International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(18s) 2026 pp. 383-397
https://doi.org/10.70917/ijcisim-2026-4877
Article

Digital Literacy, Digital Citizenship Competency, and Academic Behavior Among Secondary School Students in Bihar: A Structural Equation Modeling Approach

Ravindra Kumar[1], Ashutosh Prabhakar[2], *Ravi Kant[3], Suraksha[4]

[1]Central Institute of Educational Technology (CIET), National Council of Educational Research and Training (NCERT) City-New Delhi, India
Email: ravindra.kumarte01@gmail.com
[2]Central University of South Bihar,
Email: ashuprabhakar.007@gmail.com
https://orcid.org/0000-0002-1482-9317
[3*]Department of Teacher Education, Central University of South Bihar, India
Email: ravikantdr@cusb.ac.in
[4]NET Education & NET-JRF Visual Art and Ph.D. Fine Art
surksha.pawar@gmail.com
Corresponding Author: Ravi Kant, Email: ravikantdr@cusb.ac.in

Abstract: In today's technology driven environments digital literacy and digital citizenship are critical competencies for adolescent learners. However, their joint influence on academic behavior—particularly in under-resourced public-school settings—remains insufficiently theorized and empirically under-tested in the Indian context. This study examined the structural relationships among digital literacy (DL), digital citizenship competency (DC), and academic behavior (AB) among secondary school students (Classes 9–10) enrolled in government schools across three districts of Bihar's Magadh region: Gaya, Nawada, and Jehanabad. A cross-sectional survey was conducted with a stratified random sample of 850 students (n = 466 male; n = 384 female) from 33 government schools. Three validated scales—the Digital Literacy Scale (DLS-16), the Digital Citizenship Competency Scale (DCCS-16), and the Academic Behavior Scale (ABS-16)—were administered. Data were analyzed using a two-stage approach: confirmatory factor analysis (CFA) for measurement model validation, followed by full structural equation modeling (SEM) with bootstrapped mediation analysis. Results indicated that digital literacy ($\beta = .412$, $p < .001$) and digital citizenship ($\beta = .389$, $p < .001$) were both significant positive predictors of academic behavior. Digital literacy also predicted digital citizenship ($\beta = .574$, $p < .001$), with digital citizenship partially mediating the DL–AB relationship (indirect $\beta = .223$, 95% CI [.172, .274]). The final SEM achieved acceptable model fit ($\chi^2/df = 2.31$, CFI = .968, TLI = .961, RMSEA = .039, SRMR = .047). Multi-group invariance analysis confirmed scalar invariance across gender. Findings highlight the importance of including digital literacy and digital citizenship education in Bihar's NEP 2020 implementation roadmap.

Keywords: Digital Literacy; Digital Citizenship; Academic Behavior; Structural Equation Modeling; Bihar; NEP 2020

1. Introduction

The rapid growth of Information and Communication Technologies (ICTs) has changed the way students learn and interact with educational resources in India. Digital technologies are now an essential part of teaching and learning. Recognizing this shift, the National Education Policy (NEP) 2020 identifies digital literacy as one of the key competencies that every student should develop before completing school (Ministry of Education, 2020). However,

despite this policy emphasis, there is limited evidence on how far these goals have been achieved, especially in government schools in Bihar where resources and digital infrastructure remain limited.

The COVID-19 pandemic further increased the importance of digital technologies in education. Online learning became a necessity rather than an option. As a result, digital skills are now considered essential for students to participate effectively in education and society (van Dijk, 2020). International organizations such as the European Commission, UNESCO, and the International Society for Technology in Education (ISTE) have developed comprehensive frameworks to define digital competence (Vuorikari et al., 2022). In India, several initiatives, including PMGDISHA, PM eVIDYA, and the Digital India programme, have been launched to improve digital access and digital literacy. However, the benefits of these programmes have not reached all parts of the country equally. Rural and economically disadvantaged regions continue to face significant challenges.

Bihar is one such state where the digital divide remains a major concern. Although school enrolment has improved over the years, many government schools still struggle with inadequate computer facilities, unreliable internet connectivity, and a shortage of trained teachers (ASER, 2023; UDISE+, 2023). According to the ASER (2023) report, less than 22 percent of students studying in Classes IX and X in rural Bihar can perform a simple internet search successfully. At the national level, the corresponding figure is around 38 percent. This gap highlights the unequal development of digital skills among students.

The Bihar School Examination Board (BSEB) has introduced computer science as part of the revised secondary school curriculum. However, many schools do not have sufficient computers or internet facilities. Teachers also often lack adequate training to teach digital skills effectively (Prabhakar, 2024). As a result, there is a noticeable gap between the objectives of digital education policies and their implementation in classrooms. The effect of this gap on students' academic behaviour has not been studied extensively.

Along with digital literacy, another important concept in today's educational environment is digital citizenship. Digital citizenship refers to the responsible, ethical, and safe use of digital technologies (Ribble, 2015). Previous studies have generally examined digital literacy and digital citizenship separately (Ata & Yildirim, 2019; Choi et al., 2017). Research has shown that students with higher digital literacy often perform better academically (Hatlevik & Christophersen, 2013; Ng, 2012; Li et al., 2025). Similarly, students who demonstrate responsible digital citizenship tend to show greater academic engagement and integrity (Choi et al., 2017; Hinduja & Patchin, 2015). However, very few studies have examined the combined influence of digital literacy and digital citizenship on students' academic behaviour, particularly in the Indian school context.

