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Digital divide and fairness perceptions of computer-based testing in Vietnam

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ABSTRACT

Equity concerns are central to large-scale shifts toward computer-based testing (CBT), yet evidence from developing systems remains limited on whether institutional supports can offset household digital inequalities. This study surveyed 1,197 Vietnamese high school students (grades 10–12) using a 20-item CBT acceptance scale (α=.94) and two single-item fairness indicators. Overall acceptance was moderately positive (M=3.54, SD=0.74), whereas fairness perceptions were markedly weaker: only 31.7%–38.2% agreed that CBT ensures fair scoring and 55.1%–66.7% worried that CBT could create inequality, reflecting unequal fairness perceptions across areas, with concerns strongest in rural settings. Group comparisons showed small but consistent advantages in acceptance for students with prior CBT experience and school-level computer access (g≈.16–.20), while home computer ownership had negligible association (g≈.01). Acceptance did not differ by residential area (η^2≈.001), but fairness concerns varied across areas. These findings suggest that institutional exposure and governance practices—rather than household device ownership—are the most actionable levers for equitable CBT implementation. Practical implications include strengthening school-based access and practice opportunities, transparent proctoring and contingency procedures, and integrating fairness monitoring into CBT dashboards.

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1. INTRODUCTION

Large-scale moves from paper-and-pencil to computer-based testing (CBT) have accelerated in recent years, raising persistent questions about score comparability and fairness [1]. International and national assessment programs (e.g., Programme for International Student Assessment or PISA, National Assessment of Educational Progress or NAEP) have engineered bridge studies, tutorials, and linking designs to preserve trend interpretations across modes, yet research continues to show item- and domain-specific mode effects that may differentially burden subgroups (e.g., on-screen reading and writing tasks) [2]–[4]. From a measurement standpoint, the transition implicates core validity arguments under the Standards for Educational and Psychological Testing—including comparability of scores across conditions, consequences of use, and fairness for intended test populations [5].

Equity concerns in CBT intersect with the broader "digital divide," where disparities in access, skills, and meaningful use can translate into unequal assessment conditions [6]. Beyond device ownership, digital inequality increasingly reflects differences in how confidently and effectively students can interact

with technology—an "usage" gap that can persist even when physical access improves [7], [8]. In CBT contexts, this implies that structured opportunities to build interaction fluency (e.g., guided tutorials, mock CBT practice, troubleshooting support) may matter more for equitable participation than household devices alone [9], [10].

A second equity lens concerns test administration and integrity measures. Proctoring systems, device restrictions, and surveillance technologies can deter misconduct but may also introduce stress, privacy concerns, and perceptions of procedural unfairness that undermine legitimacy—especially when rules and contingency plans are opaque [11]. International good-practice guidance for computer- and internet-delivered testing emphasizes transparent communication, standardized administration, and predefined contingency procedures to protect both validity and fairness [12].

Despite a growing literature on CBT comparability, readiness, and governance, large-scale evidence on student acceptance and fairness perceptions remains concentrated in high-income settings. Far less is known about how these perceptions develop in rapidly digitalizing systems—such as those in Southeast Asia—where implementation may advance faster than the equalization of infrastructure and school-level supports [13]. In particular, few studies jointly examine student acceptance and fairness perceptions across multiple access dimensions (e.g., prior CBT exposure, school-level supports, home devices) and geographic contexts, leaving limited empirical basis for judging whether institutional supports can offset household-level inequalities in shaping students' experiences of CBT. Addressing this gap, the present study examines acceptance alongside dual fairness indicators across access conditions and residential areas to generate policy-relevant evidence for CBT implementation in Vietnam and comparable settings where digital divides remain salient.

Conceptually, we locate the present study at the intersection of digital equity and fairness in educational assessment. A digital equity lens foregrounds multi-dimensional access—hardware, connectivity, skills, and institutional supports—as determinants of whether learners can engage meaningfully with CBT [6], [7]. A fairness lens, informed by the Standards and recent work on procedural legitimacy in digital assessment, treats fairness as both psychometric (e.g., score comparability, absence of bias) and procedural (e.g., transparency, proctoring practices, contingency protocols) [5], [8], [9]. Bringing these lenses together directs attention to how digital access and school-level supports shape not only students' acceptance of CBT but also their perceptions of whether CBT is fair or creates inequality.

