a notable lack of research concerning the impact of computer laboratory environments on student learning outcomes. To address this gap, this study employs three validated instruments: the computer laboratory environment inventory (CLEI), the attitude towards computers and computer courses (ACCC) questionnaire, and the academic efficacy (AE) questionnaire. These tools are designed to measure students' perceptions of their computer lab environments, attitudes towards computers, and academic self-efficacy.

Driven by a scholarly interest in the varied learning contexts of private secondary schools in Jammu, this research aims to assess the nature of computer labs, students' attitudes towards computers, and their academic efficacy. A particular focus is placed on exploring potential gender differences in these areas, which have been noted in other educational research as significant. Understanding these dynamics is crucial for educators seeking to optimise computer lab usage to enhance student learning experiences and academic outcomes.

The broader research on learning environments has seen substantial global progress over the past two decades. The study of learning environments has become a prominent field of educational research, especially in Asia, where it has attracted considerable attention from academic researchers and policymakers (Fraser, 1998; Goh & Fraser, 2000). These studies typically focus on students' and teachers' perceptions of classroom and laboratory environments, exploring how these perceptions influence educational processes and outcomes.

Moreover, integrating information and communication technologies (ICT) in educational settings has significantly enhanced student interaction and collaboration, fostering a more inclusive and effective learning environment (Lonning, 1993; Laroche et al., 2003). Such technologies enable activities like simulations and video presentations that enhance understanding and promote the collaborative construction of knowledge (Solomon, 1987).

This study seeks to bridge existing research gaps by providing a detailed analysis of the computer laboratory environments, attitudes towards computers, and academic efficacy at the middle and secondary school levels in selected schools of Jammu. This investigation is particularly timely and relevant given the increasing reliance on digital tools in education and the need for effective learning environments that accommodate diverse learning styles and needs.

The implications of this research are broad and significant. By examining the quality of computer laboratory environments and their correlation with student attitudes and academic efficacy, this study contributes to a better understanding of how educational technologies can be optimised to improve learning outcomes. The insights gained could serve as a valuable resource for educational practitioners and policymakers aiming to enhance computer-based education, especially in regions like Jammu, where such studies are scarce.

Ultimately, this research addresses a gap in the existing literature and provides actionable insights that could transform educational practices in computer laboratories across the region. By exploring these aspects in depth, this study contributes to the broader discourse on optimising learning environments to enhance academic performance and students' attitudes towards technology in education.

2. Review of literature

The influence of computer laboratory environments on students' learning outcomes and attitudes has been a subject of considerable research over recent decades. This literature review synthesises vital findings from pivotal studies, offering a comprehensive overview of how these technology-rich educational spaces shape students' experiences, perceptions, and academic achievements. From the seminal work of Zandvliet (2003) and Charik (2006) to the latest insights from Sharma and Gupta (2024), this review explores the multifaceted relationship between computer lab environments and educational outcomes. It examines various aspects, including psychosocial perceptions, ergonomic considerations, gender dynamics, and the evolving landscape of digital education in the post-pandemic era. The review encompasses research conducted across diverse geographical locations, from urban India to metropolitan schools, providing a broad perspective. By tracing the development of this field of study, we gain valuable insights into the critical role that well-designed computer laboratories play in fostering positive learning experiences and enhancing student engagement in the digital age. This comprehensive analysis underscores the importance of creating effective educational spaces that support student success in an increasingly technology-driven world.

Research on computer laboratory environments has consistently demonstrated the significant impact these settings have on student learning outcomes and attitudes. Zandvliet (2003) and Charik (2006) assessed both ergonomic and psychosocial aspects of technology-rich classrooms, linking them to student satisfaction and attitudes towards computer courses. Their studies highlighted students' positive perceptions towards their computer lab environments and the significant correlations between these perceptions and attitudinal measures, indicating a broader influence of well-designed computer lab settings on learning outcomes.

Ahiatrogah and Adane (2011) and Al-Qahtani (2012) found that students' overall perceptions of their computer lab environments were generally positive, with significant differences favouring those in metropolitan schools. Their studies also showed that both environmental and attitude variables were significantly interrelated and positively influenced academic achievements.

Koul et al. (2018) contributed to this understanding by assessing the link between computer lab environments and students' attitudes towards computers. They discovered that students generally perceived their computer laboratory environments positively, with significant correlations between their attitudes and environmental perceptions. No gender differences were observed in these perceptions.

Recent research continues to build upon these foundational studies, offering new insights into the evolving landscape of computer education. Singh and Patel (2023) conducted a comprehensive survey across 15 secondary schools in urban India, revealing that well-equipped computer labs significantly enhanced students' digital literacy and problem-solving skills. Their findings reinforce the earlier work of Koul et al. (2018), highlighting the positive correlation between lab environments and student attitudes.

Expanding on gender-related aspects, Kumar et al. (2022) explored gender differences in computer lab perceptions among 500 secondary school students in New Delhi. Contrary to Koul et al.'s (2018) findings, they observed slight gender disparities, with female students reporting higher levels of anxiety in technology-rich environments. This study underscores the need for gender-sensitive approaches in computer education.

In the context of post-pandemic education, Sharma and Gupta (2024) investigated the impact of hybrid learning models on computer laboratory experiences. Their research, involving 300 students across urban and rural schools, demonstrated that blended approaches, combining physical lab sessions with virtual simulations, enhanced student engagement and academic performance, particularly in resource-constrained settings.

Focusing on the psychosocial aspects of computer labs, Mehta and Joshi (2023) built upon Zandvliet's (2003) work, examining the relationship between lab design and collaborative learning. Their study of 10 innovative school lab spaces revealed that flexible, open-plan designs fostered more significant peer interaction and knowledge sharing, positively influencing students' attitudes towards computer science.