Academic behaviour includes important learning practices such as classroom engagement, self-regulated learning, academic integrity, and collaborative learning. These behaviours play a crucial role in determining students' educational success (Zimmerman, 2002; Pintrich, 2004; Bandura, 1986). Digital competencies are likely to influence academic outcomes through these behaviours. Therefore, understanding this relationship is important for teachers, school administrators, curriculum developers, and policymakers.

The issue is also closely linked to educational equity. A large proportion of students studying in Bihar's government schools belong to Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC), and economically weaker sections of society. According to van Dijk's (2020) digital divide theory, inequalities in access to digital technologies gradually lead to inequalities in digital skills and eventually to differences in educational achievement. Unless these gaps are addressed through appropriate policies and educational support, existing social inequalities may continue to widen.

Keeping these concerns in view, the present study examines how digital literacy and digital citizenship influence the academic behaviour of secondary school students studying in government schools in the Magadh region of Bihar, which includes the districts of Gaya, Nawada, and Jehanabad. The study develops and tests a structural model to understand these relationships. The findings are expected to contribute to research on digital competencies

in Indian secondary education, support the development of reliable measurement tools for Hindi-medium students, and provide useful evidence for strengthening the implementation of the digital education goals of NEP 2020 in Bihar.

2. Theoretical Framework and Literature Review

2.1 Digital Literacy: Conceptual Foundations

Digital literacy is a widely used concept in education, but there is no single definition that is accepted by everyone. This is mainly because digital technologies continue to change rapidly, and new skills are constantly becoming important (Bawden, 2008; Ng, 2012). Earlier definitions focused mainly on basic digital skills, such as finding information, evaluating its reliability, and communicating through digital tools (Bawden, 2008). Over time, researchers have expanded the concept. Today, digital literacy includes not only technical skills but also the ability to communicate effectively, create digital content, think critically, solve problems, and use technology safely and responsibly.

One of the most widely accepted frameworks for understanding digital literacy is the European Commission's DigComp 2.2 framework (Vuorikari et al., 2022). This framework describes digital literacy through five broad areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Rather than treating digital literacy as a skill that people either have or do not have, the framework views it as a set of competencies that develop over time. It identifies twenty-three specific competencies that together reflect different levels of digital proficiency.

Many studies have shown that digital literacy is positively related to students' academic performance (Ng, 2012; Porat et al., 2018; Li et al., 2025). A recent meta-analysis by Li et al. (2025), which combined findings from 35 independent studies, reported a moderate positive relationship between digital literacy and academic achievement ($r = 0.41$). The study also found that factors such as students' grade level, subject area, and gender can influence the strength of this relationship.

Research has also shown that the benefits of digital literacy go beyond academic achievement. Students with better digital skills are often more confident in managing their own learning (Hatlevik & Christophersen, 2013; Zakir et al., 2025). They are more actively involved in classroom activities and make greater use of learning resources available online (Aesaert et al., 2015). They also tend to use effective learning strategies, such as planning, monitoring, and evaluating their own learning (Pintrich, 2004). One possible reason for these positive outcomes is self-efficacy. According to Bandura (1986), students who believe they can use digital technologies successfully are more willing to explore new learning opportunities, search for additional academic resources, and continue learning independently. Similar findings have also been reported by Zakir et al. (2025).

Although the existing research provides valuable evidence, most of these studies have been conducted in developed countries. Research from South Asian countries, especially India, is still limited. The available Indian studies mainly focus on college and university students, while very little attention has been given to students studying in government secondary schools (Bawden, 2008). This creates an important research gap. The need for such research is even greater in Bihar, where many schools continue to face shortages of computers, internet connectivity, and other digital facilities (ASER, 2023; UDISE+, 2023). At the same time, the National Education Policy 2020 expects all students to develop digital literacy as an essential life skill (Ministry of Education, 2020). Therefore, it is important to examine the level and impact of digital literacy among secondary school students in Bihar's government schools.

2.2 Digital Citizenship Competency

Digital citizenship refers to the responsible, safe, and ethical use of digital technologies. Ribble (2015) introduced this concept through nine key elements: digital access, digital commerce, digital communication, digital literacy, digital etiquette, digital law, digital rights and responsibilities, digital health and wellness, and digital security. Later, Choi et al. (2017) further developed this idea by highlighting the role of active and responsible participation in

digital spaces. Unlike earlier approaches that mainly focused on protecting users from online risks, the concept of digital citizenship encourages students to become responsible, informed, and active participants in the digital world.

For school students, some dimensions of digital citizenship are especially important. These include following appropriate online behaviour, protecting personal information, staying safe on the internet, respecting others while communicating online, and understanding both their rights and responsibilities in digital environments (Ribble, 2015; Mossberger et al., 2008). Developing these skills helps students use digital technologies more responsibly in both their academic and personal lives.

Research on digital citizenship has increased considerably in recent years, particularly after the development of the Digital Citizenship Scale by Choi et al. (2017). Studies have shown that digital citizenship education improves students' awareness of online safety and encourages safer online practices (Krumsvik, 2011). It has also been found to reduce cyberbullying and promote respectful online interactions (Hinduja & Patchin, 2015). In addition, students with stronger digital citizenship skills are more likely to follow principles of academic honesty and use digital information ethically (Choi et al., 2017).

Recent studies also suggest that digital citizenship is positively related to students' academic engagement and responsible learning behaviour. Students who understand how to use digital technologies responsibly are generally more involved in learning activities and make better decisions while using online information. Researchers have argued that digital citizenship provides the ethical and behavioural foundation that connects students' digital skills with their actual academic practices (Ata & Yildirim, 2019; Mossberger et al., 2008). In other words, knowing how to use technology is important, but using it responsibly is equally essential for achieving positive educational outcomes.

