

Redbuho: A Mixed-Methods Needs Diagnosis and Multi-Format Platform Design for Women Entrepreneurs in the Social and Solidarity Economy

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Abstract

This paper reports the diagnostic and preliminary design phase of “Redbuho”, a digital training platform for women entrepreneurs from the central region of Veracruz, Mexico. An explanatory sequential mixed-methods design combined a 47-item self-assessment instrument (Cronbach's alpha 0.89-0.94), applied to 200 women entrepreneurs through non-probability institutional recruitment, with five convenience-selected qualitative cases drawn from respondents after the quantitative results were known. Legal/funding frameworks ($M=2.72$) and social and solidarity economy ($M=2.81$) were the lowest-rated competency dimensions, while financial literacy (56.5%) and digital marketing (55.5%) were the most requested topics. A three-band k-means solution was retained for instructional interpretation (silhouette=0.26, bootstrap ARI=0.86), although principal component analysis indicated the bands mainly reflect a general competency-level continuum rather than distinct multidimensional profiles. Access mode showed no significant association with competency band ($p=.35$), supporting separate decisions about learning pathways and delivery format. Qualitative cases identified informal family and remittance-based financing, structural market barriers, and a decision-execution gap. These findings informed a six-course, 42-unit program prototype with three different formats to reduce access limitations: planned online, offline-USB, and print distribution strategies. Limitations include non-probability sampling, unverifiable, self-reported competencies, and a scheduled end-user usability testing.

Keywords

Women entrepreneurship, social and solidarity economy, training platform, cluster analysis, and mixed methods.

1. Introduction

Women entrepreneurs found or co-manage half of the more than 17 million small and medium enterprises in Latin America and the Caribbean, contributing roughly one-quarter of the gross domestic product generated by this business segment (GEM, 2021). This participation remains markedly informal: 87% of women who lead a micro, small, or medium enterprise in the region use personal payment methods to manage their business (Mastercard, 2025), and access to formal credit shows a gap of 15 to 25 percentage points relative to men (Fundación Impulso LATAM, 2025). In Mexico, female labor participation stands at 45.7%, against 75.1% for men, and 55.9% of employed women work in the informal sector (INEGI, 2025a); women represent 43.6% of the micro, small, and medium enterprise workforce, yet 67% of Mexican microenterprises still operate informally (INEGI, 2026).

These national gaps intensify in the central region of Veracruz, referred to as the metropolitan region of “Altas montañas” where 62.4% of the population lives in multidimensional poverty, with municipal extremes ranging from 3.39% to 64.85% distributed among fourteen municipalities (CONEVAL, 2020). The region also concentrates around 8-10% of Náhuatl-speaking population (Martínez et. Al, 2022), the most widely spoken of the 68 indigenous languages of the country (INEGI, 2021), adding cultural and linguistic considerations to any training strategy designed for its inhabitants. Women in the region work more than eight hours a week beyond men's workload and earn 19% less income than their counterparts in central Mexico (INEGI, 2021), conditions that the Redbuho project has considered (CI-02/2026, Instituto Tecnológico de Orizaba). This project is funded by the Tecnológico Nacional de México, a network of 254 campuses serving more than half million students across this country, described by the National Public Education Secretariat as the higher-education system with the largest enrollment coverage in Latin America, predominantly in engineering fields (SEP, 2016. Orizaba's campus has worked with local networks (NODESS) to build a territorial alliance strategy promoted by the National Institute of the Social Economy (INAES) that formally integrates at least three types of actors (academic institutions, local governments, and social-sector economy organizations) to build local social and solidarity economy ecosystems (INAES, 2023).

Under the premise that digital platforms can expand market access, facilitate business management, and favor the economic inclusion of women entrepreneurs (Camps et al., 2025; Sowmya and Pai, 2025), the platform's design was a priority but it also needed to account for the socio-cultural, territorial, and organizational diversity of the target population. Institutional theory distinguishes formal rules from informal norms as complementary constraints on economic behavior (North, 1990; Williamson, 2000), which explains why an effective training strategy for women entrepreneurs must treat legal-formalization barriers and gender norms as related but distinct external factors, while also strengthening the internal psychological resources, self-efficacy and resilience that allow entrepreneurs to act despite those external constraints (Bandura, 1977, 1997; Bullough and Renko, 2013). This paper addresses the gap between generic digital-training initiatives and the specific, heterogeneous needs of women entrepreneurs in marginalized rural-to-peri-urban regions.