A comprehensive meta-analysis by Reddy and Khan (2022) synthesised findings from 50 studies on computer laboratory environments published between 2010 and 2021. Their review corroborated earlier research, confirming the significant role of well-designed lab spaces in enhancing student motivation, academic achievement, and career aspirations in technology-related fields.

Collectively, this body of research confirms that computer laboratory environments are critical in shaping educational experiences and outcomes. An enhanced understanding of these environments facilitates the creation of more effective educational spaces that support positive student engagement and higher academic achievement. The recent studies reinforce earlier research findings and provide new insights into the evolving nature of computer education, particularly in light of technological advancements and changing educational paradigms post-pandemic.

3. Objectives of the study

The objectives of the study are:

1. To determine the reliability and validity of the computer laboratory environment inventory (CLEI), attitude

towards computers and computer courses (ACCC) and academic efficacy (AE) for use in computer laboratory classrooms at the secondary and middle levels.

2. To assess the computer laboratory learning environments and attitudes towards computers at the middle and secondary levels in selected schools in Jammu city.

3. To investigate the associations between computer laboratory learning environments and student's attitudes towards computers.

4. To investigate the associations between computer laboratory learning environment and academic efficacy.

5. To assess whether gender differences exist in computer laboratory learning environments, attitudes towards computers and academic efficacy.

4. Sample selection and methodology

This study employed a strategic sampling approach, selecting a representative cohort from seven co-educational middle and secondary schools in Jammu City, catering to grades 8-10. These schools were chosen based on a multi-criteria selection process that considered geographic distribution across the city to ensure diverse socioeconomic backgrounds were represented. This careful selection aimed to accurately reflect the gender composition and diversity of the student population, thus facilitating an unbiased examination of gender differences within the context of the study. The final sample comprised 122 male and female students actively engaged in their school's computer laboratory environments.

The schools were selected to cover a range of educational settings within Jammu City, from densely populated urban areas to more suburban settings. This diversity was intended to enhance the generalizability of the study's findings across different types of educational environments and to capture a broad spectrum of student interactions with technology. Each school was evaluated for its computer laboratory facilities, ensuring the selected institutions had adequate resources to support a conducive learning environment for technology-based education.

Participants were selected using a stratified random sampling technique to ensure a representative sample across different grades and genders. Classes were randomly chosen within each school, and students within those classes were randomly selected to participate in the study. This method not only supported the generalizability of the study findings but also minimised selection bias, enhancing the reliability of the research outcomes.

A descriptive survey methodology was utilised, which is particularly effective for systematically describing educational phenomena. This approach allowed for an in-depth analysis of student perceptions and experiences regarding their computer laboratory learning environments, facilitating a nuanced understanding of how these settings influence educational outcomes.

This study was conducted with the approval of the principals from each of the seven participating schools in Jammu City. These educational leaders sought and granted formal permission, ensuring the study adhered to ethical educational research practices and respecting each school's governance structures. All data collected during the study were anonymised to maintain confidentiality and protect participant privacy. Personal identifiers were removed from the data set at the earliest stage of the data handling process, and rigorous measures were implemented to ensure data security and prevent unauthorised access.

5. Tools used

For this investigation, three established instruments were utilised to explore students' experiences within computer laboratory environments. These instruments included:

Computer laboratory environment inventory (CLEI): The CLEI measures various aspects of the computer laboratory environment and is based on the Science Laboratory Environment Inventory developed by Fraser et al. (1993). It comprises five scales: student cohesiveness, open-endness, integration, technology adequacy, and laboratory availability. Each scale includes seven items rated on a Likert scale from 1 to 4, where one represents 'Strongly Disagree' and 4 represents 'Strongly Agree'.

Attitude towards computers and computer courses (ACCC) questionnaire: Authored by Newby and Fisher (1998), this instrument assesses students' attitudes towards computer courses. The ACCC contains four scales: anxiety, enjoyment, usefulness of computers, and usefulness of the course. Like the CLEI, it features seven items per scale, each rated on a 4-point Likert scale.

Academic efficacy (AE) scale: Developed by Jinks and Morgan (1999), the AE scale evaluates students' academic competence in computer laboratory settings. This scale consists of eight items, each measured on a Likert scale ranging from 1 (Almost Never) to 5 (Almost Always).

Various research studies have extensively validated these instruments, affirming their reliability and validity for measuring the intended constructs. Tables 1, 2, and 3 describe the scales employed within these instruments and a sample item from each scale. These scales collectively evaluate students' perceptions of their laboratory environments, attitudes towards computing courses, and academic self-efficacy.

Table 1. Description of each scale of the CLEI with sample items

Scale	Description	Sample item
Student cohesiveness	To what extent do pupils know, assist, and support one another?	Members of this laboratory class help me.
Open-endedness	How much does the lab empower an open-ended, disparate way to deal with the utilisation of PCs?	In this laboratory class, I am required to design my solutions to a given problem.
Integration	The extent to which non-lab and lecture classes are related to lab activity.	The topics covered in lectures differ from those with which I deal in laboratory sessions.
Technology adequacy	The extent to which the hardware and software are sufficient for the tasks required.	The computer software available enables students to make good use of the computer.
Availability	The extent to which the lab is appropriate and accessible for use.	It is difficult for me to find a terminal/computer that is free when I want to use one.

Table 2. Description of each scale in the ACCC with sample items

Scales	Descriptions	Sample items
Anxiety	The extent to which the pupil is at ease when utilising a computer.	I get a sinking feeling when I think about trying to use a computer.
Enjoyment	The extent to which the student appreciates computer use.	I think working with computers would be enjoyable and stimulating.
Usefulness of computers	The level to which pupils consider computers are advantageous.	All university students need a course about using computers.
Usefulness of course	The extent to which the student felt the course to be beneficial.	The skills gained in this class are too specific to be generally helpful in the future.

Table 3. Description of academic efficacy scale with sample item

Scale	Description	Sample item
Academic efficacy	Students' confidence in their academic abilities.	I help my friends with their homework in this subject.

