Tamilmanam International Research Journal of Tamil Studies
An international, peer-reviewed monthly academic research journal
ISSN: 3049-0723 (Online)
3107-7781 (Print)

தமிழ்மணம் சர்வதேசத் தமிழ் ஆய்விதழ்
Peer-Reviewed Open Access Crossref Google Scholar
SJIF Impact Factor3.5 (2024-) Multidisciplinary
: https://doi.org/10.63300/tm12042026

Vol. 12 No. 04 (2026): September 2026, **p85-97** | Available online at: www.tamilmanam.in

Original Research Paper – Peer reviewed ✓

Breaking the Invisible Barrier: Psychological Resistance to Technology Adoption Among Rural Engineering Students

A Theoretical and Case-Based Analysis with Institutional Recommendations

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Article history
Received: 20-08-2026
Revised: 30-08-2026
Accepted: **29-08-2026**
Published on: 01-09-2026

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Abstract: Although modern engineering education relies heavily on advanced digital tools, access alone does not ensure success for rural students, who often experience psychological resistance to new technologies. Rather than a lack of technical capability, this resistance is an emotional and cognitive defense against fear of failure, identity threat, and social judgment. By synthesizing theories of self-efficacy, technology acceptance, technophobia, and impostor syndrome, the paper introduces a "psychological friction layer" that explains how a student's socioeconomic and linguistic background creates anxiety in laboratory environments. Through case studies across multiple engineering disciplines, the authors contrast rural-transitioning students with urban-exposed peers and offer a four-phase institutional roadmap—spanning psychological readiness assessments, low-friction foundation modules, gamified error handling, and full system integration—to help educators transform initial anxiety into long-term technical competence.

Keywords: *psychological resistance, technology adoption, rural engineering students, Technology Acceptance Model, impostor syndrome, techno-anxiety, self-efficacy, digital divide, engineering education, CAD/CAM, version controlSarvashtakavarga (SAV); Rasi; Bhava; Karakatwas (Karaka, Phala).*

1. Introduction

Engineering curricula worldwide have undergone a rapid and largely irreversible shift toward digital-first pedagogy. Circuit design has moved from breadboards to simulation suites; mechanical drafting has moved from T-squares to parametric CAD; and software engineering education now assumes fluency with command-line interfaces, distributed version control, and cloud-based development environments before a student writes a single line of production code. For students who arrive at university already immersed in this digital ecosystem, the transition is largely seamless. For students who arrive from rural, regional-language educational backgrounds, however, the transition frequently exposes a barrier that is invisible to conventional metrics of institutional readiness: a barrier that is psychological rather than infrastructural.

Article DOI: https://doi.org/10.63300/tm12042026.08

Government and institutional interventions aimed at rural students have historically emphasized access — computer laboratories, subsidized devices, broadband connectivity, and bilingual course material [1, 10]. These interventions are necessary but not sufficient. National-level survey work on India's Digital India Program shows that even where devices and connectivity have measurably improved, adoption patterns remain uneven and are shaped as much by confidence and comfort as by availability [10]. This paper argues that engineering institutions must treat psychological readiness as a distinct variable, separable from technical access, and must design interventions that target it directly.

The remainder of the paper proceeds as follows. Section 2 develops the theoretical framework, adapting the Technology Acceptance Model to account for psychological friction unique to rural transitioning students. Section 3 reviews the broader literature on the rural-urban digital divide in Indian higher education. Section 4 examines the core psychological drivers of resistance in depth. Section 5 presents four discipline-specific case studies. Section 6 offers a comparative analysis and impact matrix, including the cascading structural consequences of unaddressed resistance. Section 7 proposes a four-phase institutional roadmap. Section 8 discusses limitations and directions for future research, followed by a conclusion.

2. Theoretical Framework

2.1 The Technology Acceptance Model and Its Limits

The Technology Acceptance Model (TAM), introduced by Davis, remains the most widely used framework for explaining why individuals accept or reject a given information technology [4, 5]. TAM proposes that a user's behavioral intention to adopt a system is jointly determined by two beliefs: perceived usefulness (PU), the degree to which a person believes a tool will improve their performance, and perceived ease of use (PEOU), the degree to which a person expects the system to be free of effort [4]. Subsequent extensions — including the Unified Theory of Acceptance and Use of Technology (UTAUT), which incorporates performance expectancy, effort expectancy, social influence, and facilitating conditions — broadened the model to account for organizational and social variables [12]. TAM and its descendants, however, were built primarily on studies of working adults adopting workplace software, and they implicitly assume that PEOU is a relatively stable, technology-driven property. For rural engineering students, this paper argues, PEOU is not stable: it is systematically distorted downward by psychological variables that have little to do with the technology itself.