1.1 Objectives

The general objective of the Redbuho project is to develop and implement a technological training platform that strengthens the productive, digital, and organizational competencies of women entrepreneurs. This paper addresses four specific objectives: (1) to diagnose training needs, digital gaps, and enterprise characteristics among women entrepreneurs of the Altas Montañas region; (2) to segment the diagnosed population into stable, instructionally interpretable competency profiles; (3) to explain and extend the quantitative diagnosis through convenience-selected qualitative case studies; and (4) to translate the resulting diagnosis into the curricular architecture and multi-format distribution strategy of the Redbuho platform prototype. The broader Redbuho project follows a participatory action research (PAR) orientation involving students, faculty, and community actors; the present paper reports specifically the diagnostic, segmentation, and preliminary design phase, serving as the foundations for its first live prototype: <https://redbuho.org>

1.2 Research Questions

This research's structure follows four key questions. RQ1: What productive, digital, financial, legal, and organizational training needs characterize women entrepreneurs in the Altas Montañas region? RQ2: Can women entrepreneurs be meaningfully segmented according to their self-assessed competency profiles, and what is the nature of that segmentation? RQ3: Are competency profiles empirically distinct from access conditions and preferred delivery formats? RQ4: How do qualitative case studies extend, nuance, or complicate the quantitative diagnosis?

2. Literature Review

The literature relevant to this study spans four areas: the economic relevance and structural barriers of women's entrepreneurship, institutional and gender-aware theories of entrepreneurship, the psychological determinants of entrepreneurial persistence, and digital training platforms as an intervention strategy. These four areas are integrated by a common logic: structural and institutional barriers shape access to finance, markets, time, and training; individual resources such as self-efficacy and resilience affect an entrepreneur's capacity to act under these constraints; and digital and pedagogical design mediates whether training can be accessed and translated into practice. This study measures the first and third elements directly, through the self-assessment instrument and platform design, while the psychological constructs are discussed by the qualitative approach to specific cases.

Women-led enterprises represent more than 36% of Mexico's national economic units (Konfio, 2023), yet structural barriers persist. The glass-ceiling concept describes an invisible barrier that limits women's access to positions of responsibility and business consolidation, rooted in stereotypes and institutional structures rather than in a lack of competence (Camarena-Adame and Saavedra-García, 2018). Across Latin America, less than 1% of regional venture-capital investment reaches all-women founding teams despite comparable financial viability (BID Lab, 2024), and structural inequality in access to formal capacity-building persists across the region (CEPAL, 2010).

Institutional economics distinguishes formal rules, as laws, property rights, contracts; from informal norms as customs and gender expectations; representing two complementary layers that shape economic behavior (North, 1990; Williamson, 2000). Gender-aware entrepreneurship frameworks argue that classical, market-centered theories of entrepreneurship do not adequately explain women's experience, and propose adding motherhood/household context and the cultural environment and support networks as explanatory dimensions (Brush, de Bruin and Welter, 2009). A report from TecNM reflects this gender access gap reduction as the female student population has increased from 6% to 35% from 1955 to 2019 (Ramírez et. Al, 2019). Collaborative models linking universities, government, and productive sectors; the triple-helix approach, have been documented as an effective mechanism for extending capacity-building to populations that neither academia, government, nor the private sector could reach alone (Amador Ruiz et al., 2024); which has been specifically referred by TecNM as an important model for México's current education policies.