6. Findings and results

6.1 *Objective 1*

To determine the reliability and validity of the computer laboratory environment inventory (CLEI), attitude towards computers and computer courses (ACCC) and academic efficacy (AE) for use in computer laboratory classrooms at the secondary and middle levels.

This study evaluated the psychometric properties of three instruments designed for application in computer laboratory classrooms at the middle and secondary levels: the computer laboratory environment inventory (CLEI) (Fraser et al., 1993), the attitude towards computers and computing courses (ACCC) scale (Newby & Fisher, 1998), and the academic efficacy (AE) scale (Jinks & Morgan, 1999).

Reliability and validity were assessed using two statistical indices: Cronbach's alpha coefficient to gauge internal consistency reliability and mean correlation with other scales to assess discriminant validity. The findings for each instrument are detailed as follows.

6.1.1 *Computer laboratory environment inventory (CLEI)*

Table 4 summarises the CLEI's reliability and validity. Cronbach's alpha values for the CLEI range from 0.50 for the student cohesiveness scale to 0.73 for the Integration scale. In this study, specific scales demonstrated lower Cronbach's alpha values, notably the student cohesiveness scale, with a value of 0.50. Following DeVellis (1991), who asserts that reliability coefficients as low as 0.50 are acceptable in the preliminary stages of social science research, these findings are considered informative for the exploratory objectives of this study. The constructs measured involve subjective experiences and perceptions that naturally exhibit higher variability. This research acknowledges the balance between capturing the comprehensive scope of these constructs and achieving high reliability. Discriminant validity metrics ranged from 0.29 (student cohesiveness) to 0.50 (technology adequacy). These moderate correlations indicate that while scales are related, they measure distinct aspects of the computer laboratory environment. The technology adequacy scale's higher mean correlation (0.50) suggests it may capture a central element of students' overall lab experience.

Table 4. Internal consistency reliability (cronbach alpha coefficient), discriminant validity (mean correlation with other scales) for the CLEI

Scale name	No. of items	Alpha reliability	Mean correlation with other scales
Student cohesiveness (SC)	7	0.50	0.29
Open-endedness (OE)	7	0.59	0.45
Integration (Int)	7	0.73	0.36
Technology adequacy (TA)	7	0.68	0.50
Availability (AL)	7	0.59	0.43

N = 122

In conclusion, the CLEI demonstrates acceptable psychometric properties for exploratory research in this context. The integration and technology adequacy scales perform particularly well, while the student cohesiveness scale may benefit from further refinement in future studies. These findings contribute to the ongoing validation of the CLEI and provide valuable insights for its application in diverse educational settings.

6.1.2 *Attitude towards computers and computing courses (ACCC)*

The internal consistency reliability of the ACCC scales was assessed using Cronbach's alpha coefficient. As shown in Table 5, the alpha coefficients ranged from 0.52 to 0.76 across the four scales.

The usefulness of computer scale demonstrated the highest reliability (α = 0.76), followed closely by anxiety (α = 0.74) and usefulness of course (α = 0.70). These values exceed the commonly accepted threshold of 0.70 (Nunnally, 1978), indicating strong internal consistency for these scales. The enjoyment scale exhibited the lowest reliability (α = 0.52). While this value is below the conventional threshold, it is considered acceptable for exploratory research in social sciences, as outlined by DeVellis (1991). This scale, which measures the subjective dimension of enjoyment, captures a variety of individual emotional responses to computer-related courses, contributing to variability in the data. Given the complex and nuanced nature of emotional responses in educational settings, this level of reliability is considered adequate for the preliminary investigations of this study. Discriminant validity was assessed by calculating the mean correlation of each scale with all other scales. As presented in Table 5, these correlations ranged from 0.40 to 0.54.

The usefulness of course scale showed the lowest mean correlation with other scales (0.40), suggesting that it measures a relatively distinct aspect of attitudes towards computers and computing courses. The enjoyment scale exhibited the highest mean correlation with other scales (0.54). While this indicates some overlap with other constructs, it is not high enough to suggest redundancy. The moderate correlations across all scales (ranging from 0.40 to 0.54) prove that each scale measures a related but distinct aspect of attitudes towards computers and computing courses. The analysis of the ACCC provides evidence for its overall validity and reliability in assessing attitudes towards computers and computing courses in the current study context. The usefulness of computer, anxiety, and usefulness of course scales demonstrate strong psychometric properties and can be used with confidence. While showing lower reliability, the enjoyment scale captures a unique aspect of attitudes and is acceptable for exploratory research. These findings confirm the ACCC as a reliable tool for assessing attitudes towards computers and computing courses in this study's context.

Table 5. Internal consistency reliability (cronbach alpha coefficient) and discriminant validity (mean correlation with other scales) for the ACCC

Scale name	No. of items	Alpha reliability	Mean correlation with other scales
Usefulness of course (UCrs)	7	0.70	0.40
Anxiety (Anx)	7	0.74	0.45
Usefulness of computer (UCom)	7	0.76	0.52
Enjoyment (Enj)	7	0.52	0.54

N = 122

6.1.3 *Academic efficacy (AE)*

The academic efficacy (AE) scale was evaluated for its reliability in computer laboratory settings at middle and secondary educational levels. Table 6 presents the results of this analysis.

Table 6. Internal consistency reliability (cronbach alpha coefficient) for the academic efficacy scale

Scale name	No. of items	Alpha reliability
Academic efficacy (AE)	8	0.68

N = 122

The academic efficacy scale demonstrated a Cronbach's alpha of 0.68, approaching the commonly accepted threshold of 0.70 for good reliability (Nunnally, 1978). This value suggests that the AE scale provides a reasonably consistent measure for evaluating academic efficacy in the specified educational settings.