2.2 Self-Efficacy and the Sources of Confidence

Bandura's self-efficacy theory provides the psychological mechanism underlying this distortion. Bandura defines self-efficacy as an individual's belief in their capacity to execute the behaviors required to produce a given outcome, and argues that efficacy expectations — not just objective skill — determine whether a person initiates a coping behavior, how much effort they expend, and how long they persist in the face of obstacles [2]. Mastery experience is identified as the strongest source of self-efficacy; without early, low-stakes opportunities to experience success with a new tool, students never accumulate the evidence base that would let them interpret an error message as a solvable problem rather than a personal failing. This theoretical link is central to the interventions proposed in Section 7.

2.3 The Impostor Phenomenon

Clance and Imes originally described the impostor phenomenon as an internal experience of intellectual phoniness in which individuals persist in believing they are not as capable as their achievements suggest, despite clear objective evidence to the contrary [3]. Although the construct was first documented among high-achieving women, later work has extended it across demographic groups and into technical and software-engineering contexts specifically. For rural engineering students who were top performers under a traditional, paper-based pedagogy, a single unreadable terminal error can be internalized not as “this tool is unfamiliar” but as “I am not built for this,” a distinction that maps directly onto the urban-versus-rural attribution styles summarized in Table 2.

2.4 Technophobia and Computer Anxiety

Rosen and Weil define technophobia as a cluster of related phenomena: anxiety about current or future interactions with technology, negative global attitudes toward computers and their social effects, and specific self-critical internal dialogue that occurs during or in anticipation of technology use [8, 9]. Later reviews note that technophobia is conceptually distinct from a simple lack of skill: experience with a technology does not reliably reduce anxiety, because highly anxious individuals tend to actively avoid the very interactions that would build competence [6]. This avoidance dynamic is precisely what is documented in the case studies in Section 5.

2.5 Diffusion of Innovations

Rogers's diffusion of innovations framework classifies adopters into innovators, early adopters, early majority, late majority, and laggards along an adoption curve, and identifies perceived attributes of an innovation — including its complexity and compatibility with existing practice — as key determinants of adoption speed [7]. Rural engineering students transitioning from manual, procedural study habits are, in Rogers's terms, encountering an innovation that is high in both perceived complexity and low in compatibility with their prior practice, which predicts slower and more hesitant adoption independent of the students' underlying technical aptitude.

2.6 An Adapted Model: The Psychological Friction Layer

Synthesizing these frameworks, this paper proposes inserting a psychological friction layer between external variables (rural schooling, regional-medium instruction, limited prior device exposure) and the TAM's perceived-ease-of-use construct, as illustrated in Figure 1. In this adapted model, perceived usefulness typically remains high — rural students generally understand and value what Git, CAD, or SPICE simulation can do for their careers — while perceived ease of use is compressed by impostor syndrome, techno-anxiety, and threatened mastery before any substantive technical learning occurs. The practical implication is significant: interventions that only increase access or explain usefulness will under-perform, because the binding constraint is not motivation but distorted self-assessment of one's own capability.