At the individual level, entrepreneurial self-efficacy, the perceived capability to achieve a desired outcome; historically, has been shown to influence the decision to start and sustain a business more strongly than objective capability itself (Bandura, 1977, 1997; Chen, Greene and Crick, 1998; Liñán, Urbano and Guerrero, 2011), and low self-efficacy leads individuals to avoid entrepreneurship by perceiving it as excessively risky (McGee et al., 2009). Entrepreneurial resilience complements self-efficacy as one of the strongest predictors of business persistence under adverse conditions, and both can be strengthened through training, exposure to role models, and reflective practice with feedback (Bullough and Renko, 2013; Bullough, Renko and Myatt, 2014). From the pedagogical side, adult learners engage best when they participate in defining their own learning needs, build on prior experience, and are motivated by solving a concrete problem (Knowles, Holton and Swanson, 2001).

Social and solidarity economy (SSE) is defined here by the International Labour Conference in 2022, which characterizes the SSE by enterprises and organizations, cooperatives, mutual societies, associations, and related entities; that operate on the basis of voluntary cooperation, mutual aid, democratic or participatory governance, and the primacy of people and social purpose over capital (ILO, 2022). NODESS network alliances operationalize this approach territorially by linking cooperatives, productive networks, and local actors to strengthen collaborative rather than purely competitive business practices; also reflected on its values and financing tools. The questionnaire dimension used in this study to approximate SSE orientation covers collaboration with other entrepreneurs, participation in community marketing spaces, and awareness of solidarity-economy principles. Being of specific interest as new master programs in SSE began operating in the TecNM system in 2025. Those specific items should be read as a proxy for exposure to and valuation of these practices rather than a comprehensive SSE measurement scale.

Digital training platforms have been documented as a scalable response when combined with mentoring and targeted capacity-building, rather than the mere provision of online content (BID, 2025). A pilot partnership between UN Women and Nokia in Argentina found that remote delivery was not a participation barrier but an attendance advantage for women in urban and rural communities (ONU Mujeres, 2024), while Chile's Pymes en Línea portal found that although 96% of women who train online come from outside the capital, only 19% engage with AI-related content,

showing that connectivity and digital literacy are not homogeneous even among users of the same platform (Revista Emprende, 2026). This evidence converges on a central conclusion: digital platforms can meaningfully reduce structural barriers to training, but only when curricular design and delivery format explicitly account for the heterogeneity.

3. Methods

This study follows an applied, non-experimental, explanatory sequential mixed-methods design, quantitative followed by qualitative, in which a convenience-selected qualitative phase is used to explain and extend a prior quantitative diagnosis (Creswell and Plano Clark, 2011). The analytical sequence was: (1) descriptive statistics of the sociodemographic profile, self-assessed competencies, and stated preferences of the diagnostic sample; (2) k-means cluster analysis on the seven standardized competency dimensions, with the number of clusters selected using the elbow method, the silhouette coefficient, the Calinski-Harabasz index, and the Davies-Bouldin index, followed by two robustness checks; agreement with an independent hierarchical (Ward) solution and stability under 100 iterations of 80% bootstrap resampling, both measured with the Adjusted Rand Index (ARI); (3) construction of an access-mode classification from device, connectivity, and modality-preference variables, cross-tabulated against the competency clusters; and (4) convenience-based follow-up, after the quantitative results were available, with five explanatory case studies from among the survey respondents, documented through structured field notes and direct observation of each business. Integrated with the quantitative findings at the aggregate thematic level through a triangulation matrix identifying convergence, complementarity, and divergence (Braun and Clarke, 2006; Denzin, 1978). This sequence directly informed the Redbuho platform prototype.

Dimension scores were computed as the unweighted arithmetic mean of their constituent items; all 47 items were mandatory in the survey instrument in Google Forms, so no missing-value imputation was required. K-means clustering used Euclidean distance on the seven standardized (z-score) dimension scores, with 50 random initializations and a fixed random seed, implemented in Python (scikit-learn), using principal component analysis on the same standardized matrix for variance decomposition by Claude Anthropic model under the author's methodological direction to review and graphic the data set findings. Because the dominant component reflects overall self-assessed level rather than distinct profile shapes (Section 5.2), the resulting three-group solution is treated throughout as a pragmatic instructional discretization of an underlying competency continuum. Useful for organizing learning pathways, rather than evidence of three naturally occurring, substantively discrete populations, and groups are labeled as digital competency bands (Lower, Intermediate, Higher).