Vietnam offers a particularly relevant case. Policy discussions increasingly emphasize the use of CBT in upper-secondary education and high-stakes examinations, yet digital infrastructure and school resources remain unevenly distributed across urban, rural, and mountainous areas. School leaders and policymakers must therefore decide how quickly to expand CBT, which supports to prioritize, and how to address concerns that CBT might advantage students with better digital access. However, systematic evidence on Vietnamese students' acceptance of CBT and their fairness perceptions, especially across different access conditions and regions, remains scarce.

Against this backdrop, we analyze a cross-sectional survey of 1,197 Vietnamese high school students (grades 10–12) to characterize overall attitudes toward CBT and to test equity-relevant differences by digital access (prior CBT experience, school-level support for computer use, home computer ownership) and geography (urban, rural, mountainous). We operationalize fairness through dual indicators—agreement that CBT "ensures fair scoring" versus concern that CBT "creates inequality"—to examine whether the same institutional supports that promote digital equity also shape fairness perceptions. Our aim is to generate system-facing evidence to inform CBT implementation in Vietnam and comparable settings where digital divides are a central policy concern. Guided by this equity-oriented lens, we articulate several research questions:

- What is the overall level of student acceptance of CBT in Vietnamese high schools?
- How does CBT acceptance differ by prior CBT experience; school-level support for using computers; and home computer ownership?
- How do perceptions of fairness (CBT ensures fair scoring) and concerns about inequality (CBT creates inequality) vary across residential areas (urban, rural, and mountainous) and prior CBT experience?
- Which policy levers emerge as most promising to reduce digital divides and strengthen perceived fairness during CBT implementation in high schools?

2. LITERATURE REVIEW

2.1. Mode effects, comparability, and fairness in CBT

A substantial body of research examines whether shifting from paper-and-pencil to computer-based delivery affects score comparability, with implications for validity and fairness. International assessments such as PISA have documented mode-related sensitivities, including differences between typed and handwritten responses, prompting the use of linking strategies to support trend interpretation [14]–[16].

At the national level, programs such as NAEP have addressed these issues through tutorials and device-related standardization to improve comparability [17]. These efforts align with foundational testing standards that treat comparability and fairness as central validity claims [18]–[20]. The contemporary consensus is not "paper vs. computer good/bad," but conditional equivalence: with careful design (e.g., tutorials, platform standards, appropriate linking) most inferences can be preserved; yet domain- and item-level exceptions remain and must be monitored [21]. Empirically isolating "mode effects" from computer familiarity and access is challenging; design choices that reduce construct-irrelevant variance (e.g., standardized devices, tutorials) are costly, and many systems cannot fully control administration conditions [22].

Taken together, research on mode transitions supports a view of conditional equivalence: comparability is often attainable when platforms, tutorials, and linking designs are deliberately engineered, yet item- and domain-level sensitivities can persist. For fairness, this implies that comparability work must be coupled with attention to uneven administration conditions, because residual mode-related variance may concentrate in subgroups when opportunities to practice and standardized delivery are not equally distributed. Thus, safeguarding validity in diverse contexts demands that stakeholders prioritize the standardization of the test-taking environment alongside the technical calibration of the test items themselves.

2.2. Digital divide as an equity lens for CBT

Beyond physical devices, digital inequality operates across multiple dimensions, including access, skills, and meaningful use, all of which can shape engagement with digital assessments [23]. Recent equity-oriented work suggests that readiness for CBT depends not only on household access, but also on opportunities to develop familiarity through institutional supports such as guided practice and mock CBTs [24]. As a result, dichotomous indicators of household access may serve as limited proxies for CBT readiness because they do not capture these more proximal school-level supports.

Viewed through an equity lens, these findings reframe the relevant "access" problem in CBT: what matters most is not simply whether students own devices, but whether they have structured opportunities to become fluent with the testing interface under supportive conditions. This perspective positions schools as the most actionable site of intervention and suggests that evaluations of CBT equity should prioritize measures of school-based exposure and supports. In turn, unequal access to such supports is likely to shape not only students' acceptance of CBT but also their judgments about whether CBT is implemented fairly.