Article DOI: https://doi.org/10.63300/tm12042026.08

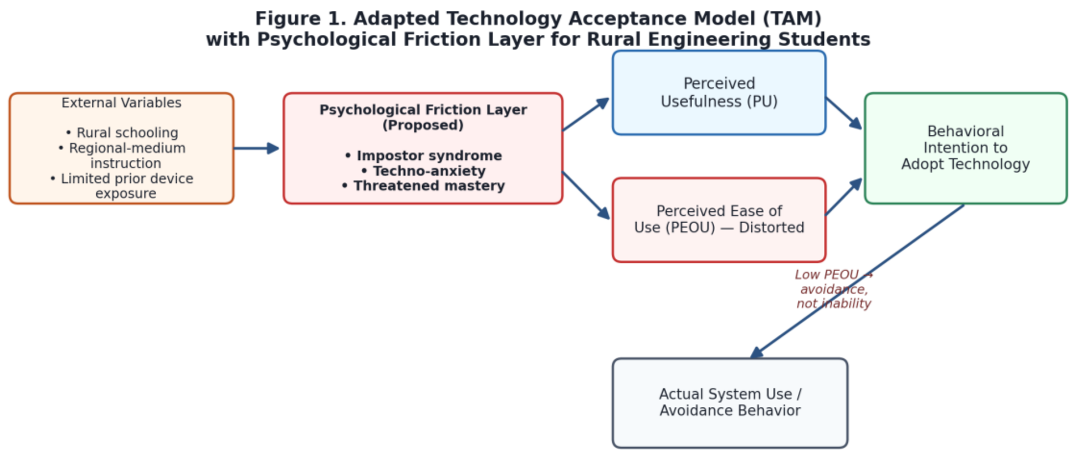

Figure 1. Adapted Technology Acceptance Model incorporating a psychological friction layer specific to rural-transitioning engineering students.

Table 1. Summary of Theoretical Frameworks Applied in This Study

Framework	Originating Source	Core Construct(s)	Application Here
Technology Acceptance Model	Davis (1989) [4]	Perceived usefulness; perceived ease of use	Baseline adoption model, adapted with friction layer
UTAUT	Venkatesh et al. (2003) [12]	Performance/effort expectancy; social influence	Explains role of peer visibility (e.g., GitHub)
Self-Efficacy Theory	Bandura (1977) [2]	Mastery experience; efficacy expectations	Basis for “zero-grade sandbox” intervention
Impostor Phenomenon	Clance & Imes (1978) [3]	Internalized intellectual fraudulence	Explains personal (vs. analytical) error attribution
Technophobia / Computer Anxiety	Rosen & Weil (1995) [8, 9]	Anxiety, avoidance, negative self-talk	Explains avoidance despite technology access
Diffusion of Innovations	Rogers (1962) [7]	Complexity; compatibility; adopter categories	Frames rural cohort as later-adopting, not less able

Table 1. Theoretical frameworks synthesized into the psychological-friction model used in this study.

3. The Rural-Urban Digital Divide in Indian Higher Education: A Brief Review

The psychological dimension of technology resistance sits alongside, and is often obscured by, a welldocumented infrastructural digital divide in India. Large-scale survey research on India's Digital India Program shows that although device and connectivity access has expanded substantially, adoption patterns still vary by education level, age, and — importantly — by the type of service used, with rural populations gravitating toward mobile-based rather than computer-based services [10]. Complementary national-level analysis finds that affordability of devices and data, digital-literacy levels, and cultural and social barriers each independently shape adoption outcomes, and that these barriers do not resolve automatically once infrastructure is deployed [1]. Comparative work specifically on rural and urban Indian college students has found that self-reported attitudes toward perceived usefulness, ease of use, and computer self-efficacy do not always differ sharply by geography once students reach engineering colleges, suggesting that by the time students arrive in higher education, the remaining gap is less about raw exposure and more about how confidently students interpret their own capability — precisely the psychological terrain this paper addresses.

Two further threads of literature are relevant. First, research on generative-AI adoption in rural Indian K-12 contexts finds that cost, language, and infrastructure barriers persist even for the newest classes of tools, indicating that each successive wave of educational technology reopens the same fault lines rather than resolving them once and for all. Second, the broader ICT-adoption literature in India stresses that digital-divide indices should combine supply-side variables (infrastructure, electrification) with demand-side variables (skills, confidence, willingness to engage) [1]; this paper's contribution is to specify the demand-side psychological mechanisms — impostor syndrome, technophobia, and threatened mastery — with enough precision that engineering educators can design against them directly, rather than treating "low digital literacy" as an undifferentiated catch-all.

4. Core Psychological Drivers of Resistance

4.A Impostor Syndrome and Socio-Linguistic Anxiety

Engineering programs predominantly operate in English and assume a baseline level of digital literacy acquired informally, outside the formal curriculum. Students from rural schools — often educated in a regional medium through Class 12 — frequently experience an intense version of the impostor phenomenon described by Clance and Imes [3] when they encounter complex command-line interfaces or English-heavy software documentation. Because the friction is linguistic and interface-level rather than conceptual, students often internalize it as a personal intellectual failure: the error is read as "I am not smart enough" rather than "this documentation was not written with me in mind."