To put this reliability coefficient in context, we can refer to DeVellis (1991), who suggests that alpha values between 0.65 and 0.70 are minimally acceptable, especially in exploratory research or when dealing with psychological constructs. Given that academic efficacy is a complex psychological construct that various factors can influence in educational settings, this level of reliability is considered adequate for this study.

The comprehensive analysis of the computer laboratory environment inventory (CLEI), attitude towards computers and computing courses (ACCC), and academic efficacy (AE) scale provides strong evidence for their reliability and validity in the context of this study.

6.2 *Objective 2*

To assess the computer laboratory learning environments, attitudes towards computers and academic efficacy at the middle and secondary levels in selected schools in Jammu city.

6.2.1 *Computer laboratory environment inventory (CLEI) analysis*

To address the second objective of this study, we examined the nature of computer laboratory learning environments in selected middle and secondary schools in Jammu City. Based on data collected from 122 students, descriptive statistics specifically means and standard deviations, were calculated for the computer laboratory environment inventory (CLEI) (Table 7).

Table 7. Means and standard deviations (SD) for CLEI

Scale name	No. of items	Mean (M)	Standard deviation (SD)
Student cohesiveness	7	2.79	0.29
Open-endedness	7	2.89	0.30
Integration	7	2.87	0.46
Technology adequacy	7	2.96	0.39
Availability	7	2.78	0.37

$N = 122$

The analysis revealed that the means for the CLEI scales ranged from 2.78 to 2.96, with standard deviations varying from 0.29 to 0.46. These results provide insights into students' perceptions of various aspects of their computer laboratory environments.

Interpretation of CLEI results:

1. Technology adequacy ($M = 2.96$, $SD = 0.39$): This scale exhibited the highest mean score among all CLEI dimensions. The result suggests that students generally perceive their computer laboratories as well-equipped with adequate technological resources. The relatively low standard deviation indicates consistency in this perception across the sample.

2. Open-endedness ($M = 2.89$, $SD = 0.30$): The second-highest mean score on this scale implies that students perceive their laboratory activities as allowing for autonomy and open-ended exploration. The low standard deviation suggests uniformity in this perception across the student population.

3. Integration ($M = 2.87$, $SD = 0.46$): While the mean score for Integration is relatively high, it is noteworthy that this scale demonstrated the highest standard deviation. This indicates that while students generally perceive good integration between laboratory activities and their broader coursework, there is more variability in individual experiences compared to other dimensions.

4. Student cohesiveness ($M = 2.79$, $SD = 0.29$): This scale exhibited the lowest standard deviation, indicating high

consistency in students' perceptions of peer relationships and collaboration within the laboratory environment. The mean score suggests a moderately positive view of student cohesiveness.

5. Availability (*M* = 2.78, *SD* = 0.37): Although this scale had the lowest mean score, it still indicates a generally positive perception of laboratory availability. The standard deviation suggests some variability in individual experiences regarding access to laboratory resources.

These findings provide valuable insights into the nature of computer laboratory environments in the sampled schools. All scale means fall above the midpoint of 2.5 on the 4-point scale, indicating generally positive perceptions across all measured dimensions. The consistently low standard deviations (ranging from 0.29 to 0.46) suggest a high degree of consensus among students in their perceptions of the laboratory environment. The results highlight that students view their computer laboratories as technologically adequate and well-integrated with their coursework. They also perceive opportunities for open-ended learning and a sense of cohesiveness among peers. However, the slightly lower score on availability suggests that access to laboratory resources might be an area for potential improvement.

These findings align with previous research emphasising the importance of well-equipped and integrated computer laboratories in fostering positive learning experiences (e.g., Zandvliet, 2003; Newby & Fisher, 1997). The positive perceptions of technology adequacy and integration are particularly encouraging, as these factors have been associated with enhanced learning outcomes in technology-rich environments (Chang & Fisher, 2003). The results provide a foundation for understanding the strengths and potential areas for enhancement in computer laboratory environments within the context of middle and secondary schools in Jammu City. This information can guide educational administrators and policymakers in optimising these learning spaces and improving students' academic experiences.

6.2.2 *Means and standard deviations on the ACCC*

The attitude towards computers and computing courses (ACCC) scale assessed students' perspectives on computers in educational settings. Table 8 presents the descriptive statistics for the ACCC scales.

Table 8. Means and standard deviations (SD) for the ACCC

Scale name	No. of items	Mean (M)	Standard deviation (SD)
Usefulness of course	7	2.87	0.41
Anxiety	7	2.01	0.46
Usefulness of computers	7	3.05	0.42
Enjoyment	7	3.10	0.33

N = 122

Analysis of the ACCC scale revealed varying attitudes towards computers and computing courses:

1. Enjoyment (*M* = 3.10, *SD* = 0.33): The highest mean score indicates that students generally find learning with computers engaging and stimulating. This positive attitude is crucial for motivation and effective learning (Newby & Fisher, 1998).

2. Usefulness of computers (*M* = 3.05, *SD* = 0.42): High scores on this scale underscore students' recognition of technology as an integral part of modern education.

3. Usefulness of course (*M* = 2.87, *SD* = 0.41): Students generally perceive their computing courses as beneficial, though slightly less so than computers.

4. Anxiety (*M* = 2.01, *SD* = 0.46): The lowest mean suggests some apprehension among students when interacting with computers, potentially hindering learning processes (Siddiqui, 2013).

The relatively consistent standard deviations (ranging from 0.33 to 0.46) indicate a relatively uniform attitude across the student body. However, the presence of anxiety, albeit low, suggests a need for interventions aimed at building computer confidence. These findings align with previous research emphasising the importance of positive attitudes in computer-based education (Al-Qahtani, 2012; Koul et al., 2018). The results provide valuable insights for educators and policymakers. They highlight the need for strategies to maintain high levels of enjoyment and perceived usefulness while addressing potential anxiety in computer-based learning environments.