2.3. Integrity practices, proctoring, and perceived fairness

Integrity safeguards (e.g., online/remote proctoring) help deter misconduct but may undermine perceived fairness/legitimacy if they introduce privacy risks, opacity, or bias [25]. A growing review literature documents concerns across legal, ethical, security, and privacy dimensions, and maps implementation patterns during pandemic-era expansions [26]. Best-practice frameworks emphasize transparency (clear data handling, explainable flags), proportionate monitoring, and contingency protocols for technical failures as integral to fairness—not add-ons [25]. Collectively, this work indicates that perceived fairness in CBT is shaped not only by technical security but by the procedural legitimacy of implementation—especially transparency, proportionality, and credible contingency planning. Accordingly, students' fairness judgments may diverge from their overall acceptance when governance features are experienced as opaque or unevenly protective across contexts.

2.4. Allocation of prominent issues within the present study's problem space

Synthesizing the previous explanation, equity in CBT hinges on four interlocking issues the current paper targets: i) score meaning under mode change—monitor residual mode/item effects and avoid over-generalizing from overall invariance [14]; ii) access beyond ownership—prioritize school-level supports and prior exposure over crude household proxies when explaining variation in acceptance [27]; iii) fairness as perception and practice—evaluate how proctoring/administration choices affect perceived fairness and trust, alongside psychometric fairness [28]; and iv) actionable implementation levers—guided practice (mock CBT), transparent protocols, and standardized environments reflect modern consensus on equitable rollout [25]. These four issues directly motivate the present study's analytic focus on acceptance and dual fairness indicators, and its comparisons across access dimensions and residential contexts to identify actionable levers for equitable CBT rollout.

3. METHOD

3.1. Study design and setting

This study employed a cross-sectional survey of Vietnamese high school students (grades 10–12). The design targets two aims aligned with the Standards for Educational and Psychological Testing—to describe student acceptance of CBT and to examine equity-relevant differences attributable to digital access

and geography [20]. Participating schools were located in the North, Central, and South regions and served urban, rural, and mountainous catchment areas, thereby providing heterogeneity in digital access and school conditions. However, schools and students were recruited through local collaborators rather than selected via a national probability sampling frame. The data should therefore be interpreted as a large, diverse convenience sample rather than a strictly nationally representative survey of all Vietnamese high school students. In keeping with national implementation guidance for digitally based assessments, we report administration conditions, scoring rules, and analytic choices to support transparency and fairness claims [29]. As a cross-sectional design, the study documents associations between access conditions, acceptance, and fairness perceptions but does not permit strong causal inferences.

3.2. Participants and recruitment

The analytic sample includes N=1,197 respondents. Students reported: gender (female/male), school region (North/Central/South), residential area (urban, rural, and mountainous), home computer ownership (yes/no), prior CBT experience (yes/no), and whether their school provides access to computers (yes/no). The survey was administered during regular school activities with institutional permission. Participation was voluntary and anonymous; no personally identifying information was collected. Although the sample is not nationally representative, the overall size (N=1,197) and coverage of key equity-relevant groups (e.g., students with and without prior CBT experience, with and without school-level computer access, and from urban, rural, and mountainous areas) provide adequate precision to estimate overall levels of acceptance and fairness perceptions and to characterize subgroup differences. Subgroup cell sizes are not perfectly balanced, particularly for students in mountainous areas, but are sufficient to compute stable descriptive statistics and standardized mean differences for the main access and geography contrasts of interest.

3.3. Instrument

The questionnaire comprised 20 Likert items (1=strongly disagree to 5=strongly agree) addressing attitudes and experiences related to CBT (e.g., perceived usefulness, confidence, concerns about technical issues, and support needs), plus six demographic/access items. The 20 attitudinal items were authored by the research team for this study, using existing work on CBT acceptance, digital equity, and fairness in educational assessment as conceptual guides rather than directly translating a single pre-existing scale. Item content was organized to cover four anticipated facets of CBT acceptance in the high school context: perceived usefulness of CBT, test-taking confidence in a digital environment, worries about technical disruptions, and perceived adequacy of school-level support (e.g., tutorials, mock tests, contingency handling). Two single-item indicators operationalize fairness perceptions in opposite directions and are treated as face-valid markers of procedural legitimacy in large-scale surveys: “CBT ensures fair scoring” and “CBT creates inequality.” Single-item fairness indicators were selected to minimize respondent burden; however, they do not capture the full construct domain and should be complemented by validated multi-item scales in future work.