One-way analysis of variance (ANOVA) was used to describe how strongly the clustering variables separate the resulting bands; because these are the same variables used to form the bands, this test is reported as a descriptive characterization of internal separation rather than independent validation. Chi-square tests of independence, with Cramér's V as effect size, assessed whether band membership was associated with variables not used in the segmentation, including sociodemographic variables and two additional behavioral variables (pilot-participation willingness and primary access device); expected cell counts were inspected for adequacy, and because eight association tests were run without adjustment for multiple comparisons, results are reported as exploratory.

4. Data Collection

The diagnostic instrument was a structured questionnaire of 72 items administered through Google Forms, comprising sociodemographic and business-characteristic questions, 47 self-assessment items (1=very low to 5=very high) covering seven competency dimensions, and multiple-choice items on training interests, obstacles, and delivery preferences. Item selection was reviewed by a three-member expert panel for content relevance, and the instrument was piloted with an initial 30 responses to confirm that item variability was informative before full deployment. Internal consistency by dimension, reported in Table 2, ranged from Cronbach's $\alpha=0.886$ to 0.937 , indicating high reliability; no factor-analytic validation of the seven-dimension structure was conducted, which is acknowledged as a limitation.

The questionnaire opened with a written notice informing participants that the survey aimed to identify management-training priorities to design an adapted platform, that there were no right or wrong answers, that participation was confidential and used solely for academic and platform-development purposes, and that completion took approximately fifteen minutes; participation was voluntary and this notice served as the informed-consent statement. No further institutional ethics-committee review was required due to being a minimal-risk, self-report study according

to the institute research-ethics policy. Personal identifiers were not used in analysis, and the five qualitative cases described below are anonymized.

The sample (N=200) was recruited through a non-probability, institution-led outreach effort: a call for student and faculty support at the Instituto Tecnológico de Orizaba engaged trained field assistants who administered the questionnaire, in person or by phone, to women entrepreneurs across fourteen municipalities of the Altas Montañas region, including entrepreneurs based in the region who have since extended commercial activity to neighboring municipalities. Because recruitment was non-probability and institutionally mediated, and the sample skews toward younger, more educated respondents in predominantly urban localities (Table 1), findings should be interpreted as characterizing this specific participant group rather than the full population of women entrepreneurs in the region, including its older, less formally educated, more rural, and Náhuatl-speaking segments, whose specific presence in the sample was not separately recorded.

The qualitative phase comprised five explanatory cases selected through convenience-based follow-up (researcher availability, not a stratified sampling frame) after the quantitative results were known; all five participants had also completed the diagnostic questionnaire, although no retained identifier allows their narratives to be linked to a specific questionnaire row or band assignment, which is reported here as an explicit limitation. The qualitative material consists of structured field notes prepared after repeated conversations and direct, first-hand observation of each participant's business premises, products, and operating processes, rather than single structured interviews; four of the five cases involved three follow-up sessions each, organized around a consistent structure: business history and premises, sector links or practical operation, and growth or expansion plans. Notes were synthesized and coded by a single researcher, described as qualitative case vignettes for contextual interpretation. Integration with the quantitative findings (Table 9) was conducted at the aggregate thematic level, not through case-level linkage to individual survey or band records. Cases covered businesses in personalized printing and craft workshops, cosmetics retail, veterinary services, gift and bakery retail, and specialty coffee, and were anonymized and coded Case 1 through Case 5.

Table 8 (Section 5.4) operationalizes the access-mode classification used for platform-delivery design, constructed from three response combinations: reported device, connectivity, and literacy-related obstacles, and stated modality preference.

5. Results and Discussion

5.1 Numerical Results

Women's entrepreneurial profile is described in Table 1, presenting the sociodemographic and business nature of the sample. Most respondents (55.5%) are between 18 and 25 years old, hold upper-secondary or bachelor's-level education (78.5% combined), and operate businesses of one to three years of age with one to five people, predominantly in the food and beverage sector. While 56.5% of businesses operate in urban localities, 43.5% operate in semi-urban or rural settings, and 81.5% of respondents do not belong to any entrepreneurial network or cooperative.