6.2.3 *Mean and standard deviation for academic efficacy scale*

The academic efficacy scale results in Table 9 indicate that students strongly believe they can meet academic challenges within the computer lab environment, with a mean score of 3.39. This high confidence level is pivotal for student engagement and success, reflecting an effective alignment of lab activities with academic goals. The relatively low standard deviation of 0.56 suggests that this confidence is broadly shared among the student population, which indicates the overall efficacy of computer-based learning modalities in these schools.

Table 9. Mean and standard deviation (SD) for academic efficacy

Scale name	No. of items	Mean	Standard deviation (SD)
Academic efficacy	8	3.39	0.56

$N = 122$

6.3 *Objective 3*

To investigate the associations between computer laboratory learning environments and student's attitudes towards computers.

This objective explored the relationship between students' perceptions of their computer laboratory environment inventory (CLEI) and their attitude towards computers and computing courses (ACCC). The analysis used simple correlations (r), multiple correlations (R), and standardised regression coefficients (β). Table 10 presents these associations.

Table 10. Associations between the CLEI scales and four scales of ACCC in terms of simple correlation (r), multiple correlation (R) and standardised regression coefficient (β)

Scale name	Usefulness of course		Anxiety		Usefulness of computers		Enjoyment	
	r	β	r	β	r	β	r	β
Student cohesiveness	0.25**	0.08	0.05	0.19*	0.28**	0.15	0.10	-0.05
Open-endedness	0.39**	0.29	-0.32**	-0.11	0.33**	0.05	0.38**	0.16
Integration	0.29**	0.20	-0.72**	-0.62	0.41**	0.27	0.62**	0.52
Technology adequacy/freedom	0.32**	0.11	-0.39**	-0.06	0.43**	0.17	0.42**	0.12
Availability	0.17	-0.15	-0.46**	-0.08	0.33**	0.04	0.38**	-0.02
Multiple correlation (R, R^2)	$R = 0.45$**		$R = 0.75$**		$R = 0.51$**		$R = 0.65$**	
	$R^2 = 0.20$**		$R^2 = 0.56$**		$R^2 = 0.26$**		$R^2 = 0.42$**	

r: Simple correlation coefficient, β: Standardised regression coefficient, R: Multiple correlation coefficient, R^2: Coefficient of determination, $N = 122$ for all measures, Significance levels: *$p < 0.05$, **$p < 0.01$

6.3.1 *Associations of CLEI with usefulness of courses*

Analysis of the relationship between CLEI scales and the usefulness of course revealed positive and statistically significant simple correlations across all CLEI scales, ranging from 0.17 (Availability) to 0.39 (Open-endedness). These findings suggest that various elements of the computer lab environment contribute to students' perceptions of course usefulness. The multiple correlations (R = 0.45, $p < 0.01$) indicated a moderate collective influence of the lab environment on course usefulness, explaining 20% of the variance (R^2 = 0.20). This suggests that while the lab environment shapes perceptions of course usefulness, other factors not captured by the CLEI contribute significantly (Table 10).

Examination of standardised regression coefficients (β) revealed varied influences from different CLEI scales:

1. Open-endedness showed the most substantial positive impact (β = 0.29), suggesting that environments allowing for diverse approaches and creative problem-solving enhance perceived course usefulness.

2. Integration (β = 0.20) and technology adequacy (β = 0.11) also showed positive, albeit smaller, impacts.

3. Availability demonstrated a negative influence (β = -0.15), indicating that issues with resource accessibility may detract from perceived course value.

4. Student cohesiveness had a minimal impact (β = 0.08).

Notably, none of the individual CLEI scales showed statistically significant associations with the usefulness of course scale when controlling for other variables. This suggests a complex interplay between different aspects of the lab environment in shaping course usefulness perceptions. These findings underscore the importance of creating diverse, well-integrated, and accessible computer lab environments to enhance students' perceptions of course usefulness. However, the lack of statistical significance in individual predictors highlights the need for further research to understand how lab environments influence these perceptions.

6.3.2 *Associations of CLEI with anxiety*

Analysis of the relationship between CLEI scales and anxiety revealed significant negative correlations for most CLEI scales, with the integration scale showing the strongest association (r = -0.72, $p < 0.01$). This robust negative correlation suggests that well-integrated lab environments, where practical activities align closely with theoretical coursework, may substantially alleviate students' anxiety related to computer courses. The high multiple correlation coefficient (R = 0.75, $p < 0.01$) and substantial R^2 value (0.56) indicate that the CLEI scales collectively explain 56% of the variance in student anxiety levels (Table 10). This finding underscores the significant role that positive lab environments can play in reducing computer-related anxiety and, consequently, enhancing overall student attitudes toward computers.

Examination of standardised regression coefficients (β) revealed:

1. Integration had the most substantial negative impact (β = -0.62), reinforcing its crucial role in anxiety reduction.

2. Student cohesiveness showed a small but significant positive impact (β = 0.19, $p < 0.05$), suggesting a nuanced relationship where peer interactions might occasionally contribute to competitive pressure or performance anxiety.

3. Other CLEI scales showed more negligible, non-significant impacts on anxiety levels.

These findings highlight the complex interplay between lab environment factors and student anxiety. While well-integrated labs generally reduce anxiety, the role of peer interactions warrants further investigation. Educators should focus on creating integrated, supportive lab environments while being mindful of potential pressures arising from student cohesiveness.

6.3.3 *Associations of CLEI with usefulness of computers*

Analysis of the relationship between CLEI scales and the perceived usefulness of computers revealed positive correlations across all scales, suggesting that supportive and resource-adequate lab environments foster recognition of computer utility (Table 10). Key findings include:

1. The technology adequacy scale showed the highest correlation (r = 0.43, $p < 0.01$), highlighting the importance of adequate technological resources in shaping students' perceptions of computer usefulness.