Although awareness of digital citizenship is growing across the world, its place in the Indian school curriculum is still limited. The National Education Policy (NEP) 2020 mentions digital citizenship as part of value-based education and twenty-first-century skills, but it does not clearly define learning outcomes or methods for assessing these competencies (Ministry of Education, 2020). As a result, schools have little guidance on how digital citizenship should be taught or evaluated.

This issue is particularly relevant in Bihar. In many government schools, students are introduced to digital education mainly through basic computer literacy courses. These courses generally focus on developing technical ICT skills, while giving much less attention to ethical, social, and civic aspects of technology use (Prabhakar, 2024). Therefore, there is a need to examine digital citizenship more closely and understand how it influences students' academic behaviour in this context.

2.3 Academic Behaviour and Its Digital Antecedents

In the present study, academic behaviour refers to four important aspects of students' learning: academic engagement, self-regulated learning, academic integrity, and collaborative learning. The concept is based on the theories proposed by Zimmerman (2002), Pintrich (2004), and Bandura (1986). These theories explain that students' learning behaviour is influenced by several factors, such as their ability to plan and monitor their learning, their learning goals, their confidence in their own abilities, and the support available in their learning environment.

Academic behaviour is different from academic achievement and academic motivation. Academic achievement refers to learning outcomes such as examination scores, while academic motivation reflects the reasons that encourage students to learn. Academic behaviour, on the other hand, focuses on what students actually do during the learning process. It includes the way they participate in classroom activities, manage their studies, work with others, and maintain honesty in academic tasks. These behaviours provide the link between students' abilities and their academic performance.

Digital technologies can influence academic behaviour in many ways. Students with good digital skills can access learning materials more easily, communicate and work with classmates through digital platforms, and learn

independently at their own pace. Digital tools also encourage students to follow ethical practices, such as giving proper credit to information sources and avoiding plagiarism. As a result, digital literacy can support academic engagement, collaborative learning, and self-regulated learning (Zimmerman, 2002; Hatlevik & Christophersen, 2013; Zakir et al., 2025).

Researchers have also highlighted the importance of digital self-efficacy in this relationship. According to Bandura's (1986) Social Cognitive Theory, students who believe that they can use digital technologies effectively are more confident in using them for learning. This confidence encourages them to explore new learning resources, solve problems independently, and participate more actively in academic activities. Recent studies have provided empirical evidence supporting this relationship (Zakir et al., 2025).

Several international studies have examined the relationship between digital competencies and academic behaviour. Positive findings have been reported in countries such as South Korea (Choi et al., 2017), Türkiye (Ata & Yildirim, 2019), and Indonesia (Zakir et al., 2025). However, similar research in the Indian school context is still limited. Very few studies have focused on government secondary schools, particularly those with limited digital resources and Hindi-medium instruction. Therefore, it cannot be assumed that findings from other countries will apply directly to Bihar. This gap in the existing literature provides a strong justification for the present study.

2.4 Theoretical Model and Hypotheses

The present study is based on several well-established theoretical frameworks. These include the DigComp 2.2 Framework (Vuorikari et al., 2022), Ribble's (2015) Digital Citizenship Model, Zimmerman's (2002) Self-Regulated Learning Theory, Bandura's (1986) Social Cognitive Theory, and the Structural Equation Modeling (SEM) approach suggested by Kline (2016) and Hair et al. (2019). Together, these theories provide the foundation for examining the relationship between digital literacy, digital citizenship, and students' academic behaviour.

Based on these frameworks, the study proposes that digital literacy influences academic behaviour in two ways. First, it has a direct effect on students' academic behaviour. Second, it indirectly affects academic behaviour by improving students' digital citizenship. In other words, students with stronger digital literacy are expected to develop better digital citizenship, which may further strengthen their academic behaviour. To examine these relationships, the following hypotheses have been formulated:

1. H1: Digital literacy has a significant positive direct effect on academic behaviour.

2. H2: Digital citizenship has a significant positive direct effect on academic behaviour.

3. H3: Digital literacy has a significant positive effect on digital citizenship.

4. H4: Digital citizenship significantly mediates the relationship between digital literacy and academic behaviour.

5. H5: Gender significantly predicts academic behaviour after controlling for digital literacy and digital citizenship.

6. H6: Home internet access significantly predicts academic behaviour after controlling for digital literacy and digital citizenship.

3. Methodology

3.1 Research Design

The study used a quantitative cross-sectional survey design, which is appropriate for Structural Equation Modeling (SEM) (Hair et al., 2019; Kline, 2016). This research design allows data to be collected from a large group of participants at a single point in time. It helps examine the relationships among different variables without changing or controlling the study environment. Since the research was conducted in government schools, an experimental design

with random assignment was neither practical nor ethically appropriate. Therefore, a cross-sectional survey was considered the most suitable approach for the present study.

3.2 Population and Sampling

The target population for this study included all students studying in Classes IX and X in government secondary schools of the Magadh division of Bihar. According to UDISE+ (2023), there are about 186,400 students enrolled in 312 government secondary schools in this region. A stratified random sampling method was used to select the participants. Using this method, a total of 850 students from 33 government secondary schools were included in the study (Table 1). The sample size was adequate for Structural Equation Modeling (SEM). It was also higher than the minimum sample size of 600 recommended by the power analysis of MacCallum et al. (1996), which provides sufficient statistical power (0.80) for models with an RMSEA value of 0.05 or lower.