3.4. Measures and coding

3.4.1. Primary outcome (CBT acceptance)

The primary outcome is the unweighted mean of the 20 Likert items (range 1–5). Negatively phrased items were reverse-scored, so higher values indicate greater acceptance. Internal consistency for the 20-item composite in this dataset is $\alpha \approx .94$, indicating that the items function well as a single pragmatic index of CBT acceptance for the purposes of this study. Given the applied focus on equity-relevant differences, we do not undertake detailed factor modeling here; future work could investigate the dimensional structure of the scale in more depth. Given the high internal consistency ($\alpha = .94$), the composite is treated as a pragmatic unidimensional index suitable for group comparisons.

3.4.2. Access and geography predictors

Three binary predictors index digital access: prior CBT experience (yes/no), school-level computer access (yes/no), and home computer ownership (yes/no). Geography is captured by residential areas (urban, rural, and mountainous). This distinction is critical for isolating whether equity gaps stem primarily from household socioeconomic disparities or from variations in school-based infrastructure.

3.4.3. Fairness perceptions

For each fairness item, we computed the percentage of students agreeing (responses 4–5) overall and by subgroups. Because each fairness construct is measured with a single item, internal consistency reliability cannot be estimated. The single-item format was chosen to limit respondent burden and to keep the questionnaire brief enough for administration during regular school lessons, while still capturing core fairness

signals. These indicators should therefore be interpreted as concise, face-valid markers of fairness beliefs and inequality concerns rather than exhaustive measures of the underlying constructs. Future research could extend this design by developing and validating multi-item fairness subscales that more fully represent the content domain.

3.5. Data processing

All Likert responses were mapped to integers 1–5. Records were screened for out-of-range values; none were detected. Missingness on analysis variables was negligible; therefore, no imputation was performed. Analyses use all available cases per comparison. To avoid construct-irrelevant variance, all scales were oriented in the same direction before forming the acceptance composite [30].

3.6. Analytic strategy

Analyses were organized to answer the four research questions:

- Report the mean and dispersion of the acceptance composite (1–5).
- For each binary contrast—prior CBT experience (yes vs. no), school-level support (yes vs. no), and home device ownership (yes vs. no)—report group means and the standardized mean difference (Hedges' g, pooled SD with small-sample correction; positive values favor the "yes" group).
- Compute agreement rates (≥4) for fair-scoring belief and inequality concern by residential area and prior CBT experience. To summarize between-area differences in the continuous acceptance composite, conduct a one-way ANOVA (urban, rural, and mountainous) and report η^2 as the effect-size index for explained between-group variance.
- Interpret the pattern of effects with reference to modern equity guidance for digital assessments—emphasizing institutional supports and prior exposure where differences are non-trivial, and highlighting null findings (e.g., home device ownership) when relevant to targeting [31].

All analyses are descriptive, comparative and non-causal by design. Inferences are bounded by the cross-sectional, nonprobability nature of the sample. To enhance reproducibility, all recoding rules and comparison metrics are specified; the analysis can be replicated in any statistical environment capable of computing means, Hedges' g, one-way ANOVA, and η^2.

4. RESULTS AND DISCUSSION

Analyses follow the prespecified plan: the primary outcome and analytic sample are established before subgroup contrasts. All estimates are based on the full sample of N=1,197 Vietnamese high school students who completed 20 five-point Likert items (1–5) and provided six demographic/access variables. The outcome—CBT acceptance—is defined as the unweighted mean of the 20 items (higher scores indicate greater acceptance) and exhibits excellent internal consistency (α=.94). Reporting proceeds in three steps: i) descriptive statistics for the composite; ii) contrasts by prior CBT experience, school-level access to computers, and home computer ownership; and iii) analyses of fairness perceptions across residential areas.

4.1. What is the overall level of student acceptance of CBT?

The acceptance distribution is moderately positive (M=3.54, SD=0.74, 1–5 scale), as shown in Table 1. Means by residential area are closely clustered—urban 3.54 (SD=0.73), rural 3.53 (SD=0.79), mountainous 3.59 (SD=0.61)—and a one-way ANOVA confirms negligible between-area variation, $F(2, 1194)=0.48$, $p=.619$, $\eta^2=.001$. This indicates that geography, per se, does not differentiate overall acceptance when measured as a multi-item scale.