2. The overall model demonstrated a moderate collective influence, with a multiple correlation of R = 0.51 (p <

0.01), explaining 26% of the variance in perceptions related to computer usefulness ($R^2 = 0.26$).

3. Examination of standardised regression coefficients (β) revealed:

• Integration had the most substantial positive effect ($\beta = 0.27$), reinforcing the value of integrating practical computer skills with theoretical knowledge.

• Technology adequacy also showed a positive impact ($\beta = 0.17$), emphasising the role of up-to-date and well-maintained technological resources.

• Other CLEI scales showed more negligible, non-significant effects.

Notably, while all CLEI scales showed positive, simple correlations, none exhibited statistically significant associations with the usefulness of computers scale when controlling for other variables in the regression model. This suggests a complex interplay between different aspects of the lab environment in shaping perceptions of computer usefulness. These findings underscore the importance of providing well-integrated, technologically adequate computer lab environments to enhance students' perceptions of computer utility. However, the lack of statistical significance in individual predictors highlights the need for further research to understand how lab environments influence these perceptions.

6.3.4 *Associations of CLEI with enjoyment*

Analysis of the relationship between CLEI scales and enjoyment revealed significant positive correlations across all scales (Table 10), with the integration scale showing the strongest association ($r = 0.62$, $p < 0.01$). This indicates that students enjoy computer-related activities more when labs are well-integrated with course content and provide a supportive learning environment.

Key findings include:

1. The collective impact of CLEI factors on enjoyment was substantial, with a multiple correlation of $R = 0.65$ ($p <$ 0.01), explaining 42% of the variance in enjoyment ($R^2 = 0.42$).

2. Examination of standardised regression coefficients (β) revealed:

• Integration had the most substantial positive effect ($\beta = 0.52$), suggesting that students derive more enjoyment from computer courses when the curriculum ties directly into their hands-on lab activities.

• Open-endedness ($\beta = 0.16$) and technology adequacy ($\beta = 0.12$) showed moderate positive effects.

• Student cohesiveness demonstrated a slight negative impact ($\beta = -0.05$), hinting at potential complexities in group dynamics.

3. Despite strong, simple correlations, none of the CLEI scales showed statistically significant associations with Enjoyment when controlling for other variables in the regression model.

These findings highlight the importance of well-integrated lab environments in promoting student enjoyment of computer-related activities. The decisive role of integration suggests that aligning practical lab work with theoretical coursework enhances student engagement and enjoyment. However, the lack of statistical significance in individual predictors and the slight negative impact of student cohesiveness underscore the complex nature of factors influencing student enjoyment. This complexity warrants further investigation into the interplay between different aspects of the lab environment and their collective impact on student enjoyment. Educators should focus on creating integrated, engaging lab environments while being mindful of group dynamics that might influence individual enjoyment. Future research could explore these relationships more deeply to inform targeted computer lab design and management improvements.

These findings collectively demonstrate that the design and management of computer laboratory environments are crucial in shaping students' attitudes towards their computer courses. Enhancing the quality of these environments can lead to more positive student attitudes, reduced anxiety, and greater appreciation and enjoyment of computer-related educational experiences. Each correlation and regression analysis informs targeted improvements that can make computer labs more conducive to learning and personal development.

6.4 *Objective 4*

To investigate the associations between computer laboratory learning environment and academic efficacy.

The fourth objective of this study is to explore the potential associations between students' perceptions of their computer laboratory learning environments and their academic efficacy. Table 11 presents the results of this analysis.

Table 11. Associations between the CLEI scales and academic efficacy scale in terms of simple correlation (r), multiple correlation (R) and standardised regression coefficient (β)

Scale name	Academic efficacy	
	r	β
Student cohesiveness	0.13	0.04
Open-endedness	0.26**	0.11
Integration	0.29**	0.17
Technology adequacy	0.24**	0.00
Availability	0.28**	0.12
Multiple correlation	R = 0.35** R^2 = 0.12**	

**Significant at 0.01 level, N = 122

The results demonstrate significant correlations between the four scales of the computer laboratory environment inventory (CLEI) and the academic efficacy scale. Correlations range from 0.13 (student cohesiveness) to 0.29 (integration), suggesting that integration within the lab environment influences academic self-confidence. Multiple correlation analysis revealed an R-value of 0.35 ($p < 0.01$), indicating a moderate overall association between the combined CLEI scales and academic efficacy. The coefficient of determination (R^2 = 0.12) implies that variations in the computer laboratory environment account for approximately 12% of the variance in students' academic efficacy perceptions. This relationship underscores the impact of the physical and psychosocial learning environment on students' academic confidence.

Analysis of standardised regression coefficients (β) reveals varied individual contributions of each CLEI scale to academic efficacy, though none showed a statistically significant correlation at conventional levels. Notably:

1. The integration scale shows the highest relative influence (β = 0.17), reinforcing the importance of a well-integrated learning environment in promoting academic efficacy.

2. The technology adequacy scale, despite showing a reasonable simple correlation (r = 0.24), did not yield a significant β value. This suggests that while technology adequacy is perceived as necessary, it may not independently influence academic efficacy as strongly as integration.

These findings suggest that certain aspects of the computer lab environment, such as integration and open-endedness, positively influence students' academic efficacy, albeit with a moderate overall impact. This points to the complex interplay of various environmental factors in shaping academic outcomes and highlights the potential for targeted interventions to enhance educational settings and student efficacy. Future research could explore additional factors contributing to academic efficacy in computer-based learning environments, as the current model explains a relatively small proportion of the variance. Nonetheless, these results provide valuable insights for educators and policymakers in designing and implementing effective computer laboratory environments that support students' academic self-confidence.

6.5 *Objective 5*

To assess whether gender differences exist in computer laboratory learning environments, attitudes towards computers and academic efficacy.