4.B Technophobia and Fear of Failure

Unlike urban peers who often grew up experimenting freely with personal laptops and smartphones, rural students frequently perceive high-end laboratory hardware and licensed software as fragile, expensive, and institutionally scarce resources that must not be damaged. Consistent with the technophobia literature [8, 9], this produces a specific fear of "breaking the system" or committing an irreparable error, which causes cognitive paralysis and a marked reluctance to engage in the self-directed, trial-and-error exploration that Rogers identifies as central to innovation adoption [7].

4.C Threat to Established Mastery

Many rural students were top academic performers in secondary school using traditional, paper-and-pencil methods; their sense of competence was built through those methods. Transitioning to algorithmic, tool-assisted engineering workflows — MATLAB scripting, Git-based version control, parametric AutoCAD modeling — invalidates the study habits that previously produced success. This creates cognitive dissonance and, following Bandura, a collapse in situational self-efficacy that prompts students to retreat toward manual methods where mastery still feels intact [2].

4.D Peer Visibility and Social Comparison

A driver not fully articulated in the source discussion but consistent with UTAUT's social-influence construct [12] is the role of public, peer-visible platforms. Tools such as GitHub, class Discord servers, or shared lab logs make a student's technical struggle visible to classmates in a way that a private notebook never was. For students already carrying impostor-phenomenon anxiety, this visibility functions as an additional deterrent layer, independent of the tool's actual technical difficulty.

5. Case Studies and Practical Examples in Engineering

The following four discipline-specific vignettes illustrate how the psychological drivers described in Section 4 manifest in concrete classroom and laboratory settings. Each case study follows the same structure — scenario, observed behavior, illustrative indicators, and psychological root cause — to allow direct comparison across disciplines.

Case Study 1: Computer Science & IT — The GitHub and Linux Terminal Hesitation

Scenario. First-year computer science students from rural backgrounds are introduced to version control using Git and Linux command-line interfaces during their data structures laboratory.

Observed Behavior. Students repeatedly write and test code in local text editors or on notebook paper and avoid pushing commits to GitHub. When errors appear in the terminal, a common response is to close the application rather than read the error log, effectively resetting progress rather than debugging it.

Psychological Root Cause

- **Language barrier:** terminal error messages are dense, idiomatic, and written in technical English with no localized glossary.
- **Fear of public exposure:** pushing code to an open platform like GitHub creates anxiety about peer judgment of code quality, amplified by the social-visibility dynamic in Section 4.D.
- **Loss of visual control:** the absence of a graphical interface strips away familiar visual cues, triggering cognitive overload consistent with technophobia [8].

Illustrative Classroom Indicators

Illustrative Indicator	Urban-Exposed Pattern	Rural-Transitioning Pattern
Terminal usage per lab session	High — frequent, exploratory	Low — avoided where possible
Commits pushed to GitHub weekly	Multiple, including in-progress work	Rare; usually only final, “polished” code
Response to a red error message	Analytical — search, paste, or ask	Personal — close window, restart

Table 2. Illustrative (non-statistical) classroom indicators for Case Study 1, offered as a discussion aid rather than survey data.

Case Study 2: Mechanical & Civil Engineering — Manual Drafting vs. CAD/CAM Systems

Scenario. Second-year mechanical engineering students transition from manual engineering drawing on drafting boards to SolidWorks or AutoCAD.

Observed Behavior. Students spend hours attempting to solve design problems on paper first, manually calculating dimensions before entering them into the software, rather than using the parametric modeling features that would let the software perform iterative recalculation for them.

Psychological Root Cause

- **Habitual inertia:** students trust physical tools — scales, T-squares, compasses — because tactile feedback provides an immediate, embodied sense of accuracy and control that a mouse cursor does not.
- **Low perceived self-efficacy:** the overwhelming density of CAD toolbars produces software fatigue, consistent with Bandura's account of how repeated small failures erode efficacy expectations before real learning begins [2].

Illustrative Classroom Indicators

Illustrative Indicator	Urban-Exposed Pattern	Rural-Transitioning Pattern
Time spent hand-calculating before modeling	Minimal — models directly, iterates in software	Extensive — full manual solution first
Use of parametric/constraint tools	Explored proactively	Avoided; dimensions entered as fixed values
Reaction to a failed constraint solve	Treated as a puzzle to adjust	Treated as confirmation of personal error

Table 3. Illustrative classroom indicators for Case Study 2.

Case Study 3: Electrical & Electronics Engineering — Simulation vs. Physical Breadboards

Scenario. EEE students are asked to test circuit designs on Proteus or LTspice before building the corresponding physical circuits on breadboards.