Table 1. Sample Distribution by District, School, and Gender

District	School Count	Male (n)	Female (n)	Total (n)	% of Sample
Gaya	12	143	112	**255**	30.0%
Nawada	10	128	107	**235**	27.6%
Jehanabad	11	195	165	**360**	42.4%
Total	**33**	**466**	**384**	**850**	**100%**

Note: Schools were selected using stratified random sampling.

3.3 Instruments

Three Likert-type scales (1 = Strongly Disagree to 5 = Strongly Agree) were employed. Digital Literacy Scale (DLS-16): A 16-item instrument adapted from Ng (2012) and Hatlevik et al. (2015), organized across four subscales aligned with the DigComp 2.2 framework (Vuorikari et al., 2022). Digital Citizenship Competency Scale (DCCS-16): The Digital Citizenship Competency Scale consisted of 16 items adapted from the instrument developed by Choi et al. (2017). The scale measured four dimensions of digital citizenship based on Ribble's (2015) digital citizenship model. Academic behaviour Scale (ABS-16): The Academic behaviour Scale included 16 items designed to measure students' academic behaviour across four dimensions. The scale was developed using the concepts of self-regulated learning proposed by Zimmerman (2002) and the principles of Social Cognitive Theory developed by Bandura (1986). Items were contextualized for Bihar government school students through an expert review panel of five mathematics and science teachers. All three scales were translated into Hindi using a forward-backward translation protocol. A pilot study with 60 students returned Cronbach's α values of .871, .883, and .886 for DLS-16, DCCS-16, and ABS-16 respectively.

3.4 Data Collection Procedure

Data were collected between January and March 2024 following institutional ethical clearance and written parental consent. Responses were screened for straightlining and inattentive responding (Meade & Craig, 2012); 23 questionnaires (2.6%) were excluded, yielding N = 850. Missing data were negligible (< 0.4% per item) and handled using full-information maximum likelihood (FIML) estimation.

3.5 Analytical Strategy

Data analysis proceeded in three stages using R (version 4.3.2) with the lavaan and semTools packages (Kline, 2016). Model fit was evaluated using indices recommended by Hu and Bentler (1999): $\chi^2/df < 3.00$, CFI ≥ .95, TLI ≥ .95, RMSEA < .06, and SRMR < .08. Convergent validity was assessed via composite reliability (CR > .70) and average variance extracted (AVE > .50); discriminant validity via the HTMT ratio (Henseler et al., 2015) with a threshold of < .85.

4. Results

4.1 Descriptive Statistics and Reliability

Table 2 presents means, standard deviations, skewness, kurtosis, and Cronbach's α for all constructs. Mardia's coefficient for multivariate kurtosis was 7.14 (critical ratio = 4.82), addressed by using robust maximum likelihood (MLR) estimation following Bentler (2006). Cronbach's α values ranged from .843 to .894, exceeding the threshold recommended by Nunnally (1978). Harman's single-factor test accounted for 31.4% of total variance, indicating that common method variance is not a serious threat.

Table 2. Descriptive Statistics and Reliability Coefficients (N = 850)

Variable / Construct	n	Mean	SD	Skewness	Kurtosis	α
Digital Literacy (DL)	850	3.74	0.61	−0.34	0.18	**.887**
DL1 – Information Literacy	850	3.81	0.59	−0.29	0.12	.861
DL2 – Communication & Collaboration	850	3.68	0.64	−0.31	0.21	.854
DL3 – Digital Content Creation	850	3.72	0.67	−0.38	0.25	.843
DL4 – Safety & Problem-Solving	850	3.75	0.58	−0.28	0.09	.858
Digital Citizenship (DC)	850	3.61	0.68	−0.41	0.31	**.891**
DC1 – Digital Rights & Responsibilities	850	3.58	0.71	−0.45	0.39	.865
DC2 – Digital Etiquette	850	3.64	0.66	−0.37	0.27	.849
DC3 – Online Safety & Privacy	850	3.59	0.73	−0.43	0.35	.871
DC4 – Digital Access & Inclusion	850	3.63	0.64	−0.39	0.29	.857
Academic Behavior (AB)	850	3.69	0.65	−0.36	0.22	**.894**
AB1 – Academic Engagement	850	3.73	0.62	−0.33	0.18	.868

AB2 – Self-Regulated Learning	850	3.67	0.68	−0.38	0.24	.855
AB3 – Academic Integrity	850	3.71	0.63	−0.35	0.20	.862
AB4 – Collaborative Learning	850	3.65	0.67	−0.37	0.23	.851

Note. DL = Digital Literacy; DC = Digital Citizenship; AB = Academic Behavior; α = Cronbach's alpha.

4.2 Confirmatory Factor Analysis and Measurement Model

Four competing factorial structures were specified and compared following best-practice SEM guidelines (Kline, 2016; Hair et al., 2019). The three-factor correlated model achieved substantially superior fit (Table 3): $\chi^2/df = 2.14$, CFI = .971, TLI = .965, RMSEA = .037 [90% CI: .031–.042], SRMR = .044. All standardized factor loadings ranged from .714 to .841 (all $p < .001$), exceeding the minimum threshold of .50 (Hair et al., 2019).

Table 3. Competing CFA Model Fit Comparison

Model	χ^2/df	CFI	TLI	RMSEA [90% CI]	SRMR
Recommended Threshold	< 3.00	≥ .95	≥ .95	< .06 [—]	< .08
One-Factor (all items)	6.41	.781	.763	.082 [.077–.087]	.112
Two-Factor (DL+DC, AB)	3.87	.891	.874	.061 [.056–.066]	.074
Three-Factor Uncorrelated	3.22	.924	.917	.052 [.047–.057]	.063
Three-Factor Correlated (Final)	**2.14**	**.971**	**.965**	**.037 [.031–.042]**	**.044**

Note. CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation. Estimation method: MLR.