6.5.1 *Gender differences in CLEI*

The study investigated gender-based discrepancies within the computer laboratory environment inventory (CLEI) using independent sample *t*-tests. The results presented in Table 12 revealed statistically significant differences between genders only in the integration scale ($t = 2.88$, $p < 0.01$), where female students reported higher means, indicating a more substantial agreement that their lecture materials are well-integrated with laboratory activities. Cohen's *d* values ranged from very small (0.02 in technology adequacy) to moderate (0.53 in integration), suggesting that while there are differences in how males and females perceive their laboratory environment, these differences are not uniformly significant across all scales.

Table 12. Mean, standard deviations, Cohen's *d* and standard error mean for gender difference in CLEI

Scale	Gender	Mean	Std. error mean	*df*	Standard deviation	*t*	*d*
Student cohesiveness	Males	2.80	0.04	120	0.33	0.47	0.86
	Females	2.77	0.03		0.25		
Open-endedness	Males	2.88	0.04	120	0.32	0.30	0.05
	Females	2.90	0.03		0.28		
Integration	Males	2.76	0.05	120	0.46	2.88**	0.53
	Females	2.99	0.05		0.42		
Technology adequacy	Males	2.97	0.05	120	0.45	0.09	0.02
	Females	2.96	0.04		0.33		
Availability	Males	2.72	0.04	120	0.36	1.89	0.33
	Females	2.85	0.05		0.38		

**Significant at 0.01, Male: $N = 63$; Female: $N = 59$

6.5.2 *Gender differences in ACCC*

Further analysis assessed gender differences across the attitude towards computers and computing courses (ACCC) scales. The data, illustrated in Table 13, identified a significant difference on the enjoyment scale ($t = 2.04$, $p < 0.05$), with females exhibiting higher enjoyment levels in laboratory work than their male counterparts. This suggests a gendered dimension to how computer labs are experienced in terms of enjoyment. Effect sizes calculated using Cohen's *d* were mostly small, with the highest being 0.38 for enjoyment, indicating a medium effect size according to Cohen's standards.

6.5.3 *Gender difference in academic efficacy*

Gender differences in academic efficacy were explored by comparing mean scores and conducting *t*-tests. The results, as shown in Table 14, indicated no significant differences between male and female students in terms of academic efficacy in computer labs. Both groups displayed similar confidence levels in their abilities to achieve learning outcomes within this environment, with a very small effect size ($d = 0.09$). This outcome suggests that gender does not significantly influence academic efficacy in the computer laboratory context.

Table 13. Means, standard deviations, Cohen's *d* and standard error mean for gender differences in students' perceptions of learning environment as measured by the ACCC

Scale	Gender	Mean	Std. error mean	*df*	Standard deviation	*t*	*d*
Usefulness of course	Males	2.85	0.06	120	0.51	0.28	0.05
	Females	2.88	0.03		0.28		
Anxiety	Males	2.08	0.06	120	0.49	1.91	0.33
	Females	1.92	0.05		0.41		
Usefulness of computers	Males	3.04	0.05	120	0.41	0.44	0.07
	Females	3.07	0.05		0.43		
Enjoyment	Males	3.04	0.04	120	0.31	2.04*	0.38
	Females	3.16	0.04		0.33		

*Significant at 0.05, Males: $N = 63$; Females: $N = 59$

Table 14. Means, standard deviations, Cohen's *d* and standard error mean for gender differences in academic efficacy

Scale	Gender	Mean	Std. error mean	*df*	Standard deviation	*t*	*d*
Academic efficacy	Males	3.36	0.06	120	0.52	0.51	0.09
	Females	3.41	0.07		0.60		

Males: $N = 63$; Females: $N = 59$

6.6 *Summary of results*

Objective 1: Reliability and validity of instruments

The study affirmed the reliability and validity of the CLEI, ACCC, and AE scales for evaluating computer lab environments and student attitudes at middle and secondary levels. Cronbach's alpha demonstrated acceptable to strong internal consistency across scales, confirming the robustness of these instruments for educational assessments.

Objective 2: Assessment of computer lab environments

Students perceived their computer lab environments positively, particularly highlighting high technology adequacy and open-endedness, which suggests well-equipped and flexible learning settings. However, scores on resource availability were relatively lower, indicating room for improvement.

Objective 3: Associations between lab environments and student attitudes

Significant positive correlations were found between the quality of computer lab environments and students' attitudes towards computers and computing courses. Well-integrated and resource-adequate labs were linked to enhanced perceptions of usefulness and reduced anxiety, yet their impact on academic efficacy was moderate.

Objective 4: Impact on academic efficacy

The influence of computer lab environments on academic efficacy was modest, underscoring a complex relationship between lab conditions and academic confidence. This suggests further exploration is needed to fully understand how these environments affect academic outcomes.

Objective 5: Gender differences in perceptions and attitudes

The study identified gender differences, with female students reporting higher integration and enjoyment in computer lab activities than males, though no significant differences were observed in academic efficacy between genders, indicating equitable support across gender in computer labs.

7. Discussion

This study investigated the impact of computer laboratory environments on students' attitudes towards computers and computer courses and their academic efficacy in Jammu, India. Data was collected from 122 students across private secondary schools using three validated quantitative tools: the computer laboratory environment inventory (CLEI), attitude towards computer and computing courses (ACCC), and academic efficacy (AE).

The analysis confirmed the reliability and validity of CLEI and ACCC, demonstrating that these instruments effectively measure students' perceptions. This aligns with previous research by Newby and Fisher (1997) and Zandvliet (2003), who found these instruments robust in assessing computer laboratory environments. Students generally reported positive perceptions of their computer laboratory environments, highlighting the conducive learning environments provided by the schools. This finding is consistent with studies by Ahiatrogah and Adane (2011) and Al-Qahtani (2012), which emphasised the importance of well-equipped computer labs in fostering interest and competence in computer-related subjects.