Observed Behavior. Students frequently skip the simulation step entirely, or copy simulation results from peers, preferring to move directly to hardware wiring despite the higher error rates and safety risks this

Article DOI: https://doi.org/10.63300/tm12042026.08

entails.

Psychological Root Cause

- **Abstraction resistance:** virtual components feel abstract and untrustworthy compared to physical wires and resistors that can be seen, touched, and re-checked by hand.
- **Lack of a guided scaffold:** without a structured, low-stakes environment in which making a software mistake carries no real consequence, the simulation interface itself feels alien rather than supportive.

Illustrative Classroom Indicators

Illustrative Indicator	Urban-Exposed Pattern	Rural-Transitioning Pattern
Simulation attempted before hardware build	Standard practice	Frequently skipped
Source of simulation results submitted	Own trial-and-error runs	Sometimes copied from peers
Comfort narrating a simulation error aloud	Comparatively high	Comparatively low

Table 4. Illustrative classroom indicators for Case Study 3.

Case Study 4: Chemical Engineering — Process Simulation Software (Aspen HYSYS / Aspen Plus)

Scenario. Third-year chemical engineering students are asked to model a distillation or heat-exchanger unit in Aspen HYSYS after having previously solved equivalent mass- and energy-balance problems entirely by hand.

Observed Behavior. Students frequently re-derive the entire balance manually before entering a single value into the simulator, use the software only to "check" an answer they have already committed to on paper, and rarely explore convergence warnings or sensitivity-analysis tools, treating any solver warning as proof that they have made an error rather than as a normal part of iterative process design.

Psychological Root Cause

- **Perceived stakes of a wrong model:** process simulation is associated in students' minds with industrial-scale, safety-critical decisions, which raises the perceived cost of any visible mistake and intensifies fear of failure beyond what a purely academic exercise would warrant.
- **Compressed perceived ease of use:** as in the adapted TAM model in Figure 1, perceived usefulness of process simulation is rarely in doubt — students recognize its industrial value — while perceived ease of use is suppressed by unfamiliarity with the software's non-linear solver behavior.

Illustrative Classroom Indicators

Illustrative Indicator	Urban-Exposed Pattern	Rural-Transitioning Pattern
Order of operations	Models in software, verifies by hand selectively	Solves fully by hand, then re-enters in software
Response to a convergence warning	Adjusts initial estimates, retries	Assumes the whole model is wrong, restarts

Illustrative Indicator	Urban-Exposed Pattern	Rural-Transitioning Pattern
Use of sensitivity-analysis tools	Explored to understand the process	Rarely used unless explicitly assigned

Table 5. Illustrative classroom indicators for Case Study 4.

6. Comparative Analysis and Impact Matrix

Understanding the difference between urban-exposed and rural-transitioning students helps isolate psychological factors from raw technical ability. Table 6 synthesizes the comparison introduced across the four case studies into a single cross-cutting matrix.

Table 6. Psychological Factors Comparison

Resistance Dimension	Typical Urban Student Profile	Rural Transitioning Student Profile
Initial mindset toward new software	Exploratory ("Let me click around and figure it out")	Cautious ("Let me wait for exact instructions")
Response to system errors	Analytical ("Google the error code / paste into AI")	Personal ("I did something wrong; I'm not built for this")
Peer interaction around technology	Collaborative and public (Discord, GitHub, Reddit)	Private and hesitant (afraid to ask "basic" questions)
Primary learning style	Digital-native trial and error	Linear, textbook-driven, rote-procedural
Relationship to failure	Treated as diagnostic information	Treated as evidence of inadequacy

Table 6. Comparative psychological factors across urban-exposed and rural-transitioning engineering student profiles.

6.1 The Domino Effect of Unaddressed Resistance

If left unaddressed during the early years of an engineering program, psychological resistance does not remain static; it compounds into a cumulative structural deficit. Reduced hands-on exploration in the first year produces measurably lower practical technical competence by the second year, which in turn deepens impostor-phenomenon anxiety rather than resolving it through experience — the opposite of the mastery-experience mechanism Bandura identifies as the primary route to self-efficacy [2]. Figure 2 traces this six-stage cascade.