4.3 Convergent and Discriminant Validity

Table 4 reports CR, AVE, MSV, and √AVE for each construct. All CR values exceeded .89 and all AVE values exceeded .68, confirming convergent validity. Discriminant validity was confirmed as all HTMT ratios (Table 5) fell below the .85 threshold (Henseler et al., 2015).

Table 4. Convergent and Discriminant Validity Indices

Construct	CR	AVE	MSV	√AVE	Max r
Threshold	> .70	> .50	< AVE	> Max r	—
Digital Literacy	**.903**	**.702**	.487	**.838**	.698

Digital Citizenship	**.911**	**.718**	.501	**.847**	.707
Academic Behavior	**.897**	**.689**	.478	**.830**	.691

Note. CR = Composite Reliability; AVE = Average Variance Extracted; MSV = Maximum Shared Variance.

Table 5. Inter-Construct Correlations and HTMT Ratios (N = 850)

Construct	1. DL	2. DC	3. AB
1. Digital Literacy (DL)	—	.713	.698
2. Digital Citizenship (DC)	.683*	—	.707
3. Academic Behavior (AB)	.671*	.694*	—

Note. Below diagonal = Pearson correlations (*p < .001); Above diagonal = HTMT ratios. HTMT < .85 indicates discriminant validity.

4.4 Structural Model and Hypothesis Testing

The structural model was analysed using the Maximum Likelihood Robust (MLR) estimation method with Full Information Maximum Likelihood (FIML) to handle missing data. The results are presented in Table 6. The table shows the standardized path coefficients, standard errors, *t*-values, *p*-values, and 95% confidence intervals for all six proposed hypotheses. The results supported H1. Digital literacy had a significant and positive direct effect on academic behaviour (β = .412, SE = .038, $t = 10.84$, $p < .001$). This indicates that students with higher levels of digital literacy were more likely to demonstrate positive academic behaviour. The findings also supported H2. Digital citizenship showed a significant positive direct effect on academic behaviour (β = .389, SE = .041, $t = 9.49$, $p < .001$). This suggests that students with stronger digital citizenship competencies also displayed better academic behaviour. H3 was also supported: digital literacy significantly predicted digital citizenship (β = .574, SE = .044, t = 13.05, p < .001). H4 was supported via bootstrapped indirect effect (β = .223, 95% CI [.172, .274]). H5 and H6 were supported: gender (β = .089, p = .007) and home internet access (β = .134, p < .001) each contributed unique variance to academic behavior.

Table 6. Structural Path Coefficients, Standard Errors, and Hypothesis Outcomes

Hypothesized Path	β	SE	t-value	p	95% CI	Decision
H1: DL → AB	.412	.038	10.84***	< .001	[.338, .487]	**Supported**
H2: DC → AB	.389	.041	9.49***	< .001	[.309, .469]	**Supported**
H3: DL → DC	.574	.044	13.05***	< .001	[.488, .660]	**Supported**
H4: DL → DC → AB (Indirect)	.223	.026	8.58***	< .001	[.172, .274]	**Supported**
H5: Gender → AB	.089	.033	2.70**	.007	[.024, .154]	**Supported**

H6: Internet Access → AB	.134	.035	3.83***	< .001	[.065, .203]	**Supported**

Note. β = standardized path coefficient. ***p < .001; **p < .01.

4.5 Overall Model Fit

The proposed structural model achieved excellent fit (Table 7): $\chi^2/df = 2.31$, CFI = .968, TLI = .961, RMSEA = .039 [90% CI: .033–.045], SRMR = .047, AIC = 24,318.

Table 7. Final SEM Global Fit Indices

Index	χ^2/df	CFI	TLI	RMSEA	SRMR	AIC / BIC
Recommended	< 3.00	≥ .95	≥ .95	< .06	< .08	Lower = Better
Full SEM (Proposed)	**2.31**	**.968**	**.961**	**.039**	**.047**	**24,318 / 24,621**
Saturated Model	1.00	1.000	1.000	.000	.000	24,281 / 24,793
Independence Model	18.74	.000	.000	.148	.342	31,447 / 31,593

Note. MLR estimation with FIML for missing data.

4.6 Mediation Analysis

Table 8 presents the decomposition of effects. Digital citizenship accounts for approximately 35.1% of the total influence of digital literacy on academic behavior. The bootstrapped 95% CI [.172, .274] excludes zero, providing strong evidence for the indirect pathway (Hayes, 2018), consistent with partial mediation (Baron & Kenny, 1986).

Table 8. Mediation Analysis: Direct, Indirect, and Total Effects (5,000 Bootstrap Resamples)

Mediation Path	Direct (β)	Indirect (β)	Total (β)	95% BootCI	Mediation Type
DL → DC → AB	.412	.223	.635	[.172,.274]	**Partial**
DC → AB (direct only)	.389	—	.389	—	**Direct**

Note. Bootstrapped confidence intervals computed with 5,000 resamples. Indirect effect CI excludes zero, confirming mediation.

4.7 Multi-Group Invariance Analysis

Sequential multi-group invariance testing (Table 9) confirmed configural, metric, scalar, and strict invariance across gender, with ΔCFI values ranging from −.003 to −.006—within Cheung and Rensvold's (2002) criterion of $|\Delta CFI| \leq .010$ (Kline, 2016).