Table 1. Descriptive statistics for CBT acceptance and sample structure

SN	Measure	Value
1	Students (N)	1,197
2	Acceptance (1–5)	M=3.54, SD=0.74
3	Scale reliability (20 items)	α=.94
4	Residential area (n)	Urban 583; Rural 450; Mountainous 164
5	Acceptance by area (M, SD)	Urban 3.54 (0.73); Rural 3.53 (0.79); Mountainous 3.59 (0.61)

4.2. How does acceptance differ by prior CBT experience, school-level access, and home computer ownership?

Welch's tests (robust to heteroscedasticity) summarize three access contrasts, as shown in Table 2. Acceptance was modestly higher among students with prior CBT experience and those reporting school-level computer access (small effects; g≈.16–.20), whereas home computer ownership showed a null association

(g≈.01). These effects are statistically reliable but small in magnitude, indicating modest yet consistent advantages associated with institutional exposure.

A parsimonious ordinary least squares (OLS) model—including the three access indicators and residential area (reference=mountainous)—explains a small share of variance (R^2=.012), but unique associations remain: prior CBT (B=0.117, p=.012) and school access (B=0.135, p=.022) are positive; home computer is not (B=−0.072, p=.145). Area coefficients are nonsignificant (urban p=.432; rural p=.433). Concordance between Welch and OLS estimates strengthens confidence in the small yet consistent links for exposure and institutional access. Figure 1 visualizes these contrasts with 95% CIs, reinforcing the ranking (school access≈prior CBT>home computer≈0) and the small magnitude of differences (substantial CI overlap).

Table 2. Group means and Welch's t tests for CBT acceptance (RQ2)

Contrast	Group A (n)	M (SD)	Group B (n)	M (SD)	Welch t	p	Hedges' g
Prior CBT: Yes vs. No	706	3.59 (0.73)	491	3.47 (0.74)	2.72	.007	.16
School access: Yes vs. No	1,002	3.57 (0.72)	195	3.42 (0.83)	2.37	.019	.20
Home computer: Yes vs. No	765	3.54 (0.75)	432	3.55 (0.71)	−0.23	.815	−.01

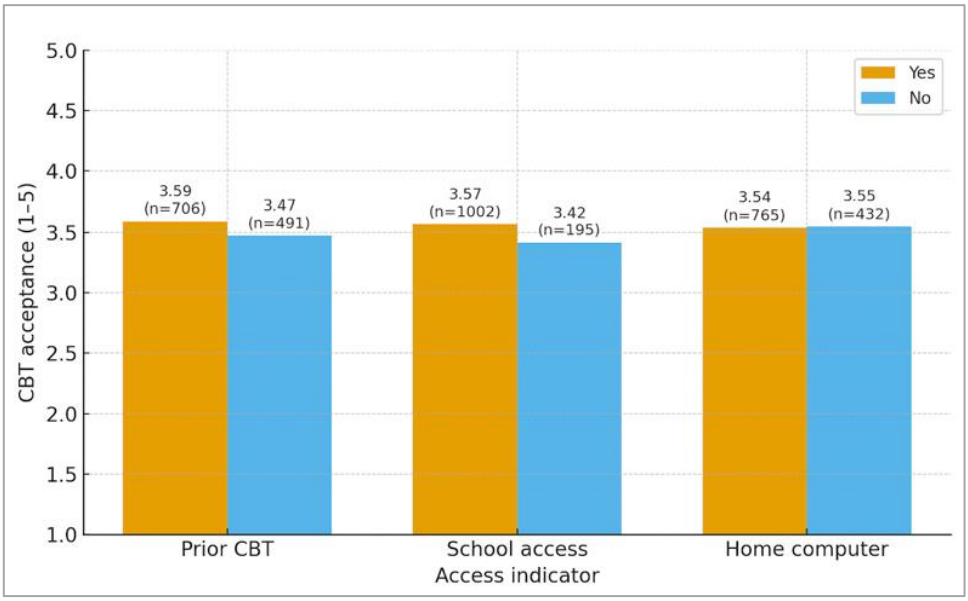

Figure 1. Mean CBT acceptance by access indicators (95% CI)

4.3. How do perceptions of fairness vary by residential area and prior CBT experience?

Two single-item indicators were examined as agreement rates (responses≥4), with χ^2 tests used to assess subgroup differences by residential area and prior CBT experience, as shown in Tables 3 and 4. Across groups, endorsement of the statement that CBT "ensures fair scoring" was consistently low—approximately one-third of students—and did not vary significantly by residential area or prior CBT exposure. In contrast, agreement that CBT "creates inequality" was more prevalent and showed a clear area gradient: students in rural settings reported the highest level of concern, whereas rates in urban and mountainous areas clustered in the mid-50% range (Table 3). Notably, inequality concern did not differ by prior CBT experience (Table 4), suggesting that exposure alone may be insufficient to alleviate legitimacy-related worries when broader access conditions and governance perceptions remain salient.