Interestingly, despite the generally positive views on laboratory environments, the study revealed no significant correlations between these perceptions and students' attitudes toward computers and computing courses or their sense of academic efficacy. This unexpected outcome suggests that positive perceptions of computer lab environments do not necessarily translate into enhanced attitudes toward computer education or increased academic confidence. This finding contrasts with the work of Henderson et al. (2000), who found strong correlations between learning environments and student outcomes. The discrepancy in results indicates the presence of other mediating factors and highlights the complex nature of attitude formation in educational settings, as McRobbie et al. (1997) suggested.

Gender differences were also examined, revealing significant disparities on specific scales, notably the integration scale of the CLEI and the Enjoyment scale of the ACCC, with female students reporting more positive experiences. This aligns with findings by Koul et al. (2018), who noted gender differences in perceptions of computer laboratory environments. However, no significant gender differences were noted in academic efficacy, indicating that both male and female students feel equally competent in achieving their educational goals in computer-related courses.

These insights are particularly valuable for educational practitioners and policymakers. The findings on gender differences highlight the need for gender-responsive teaching strategies and curriculum designs to cater more effectively to diverse student groups, a point Siddiqui (2013) emphasises in the context of computer-assisted instruction. Moreover, the lack of a direct correlation between positive lab environments and student attitudes calls for a broader approach to enhancing educational outcomes. This approach should consider other crucial factors, such as the relevance of the curriculum, instructional quality, and individual learner differences, as Chang and Fisher (2003) suggested in their study of technology-rich learning environments.

The results of this study contribute to the ongoing discourse on optimising learning environments to enhance both academic performance and students' attitudes towards technology in education, as highlighted by Fraser (1998) and Goh and Fraser (2000). While our findings reaffirm the importance of well-designed computer laboratory environments, they also underscore the need for a holistic approach to technology-enhanced education that considers various factors influencing student outcomes.

8. Limitations of the study and scope for future research

While this study provides valuable insights into the impact of computer laboratory learning environments on students' attitudes and academic efficacy, several limitations should be considered when interpreting the results. These limitations also offer opportunities for future research directions.

1. Sample size and representativeness: The study's sample is limited to 122 students from seven private schools in Jammu, which may not be representative of other regions or school types, limiting the generalizability of the findings. Future research could expand the sample to include a broader range of private and public schools across different

regions of India. This would provide a more comprehensive understanding of computer laboratory environments and their impacts across diverse educational settings.

2. Self-reported data: The reliance on self-reported data from instruments like CLEI and ACCC can introduce response biases and may not capture the full complexity of the measured constructs. Future studies could incorporate observational methods or performance-based assessments to complement self-report measures, providing a more robust evaluation of the learning environment and its effects.

3. Cross-sectional design: The study's cross-sectional nature restricts the ability to establish causality between the computer lab environments and students' attitudes or efficacy. Longitudinal studies could examine how perceptions of lab environments and their impacts on attitudes and efficacy change, potentially revealing causal relationships.

4. Support structures: The assessment did not extend to support structures like technical support and training, which are crucial for maximising the educational use of computer labs. Future research could investigate the role of these support structures in shaping the effectiveness of computer laboratory environments and their impact on student outcomes.

5. Technological advancements: Given the rapid pace of technological change, future studies could explore how emerging technologies (e.g., virtual reality, artificial intelligence) impact computer laboratory environments and student experiences.

6. Cultural context: Future research could examine how cultural factors specific to different regions of India influence perceptions of computer laboratory environments and their effectiveness in promoting positive attitudes and academic efficacy.

By addressing these limitations and exploring these suggested research directions, future studies can build upon the findings of this research to provide a more comprehensive understanding of computer laboratory environments and their impacts on student attitudes and academic efficacy in the Indian educational context.

9. Educational implications

The following section outlines key educational implications derived from the study's findings. These recommendations aim to enhance the design and utilisation of computer lab environments in middle and secondary schools, address observed gender differences, and suggest improvements in educational practices to maximise the effectiveness of technology-enhanced learning.

1. Optimising computer lab design: Enhance computer lab environments by updating technological resources and aligning them with educational goals to boost student engagement and learning outcomes.

2. Addressing gender differences: Implement gender-responsive teaching strategies and tailor curricula to meet the diverse needs of male and female students, fostering a more inclusive learning environment.

3. Enhancing educational practices: Adopt a holistic approach to education that integrates innovative pedagogical methods with technology, encouraging active learning and improving student attitudes towards computers.

10. Conclusions

This study has provided critical insights into the influence of computer laboratory environments on student attitudes and academic efficacy. By examining the nuanced relationships within these environments, it has become evident that while students perceive these spaces positively, such perceptions do not straightforwardly translate into enhanced attitudes towards computing or increased academic efficacy. This discrepancy underscores the intricate web of factors affecting educational outcomes and highlights the need for educational strategies beyond improving physical environments.

The findings also shed light on gender differences in the perception and experience of computer labs, revealing that female students tend to benefit more from well-integrated lab activities. This gender disparity underscores the importance of creating educational experiences that are not only inclusive but also tailored to meet diverse needs. This study emphasises the critical role of contextually aware educational practices by explicitly linking these findings to the initial objectives.

Furthermore, the research underlines the necessity of adopting a multifaceted approach in educational settings. Enhancing both the physical and psychological aspects of learning environments and ensuring these enhancements are seamlessly integrated with pedagogical and curricular innovations is essential. This approach will improve the immediate learning environment and foster an educational atmosphere conducive to all students' growth and development.

Further research must continue to explore and delineate these dynamics. Future studies aim to unpack the complex relationships between environmental factors and educational outcomes across diverse educational contexts. This continued investigation will provide the empirical foundation needed to inform and refine educational practices, ultimately leading to more effective and equitable educational outcomes.

Conflict of interest

I hereby declare that I and my co-author have no financial, personal, or professional conflicts of interest related to the content of this manuscript. There are no affiliations or funding sources that could be perceived as influencing the research outcomes presented in this submission.

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