Table 9. Multi-Group Measurement Invariance Across Gender

Model	χ^2	df	CFI	ΔCFI	Decision
Configural (Baseline)	384.21	168	.966	—	**Established**

Metric (Factor Loadings Fixed)	401.87	180	.962	−.004	**Supported**
Scalar (Intercepts Fixed)	421.34	192	.959	−.003	**Supported**
Strict (Residuals Fixed)	448.76	204	.953	−.006	**Supported**

Note. ΔCFI criterion: |ΔCFI| ≤ .010 indicates invariance. Groups: Male (n = 466); Female (n = 384).

5. Discussion

5.1 Digital Literacy as a Direct Predictor of Academic Behavior

The findings of this study showed that digital literacy had a significant positive effect on academic behaviour (β = .412, $p < .001$). This result is similar to the findings reported by Li et al. (2025) in their meta-analysis. It also agrees with earlier studies conducted in South Korea (Choi et al., 2017), Türkiye (Ata & Yildirim, 2019), Norway (Hatlevik & Christophersen, 2013), and Indonesia (Zakir et al., 2025). These studies also found that students with better digital literacy tend to show more positive academic behaviours.

The present findings can be explained using Bandura's (1986) Social Cognitive Theory and Zimmerman's (2002) Self-Regulated Learning Theory. Students who feel confident about using digital technologies are more likely to take responsibility for their own learning. They are more willing to search for digital learning resources, complete academic tasks independently, and remain actively engaged in their studies. In other words, digital self-efficacy appears to play an important role in improving students' academic behaviour.

These findings are especially important in the context of government schools in Bihar. Many schools have limited teaching and learning resources, and students often depend mainly on their teachers for academic support (ASER, 2023). In such situations, improving students' digital literacy can help them access additional learning materials independently and become more active participants in the learning process.

5.2 Digital Citizenship as Both Predictor and Mediator

The results of the study showed that digital citizenship had a significant positive effect on academic behaviour (β = .389, $p < .001$). This finding adds to the existing research on digital citizenship, which has mostly focused on students' attitudes and perceptions rather than their actual academic behaviour (Ribble, 2015; Choi et al., 2017). The results suggest that students who understand their rights and responsibilities in the digital world, follow appropriate online behaviour, and protect their privacy are more likely to use digital technologies in ways that support their learning. This finding is consistent with the ideas proposed by Krumsvik (2011) and Mossberger et al. (2008), who emphasized the importance of responsible and active participation in digital environments.

The study also found that digital citizenship partially mediated the relationship between digital literacy and academic behaviour (indirect β = .223, 95% CI [.172, .274]). This means that digital literacy by itself does not fully explain positive academic behaviour. Students also need to develop responsible digital attitudes and behaviours for their digital skills to be used effectively for learning. In other words, knowing how to use technology is important, but using it responsibly is equally important.

These findings have important implications for school education. Digital education programmes should not focus only on teaching technical skills. They should also help students develop responsible digital habits, ethical online behaviour, and an understanding of their rights and responsibilities in digital spaces. A balanced approach can help students use technology more effectively to support their academic learning.

5.3 Gender and Internet Access as Covariates

The study found that gender had a significant effect on academic behaviour (β = .089, p = .007). This finding is consistent with earlier studies conducted among Indian school students, including the report published by NCERT (2022). It suggests that gender plays a role in shaping students' academic behaviour. Home internet access also had a significant positive effect on academic behaviour (β = .134, p < .001). Students who had internet access at home were more likely to demonstrate positive academic behaviour. This finding highlights the importance of digital resources in supporting learning. It also supports van Dijk's (2020) theory of the digital divide, which explains that unequal access to digital technologies can lead to differences in learning opportunities and educational outcomes.

5.4 Psychometric and Methodological Contributions

The findings of this study support the use of the DLS-16, DCCS-16, and ABS-16 scales among Hindi-medium students studying in government schools. The results show that these instruments can be used reliably in this context to measure digital literacy, digital citizenship, and academic behaviour. The study also established scalar measurement invariance across gender, following the guidelines proposed by Cheung and Rensvold (2002). This indicates that the scales measure the same constructs in the same way for both male and female students. The use of a rigorous Structural Equation Modeling (SEM) approach, as recommended by Kline (2016), further strengthens the validity of the findings. As a result, future researchers can confidently use these instruments to compare digital literacy, digital citizenship, and academic behaviour across gender groups.

6. Implications

6.1 Policy Implications: NEP 2020 Implementation in Bihar

The National Education Policy (NEP) 2020 identifies digital literacy as an essential competency that students should develop throughout their school education (Ministry of Education, 2020). The findings of the present study support this policy direction. Digital literacy and digital citizenship together explained a substantial proportion of the variation in students' academic behaviour (R^2 = .487). This shows that both competencies play an important role in improving students' learning behaviour. Based on these findings, several steps can be considered to strengthen digital education in Bihar. First, the Government of Bihar and the Bihar School Examination Board (BSEB) may introduce dedicated digital literacy periods for students of Classes IX and X. These sessions can be planned in line with the DigComp 2.2 framework (Vuorikari et al., 2022). Second, the ICT curriculum should include structured lessons on digital citizenship based on Ribble's (2015) model. Such lessons can help students develop responsible, safe, and ethical digital practices. Finally, teacher education and training programmes under the Integrated Teacher Education Programme (ITEP) should give greater emphasis to digital pedagogy. This will help trained graduate teachers (TGTs) develop the knowledge and teaching skills needed to effectively promote digital literacy and digital citizenship in schools.