Table 3. Fairness perceptions—agreement rates (%) and χ^2 tests (by residential area)

Item	Urban (n=583)	Rural (n=450)	Mountainous (n=164)	χ^2(df)	p
CBT ensures fair scoring (Q11)	34.8	38.2	31.7	2.58 (2)	.275
CBT creates inequality (Q13)	55.1	66.7	57.9	14.52 (2)	< .001

Table 4. Fairness perceptions—agreement rates (%) and χ^2 tests (by prior CBT experience)

Item	No prior (n=491)	Prior (n=706)	χ^2(df)	p
Q11 (fair scoring)	35.2	36.0	0.04 (1)	.839
Q13 (inequality)	60.5	59.3	0.11 (1)	.737

4.4. Consolidated reading of access and fairness signals

Tables 5 and 6 consolidate the area contrasts and the multivariable regression. The ANOVA reiterates the geographic flatness of the continuous acceptance composite ($F(2, 1194)=0.48$, $p=.619$, $\eta^2=.001$). The OLS model confirms small but consistent positive associations for prior CBT ($B=0.117$, $p=.012$) and school access ($B=0.135$, $p=.022$), with home computer nonsignificant ($B=-0.072$, $p=.145$) and area coefficients also nonsignificant (urban $p=.432$; rural $p=.433$). Overall, exposure and institutional supports are the access dimensions most associated with higher acceptance; household device ownership alone is not informative.

Table 5. One-way ANOVA (urban, rural, mountainous)

Statistic	Value
F(2, 1194)	0.48
p	.619
η^2	.001

Table 6. OLS regression (reference=mountainous)

Predictor	B	SE	t	p
Intercept	3.450	0.081	42.78	< .001
Area: rural	−0.054	0.069	−0.78	.433
Area: urban	−0.051	0.065	−0.79	.432
Prior CBT (1 = yes)	0.117	0.047	2.51	.012
School access (1 = yes)	0.135	0.059	2.29	.022
Home computer (1 = yes)	−0.072	0.049	−1.46	.145

Model fit: $R^2=.012$. Coding: residential area treated as categorical with mountainous as the reference group

The study documents a moderately positive level of CBT acceptance among Vietnamese high school students ($M=3.54$, 1–5 scale), with small yet consistent associations for prior CBT experience and school-level access to computers, and a null association for home computer ownership. Acceptance is geographically flat (urban, rural, and mountainous; $\eta^2=.001$), whereas fairness signals are asymmetric: agreement that CBT "ensures fair scoring" is uniformly modest, but concerns that CBT "creates inequality" are elevated in rural areas. This pattern empirically separates readiness (acceptance) from perceived fairness, indicating that institutional exposure and supports—rather than household devices—align more closely with acceptance, while fairness judgments appear sensitive to contextual features of delivery and governance.

Conceptually, the findings reinforce a distinction between readiness and legitimacy in digital assessment. Acceptance appears responsive to exposure and institutional support, whereas fairness perceptions remain sensitive to contextual and governance factors—particularly in rural settings—where procedural concerns can signal legitimacy risks even when overall acceptance is stable [32]. This suggests that strategies focused solely on increasing technical familiarity may fail to address the deeper, trust-based barriers to equitable assessment.

4.5. Relation to prior research

The acceptance results align with contemporary views that CBT transitions are educationally viable provided systems invest in standardized delivery, tutorials, and score-linking/equating; residual domain- and item-level exceptions remain and warrant monitoring [2], [10]–[12], [14], [15], [17]. The observed increments associated with prior CBT and school-level access (Hedges' $g\approx.16$–$.20$) are consistent with work emphasizing that interaction fluency—cultivated through guided practice and mock administration—reduces interface-related load and anxiety [20]. By contrast, the null effect for home ownership reinforces a shift in the digital-divide literature away from device counts toward meaningful, supported use [19], [22]. Fairness findings intersect with the literature on test integrity and procedural legitimacy. The modest endorsement that CBT ensures fair scoring, paired with heightened inequality concerns in rural settings, mirrors cautions that security and proctoring technologies can generate privacy, bias, and opacity concerns if implemented without transparent safeguards [8], [9], [21], [23]. The present data suggest that comparability engineering (linking) and exposure are necessary but not sufficient; trust-building through clear proctoring policies, data-handling transparency, and credible contingency plans for disruptions is integral to perceived fairness.