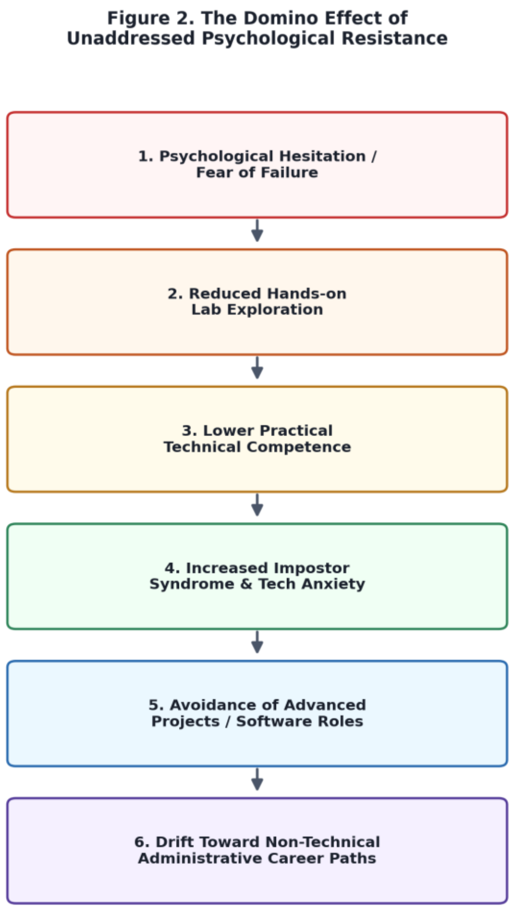

Figure 2. The domino effect of unaddressed psychological resistance, from initial hesitation to eventual career drift.

This cycle often results in capable rural students shifting away from core technical, software, or design roles toward non-technical administrative jobs, despite possessing strong theoretical and mathematical foundations. The loss is therefore not one of raw ability but of accumulated, avoidable friction — which is precisely why the intervention framework in Section 7 targets the earliest stages of the cascade rather than attempting later-stage remediation.

7. Strategic Interventions and Institutional Roadmap

Overcoming psychological resistance requires institutional strategies that address the emotional and cognitive entry barriers before pushing technical content. The recommendations below are organized into pedagogical interventions for individual educators and a phased institutional framework for programs as a whole.

7.1 Pedagogical Interventions for Engineering Educators

- **Low-stakes playground environments:** introduce mandatory “zero-grade sandbox sessions” in which students are intentionally tasked with breaking code or generating errors in CAD. Normalizing error logs as an expected part of the workflow reduces the fear of system failure described in Section 4.B.

- **Bilingual technical scaffolding:** provide initial technical documentation with regional-language glossaries — for example, mapping English terminal commands or CAD terminology to explanations in the students' regional medium of instruction.
- **Peer-led micro-mentorship:** pair rural students with upper-year peers who share similar demographic backgrounds and have successfully overcome early technical anxiety, directly countering the private-and-hesitant interaction pattern documented in Table 6.
- **Reframed error messaging:** wherever institutionally feasible, supplement default terminal and compiler error output with plain-language annotations, reducing the socio-linguistic anxiety identified in Section 4.A.

7.2 Strategic Institutional Framework

The following four-phase roadmap, illustrated in Figure 3, sequences interventions across a student's first year so that psychological readiness is assessed and built before students are expected to operate in fully open, peer-visible technical environments.

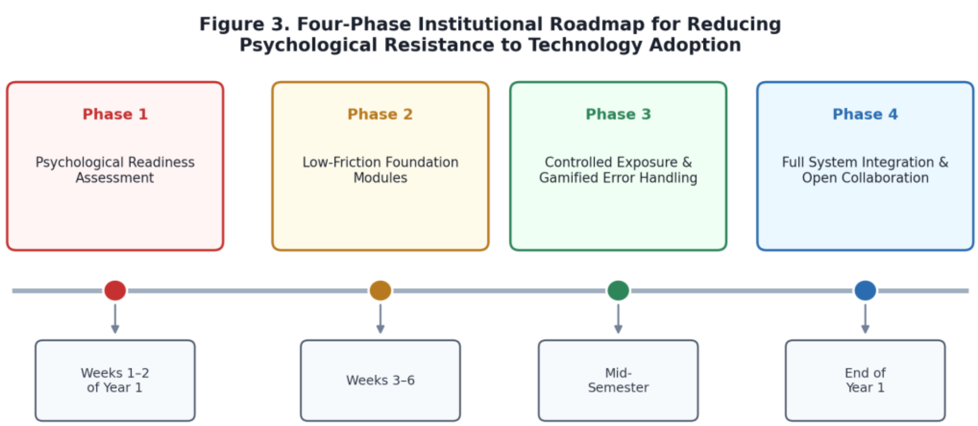

Figure 3. Four-phase institutional roadmap for reducing psychological resistance to technology adoption.