6.2 Pedagogical Implications for School Practice

The findings of this study have important implications for school administrators and teachers. The mediation results underscore that students need both digital skills and an understanding of responsible digital behaviour. Focusing on only one of these areas may not be enough to improve students' academic behaviour (Choi et al., 2017; Ribble, 2015). One practical way to achieve this is through project-based learning activities. Teachers can design tasks that encourage students to search for information online, combine ideas from different digital sources, and properly acknowledge the sources they use. Such activities help students improve their digital literacy while also developing responsible and ethical digital practices. The study also found that home internet access has a positive influence on academic behaviour. This highlights the need to provide internet facilities for students who do not have access at home. Schools may consider offering internet access beyond regular school hours so that all students have equal opportunities to use digital resources for learning. This recommendation is in line with the objectives of the PM eVIDYA and Digital India initiatives (Ministry of Education, 2020).

7. Limitations and Future Directions

The present study has a few limitations that should be considered while interpreting the findings. First, the study used a cross-sectional research design. Since the data were collected at only one point in time, it is not possible to establish cause-and-effect relationships between the variables. Future studies may use longitudinal or experimental research designs to examine these relationships more clearly (Kline, 2016). Second, the study was conducted only in three districts of the Magadh region of Bihar. Therefore, the findings may not fully represent students from other districts or states. Future research involving a wider geographical area would help improve the generalizability of the results. Third, self-report measures are susceptible to social desirability bias despite Harman's test evidence to the contrary (Meade & Craig, 2012). Fourth, teacher-level and school-level variables that may moderate the DL–AB relationship are not captured; multi-level SEM designs would be valuable extensions (Kline, 2016). Future research should examine whether the mediation structure replicates in senior secondary populations, whether AI-TPACK competency moderates students' digital literacy development (Prabhakar, 2024), and whether interventional digital literacy programs produce the academic behavior improvements predicted by the structural model.

8. Conclusion

This study set out to examine the structural interplay among digital literacy, digital citizenship competency, and academic behavior in a population that has received virtually no targeted empirical attention in the global digital education literature: secondary school students enrolled in government schools in Bihar's Magadh region. The findings are both statistically robust and theoretically coherent. Digital literacy and digital citizenship together account for 48.7% of the variance in academic behavior ($R^2 = .487$), a figure that speaks compellingly to the practical significance of digital competency development as an academic intervention in resource-constrained school settings.

The structural model confirmed six hypothesized pathways. One of the most important findings of this study is that digital citizenship partially mediates the relationship between digital literacy and academic behaviour (indirect $\beta = .223$, 95% CI [.172, .274]). This result is consistent with the mediation framework proposed by Baron and Kenny (1986) and was further confirmed using the bootstrap method recommended by Hayes (2018). The findings show that nearly 35% of the total effect of digital literacy on academic behaviour operates through digital citizenship. This suggests that digital literacy improves students' academic behaviour not only directly but also by helping them become more responsible and ethical users of digital technologies. To the best of the researcher's knowledge, this is one of the first studies to provide such evidence among secondary school students in the Indian context.

The findings can also be understood through Bandura's (1986) Social Cognitive Theory. Students who feel confident in using digital technologies are more likely to use them effectively for learning. This confidence, often referred to as digital self-efficacy, encourages students to participate actively in academic activities and use digital resources responsibly. Similar observations have been reported by Zakir et al. (2025). These results suggest that programmes designed to improve students' confidence in using digital technologies, along with promoting responsible digital behaviour, may have a greater impact on academic behaviour than programmes that focus only on technical digital skills.

The structural model used in this study showed a good overall fit to the data ($\chi^2/df = 2.31$, CFI = .968, RMSEA = .039), meeting the recommended criteria suggested by Hu and Bentler (1999). The study also established scalar measurement invariance across gender, following the guidelines of Cheung and Rensvold (2002). These findings indicate that the measurement scales performed consistently for both male and female students. The use of a rigorous Structural Equation Modeling (SEM) approach, as recommended by Kline (2016), further strengthens the reliability of the results. In addition, the Hindi-medium versions of the instruments provide useful tools for future studies involving students from Bihar and other Hindi-speaking states such as Jharkhand and Uttar Pradesh.

The findings also have important policy implications. They support the emphasis placed on digital literacy in the National Education Policy (NEP) 2020 (Ministry of Education, 2020). The results indicate that investing in digital literacy and digital citizenship is not only important for improving students' digital skills but also for strengthening

their academic behaviour. Therefore, these competencies should be given greater importance in secondary school education. The recommendations of this study can be incorporated into the ongoing curriculum reforms of the Bihar School Examination Board (BSEB) under the National Curriculum Framework for School Education (NCF-SE) 2023. The DigComp 2.2 framework (Vuorikari et al., 2022) can also provide useful guidance for planning and implementing digital education programmes.

Another important finding relates to educational equity. Home internet access had a significant positive effect on academic behaviour ($\beta = .134$, $p < .001$). This suggests that the digital divide in Bihar is not limited to unequal access to technology. It also affects students' learning experiences and academic behaviour. This finding supports van Dijk's (2020) view that differences in digital access can lead to wider educational inequalities. Expanding internet connectivity through initiatives such as BharatNet, along with integrating digital literacy and digital citizenship into the school curriculum, can help reduce these inequalities and provide better learning opportunities for students, especially those studying in government schools.

Overall, the present study provides empirical evidence on the relationship between digital literacy, digital citizenship, and academic behaviour among secondary school students in Bihar. The findings contribute to the growing literature on digital competencies in school education and provide useful evidence for policymakers, educators, and researchers. Future studies may build on this work by using longitudinal research designs, multilevel analyses, or intervention-based approaches to gain a deeper understanding of how digital competencies influence students' learning and academic behaviour over time.