4.6. Practical implications

Prior exposure and in-school access as primary levers: the small, reliable associations for prior CBT and school access indicate that institutional opportunity to practice is the most actionable pathway to lift acceptance at scale: scheduled lab access, mock CBT, walkthrough tutorials, and on-site troubleshooting. These measures are directly controllable by schools and align with international guidance for digitally based assessments [2], [24].

Fairness as communication and contingency: because fairness indicators behave differently from acceptance—and are area-sensitive—rollouts should pair exposure-building with a fairness protocol: plain-language proctoring charters, explicit data-use statements, and contingency playbooks for connectivity and device failures. Such steps respond to known legitimacy risks while preserving integrity [8], [9], [21], [23].

Operational monitoring: a fairness dashboard that tracks acceptance, fair-scoring belief, and inequality concern—disaggregated by residential area and access supports—would translate the present signals into ongoing oversight during scale-up, enabling rapid course-correction where concerns concentrate. Ultimately, integrating these feedback loops ensures that equity is treated as a dynamic performance indicator rather than a static compliance check.

4.7. Measurement considerations

The effect sizes for access variables are small and the OLS R^2=.012, a typical profile for attitude constructs in population surveys. Even so, the directional coherence across Welch tests and OLS estimates supports the conclusion that exposure and institutional supports are the relevant levers. Future operational cycles should: i) employ linking/equating when policy requires trend comparability [2], [10], [11], [17]; ii) evaluate measurement invariance of the acceptance scale across access and area groups; and iii) unpack acceptance into facets (usefulness, anxiety, technical trust) to sharpen diagnostic value [14], [16].

4.8. Limitations and directions

These limitations point to several priorities for future research. First, longitudinal or staged-implementation designs could track how acceptance and fairness perceptions evolve as schools introduce CBT and as students accumulate experience. Second, validated multi-item fairness scales (covering procedural, distributive, and interactional facets) would provide stronger construct coverage than the present single-item indicators. Third, linking student surveys with technical incident logs (e.g., connectivity failures, proctoring alerts) and multi-level data would help disentangle school- and student-level contributions to acceptance and perceived fairness.

5. CONCLUSION

This study provides large-sample evidence on CBT acceptance and fairness perceptions among Vietnamese high school students, highlighting how institutional access and experience shape student responses during assessment digitalization. Across analyses, school-level exposure (computer access at school and prior CBT experience) showed small but consistent links to higher acceptance, whereas household device ownership was negligible. Fairness concerns were substantially more prevalent than positive fairness beliefs and varied across residential areas. For education systems expanding CBT under conditions of uneven digital access, the central equity challenge is not whether students have computers at home, but whether schools provide structured exposure, transparent governance, and credible safeguards for fairness. Practically, we propose coupling a reliable acceptance composite with brief fairness indicators as part of a monitoring dashboard to identify where targeted communication, practice opportunities, or administrative safeguards are most needed. In short, equitable CBT is built through school-based exposure and sustained through transparent, accountable administration.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial, personal, or professional interests that could have influenced the work reported in this paper. The authors state no conflict of interest.

INFORMED CONSENT

The protection of privacy is a legal right that must not be breached without individual informed consent. In cases where the identification of personal information was necessary for scientific reasons, we obtained full documentation of informed consent, including written permission from all individuals prior to their inclusion in this study.

ETHICAL APPROVAL

The research involving human participants complied with all relevant national regulations and institutional policies, in accordance with the tenets of the Declaration of Helsinki. Under the University of Education, Hue University's research governance for minimal-risk, fully anonymous educational surveys, formal ethics committee review was not required. The study involved no intervention or deception. No IP addresses or direct identifiers were collected; indirect identifiers were minimized, and small cells are not reported to mitigate re-identification risk.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [TTNA], upon reasonable request. Due to privacy and ethical considerations, the data are not publicly available.

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