Phase	Focus	Core Activities	Timing
Phase 1	Psychological Readiness Assessment	Conduct anonymous self-efficacy surveys measuring digital comfort, English technical comprehension, and fear of software failure, rather than testing raw technical skill.	Weeks 1–2, Year 1
Phase 2	Low-Friction Foundation Modules	Introduce basic tools — GUI-based tools before CLI, visual block programming before syntax-heavy code — to build early mastery experiences, following Bandura's self-efficacy theory [2].	Weeks 3–6
Phase 3	Controlled Exposure & Gamified Error Handling	Incorporate debugging exercises where students earn points for identifying, explaining, and fixing common software errors, reframing bugs as puzzles rather than failures.	Mid-Semester
Phase 4	Full System Integration & Open Collaboration	Transition students to industry-standard tool chains (Git, CAD/CAM, SPICE) with open peer reviews	End of Year 1

Article DOI: https://doi.org/10.63300/tm12042026.08

Phase	Focus	Core Activities	Timing
		and collaborative group projects.	

Table 7. Four-phase institutional roadmap with corresponding activities and timing.

8. Discussion, Limitations, and Directions for Future Research

The framework and case studies presented here are conceptual and illustrative rather than the product of a controlled empirical study; the classroom indicator tables in Section 5 are offered as discussion aids grounded in the theoretical literature rather than as reported survey results. This is an appropriate first step given how little discipline-specific attention psychological resistance has received in engineering-education research relative to purely infrastructural digital-divide work [1, 10], but it also means the specific magnitudes implied in Tables 2 through 5 should be treated as hypotheses to be tested, not established findings.

Three directions for future research follow directly from this limitation. First, the adapted TAM model in Figure 1 generates a testable prediction — that perceived usefulness and perceived ease of use will diverge more sharply for rural-transitioning students than for urban-exposed peers — that could be assessed using the validated PU/PEOU scales originally developed by Davis [4]. Second, longitudinal tracking of the domino effect in Figure 2 would clarify how quickly early hesitation compounds into competence gaps, and at which stage interventions produce the largest return. Third, comparative work across regional-language groups and across engineering disciplines beyond the four examined here (for example, biomedical or aerospace engineering) would test whether the psychological drivers identified in Section 4 generalize or vary by field.

A further limitation is that this paper treats “urban” and “rural” as a binary for expository clarity; in practice, students' prior digital exposure lies on a continuum shaped by school type, family occupation, and regional infrastructure, and some empirical work on Indian college students has found that self-reported attitudes toward technology acceptance do not always differ sharply by geography once students reach engineering colleges. The psychological-friction framework proposed here is intended to apply to any student — rural or otherwise — whose prior educational experience left them with limited low-stakes exposure to digital tools, and institutions should assess readiness directly (as in Phase 1 of Section 7.2) rather than assuming geography alone predicts need.

9. Conclusion

Psychological resistance to technology adoption among rural engineering students is not an intellectual deficit — it is an emotional and cultural mismatch between traditional background experiences and modern digital learning environments. The Technology Acceptance Model, self-efficacy theory, the impostor phenomenon, and the literature on technophobia together explain why perceived ease of use collapses for these students even when perceived usefulness remains high, and why that collapse manifests as avoidance rather than as a simple absence of skill. By addressing the psychological drivers of resistance — language anxiety, fear of failure, and threatened self-efficacy — through structured, sequenced interventions such as the four-phase roadmap proposed in Section 7, engineering institutions can unlock immense latent talent and ensure a technical education that is inclusive not only in access, but in confidence.

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Conflict of Interest Statement

The author declares no conflict of interest, financial or otherwise, related to the research, authorship, or publication of this article. No funding, sponsorship, or third-party financial support was received for the preparation of this manuscript. All software, platforms, and tools named in this paper (including Git, GitHub, SolidWorks, AutoCAD, Proteus, LTspice, and Aspen HYSYS/Aspen Plus) are referenced solely for illustrative and educational purposes; the author has no commercial affiliation with, or financial interest in, any of the vendors of these products.

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