9. Author Contributions

Ravindra Kumar: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Ashutosh Prabhakar: Writing – Review & Editing, Visualization, Project Administration. Ravi Kant: Data Curation, Investigation, & Editing, Supervision.

10. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

11. Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

12. Ethical Statement

Written informed consent was obtained from parents or legal guardians of all participating minors. Ethical clearance was granted by the Institutional Review Committee of Central University of South Bihar.

REFERENCES

1. Aesaert, K., Van Nijlen, D., Vanderlinde, R., Tondeur, J., Devlieger, I., & van Braak, J. (2015). The contribution of pupil, classroom and school level characteristics to primary school pupils' ICT competences: A performance-based approach. *Computers & Education*, 87, 55–69. https://doi.org/10.1016/j.compedu.2015.03.014
2. Annual Status of Education Report [ASER]. (2023). Annual Status of Education Report 2023 (Rural). ASER Centre. https://asercentre.org/
3. Ata, R., & Yildirim, K. (2019). Turkish pre-service teachers' perceptions of digital citizenship in education programs. *Journal of Information Technology Education: Research*, 18, 419–436. https://doi.org/10.28945/4392
4. Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall.
5. Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173
6. Bawden, D. (2008). Origins and concepts of digital literacy. In C. Lankshear & M. Knobel (Eds.), Digital literacies: Concepts, policies and practices (pp. 17–32). Peter Lang.

7. Bentler, P. M. (2006). EQS 6 structural equations program manual. Multivariate Software.
8. Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5
9. Choi, M., Glassman, M., & Cristol, D. (2017). What it means to be a citizen in the internet age: Development of a reliable and valid digital citizenship scale. *Computers & Education,* 107, 100–112. https://doi.org/10.1016/j.compedu.2017.01.002
10. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage.
11. Hatlevik, O. E., & Christophersen, K. A. (2013). Digital competence at the beginning of upper secondary school: Identifying factors explaining digital inclusion. *Computers & Education*, 63, 240–247. https://doi.org/10.1016/j.compedu.2012.11.015
12. Hatlevik, O. E., Guðmundsdóttir, G. B., & Loi, M. (2015). Examining a two-dimensional model of students' key competences in ICT. *Education and Information Technologies, 20*(2), 249–263. https://doi.org/10.1007/s10639-013-9292-1
13. Hayes, A. F. (2018). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (2nd ed.). Guilford Press.
14. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8
15. Hinduja, S., & Patchin, J. W. (2015). Bullying beyond the schoolyard: Preventing and responding to cyberbullying (2nd ed.). Corwin.
16. Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118
17. Kline, R. B. (2016). Principles and practice of structural equation modeling (4th ed.). Guilford Press.
18. Krumsvik, R. J. (2011). Digital competence in the Norwegian teacher education and schools. *Högre Utbildning, 1*(1), 39–51.
19. Li, F., Cheng, L., Wang, X., Shen, L., Ma, Y., & Islam, A. Y. M. A. (2025). The causal relationship between digital literacy and students' academic achievement: A meta-analysis. *Humanities and Social Sciences Communications,* 12, 108. https://doi.org/10.1057/s41599-025-04399-6
20. MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods, 1*(2), 130–149. https://doi.org/10.1037/1082-989X.1.2.130
21. Meade, A. W., & Craig, S. B. (2012). Identifying careless responders in survey studies. *Journal of Applied Psychology, 97*(5), 1167–1176. https://doi.org/10.1037/a0028085
22. Ministry of Education, Government of India. (2020). National Education Policy 2020. Ministry of Education. https://www.education.gov.in/
23. Mossberger, K., Tolbert, C. J., & McNeal, R. S. (2008). Digital citizenship: The internet, society, and participation. MIT Press.
24. NCERT. (2022). National Achievement Survey 2021: National Report. National Council of Educational Research and Training. https://ncert.nic.in/
25. Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education, 59*(3), 1065–1078. https://doi.org/10.1016/j.compedu.2012.04.016
26. Nunnally, J. C. (1978). Psychometric theory (2nd ed.). McGraw-Hill.
27. Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16*(4), 385–407. https://doi.org/10.1007/s10648-004-0006-x
28. Porat, E., Blau, I., & Barak, A. (2018). Measuring digital literacies: Junior high-school students' perceived competencies versus actual performance. *Computers & Education,* 126, 23–36. https://doi.org/10.1016/j.compedu.2018.06.030
29. Prabhakar, A. (2024). AI-TPACK competency and teaching efficacy among teacher educators in Bihar: A structural analysis. [Journal name and DOI to be updated upon publication].
30. Ribble, M. (2015). Digital citizenship in schools: Nine elements all students should know (3rd ed.). International Society for Technology in Education.
31. UDISE+. (2023). Unified District Information System for Education Plus 2022–23: District Report Cards. Department of School Education and Literacy, MoE.
32. van Dijk, J. A. G. M. (2020). The digital divide. Polity Press.
33. Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The digital competence framework for citizens. Publications Office of the European Union. https://doi.org/10.2760/115376
34. Zakir, S., Hoque, M. E., Susanto, P., Nisaa, V., Alam, M. K., Khatimah, H., & Mulyani, E. (2025). Digital literacy and academic performance: The mediating roles of digital informal learning, self-efficacy, and students' digital competence. *Frontiers in Education*, 10, 1590274. https://doi.org/10.3389/feduc.2025.1590274
35. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2