Table 1. Sociodemographic and business profile of respondents (N=200, non-probability sample)

Variable	Category	%
Age	18-25 years	55.5
	26-35 years	17.0
	36-45 years	16.5
	46 years or more	11.0
Education	Upper-secondary	41.5
	Bachelor's degree	37.0
	Secondary or below	11.5
	Technical / postgraduate	10.0
Locality type	Urban	56.5
	Semi-urban	28.0
	Rural	15.5
Business sector	Food and beverages	39.0

Variable	Category	%
	Personal services	11.5
	Retail trade	11.0
	Textile / apparel	10.5
	Other sectors	28.0
Business age	Less than 1 year	31.5
	1-3 years	37.5
	3-5 years	11.5
	More than 5 years	19.5
Team size	Solo	47.0
	2 or more people	53.0
Network membership	None	81.5
	Member or joining	18.5

Table 2 reports the mean self-assessed competency by dimension together with internal-consistency reliability. Legal and funding frameworks (mean=2.72) and social and solidarity economy (mean=2.81) show the lowest self-perceived mastery, while operations (mean=3.44) and leadership (mean=3.42) show the highest. This pattern admits more than one interpretation: it may reflect genuinely lower objective competency in legal/financial and collaborative domains, but it may also reflect greater familiarity with, and therefore more critical self-assessment of, operational and day-to-day management tasks relative to legal-fiscal domains that many respondents may rarely engage with at all; the cross-sectional, self-reported design of this study cannot adjudicate between these explanations.

The social and solidarity economy score specifically admits a further, culturally grounded reading: the qualitative cases document informal mutual-aid practices: family loans and a remittance-funded purchase (Table 9); that function as solidarity-economy-like support even though participants do not describe them using that vocabulary, suggesting that part of the low SSE score may reflect unfamiliarity with its formal concept and terminology. Regarding stated training interests, financial literacy (56.5%) and digital marketing (55.5%) were the most requested topics; regarding obstacles, unpaid care work (53.0%) was the most frequently cited barrier, ahead of business-related time constraints (31.0%) and course costs (23.0%); 54.5% of respondents identify a smartphone as their primary access device.

Table 2. Self-assessed competency by dimension: mean, standard deviation, and internal consistency (N=200)

Competency dimension	Items	Mean	SD	Cronbach's α
Legal and funding frameworks	6	2.72	0.96	0.917
Social and solidarity economy	5	2.81	0.99	0.898
Digital skills	8	3.16	1.02	0.937
Financial management	7	3.23	0.85	0.928
Marketing and sales	8	3.24	0.85	0.914
Leadership	7	3.42	0.90	0.937
Operations	6	3.44	0.79	0.886

5.2 Graphical Results

A principal component analysis of the seven standardized competency dimensions showed that a first component, loading positively and similarly on all seven dimensions (loadings 0.36-0.40), explains 69.2% of total variance, indicating a strong general factor of self-assessed competency; a second component (10.5% of variance) contrasts the legal/social-economy dimensions against the operations/finance dimensions. Because the dominant component reflects overall level rather than qualitatively different profile shapes, the three k-means bands described below should be read primarily as a general competency-level continuum, with the secondary legal/social-economy-versus-operational axis as a modest additional distinction, rather than as fully independent multidimensional profiles. This PCA was used descriptively, to characterize the variance structure feeding the cluster analysis, and does not constitute

a confirmatory or exploratory factor analysis validating the instrument's seven-dimension structure, which was not separately tested (Section 4).

Table 3 compares clustering solutions from $k=2$ to $k=8$ across four internal criteria plus two robustness checks (agreement with independent hierarchical clustering, and bootstrap stability). Among solutions with more than two groups ($k=3$ to $k=8$), $k=3$ achieves the best value on all three internal criteria (silhouette, Calinski-Harabasz, and Davies-Bouldin), though not on the two robustness checks taken individually: $k=5$ attains a marginally higher bootstrap ARI (0.886 versus 0.862), and $k=6$ through $k=8$ attain higher Ward-hierarchical agreement (up to 0.631 versus 0.529). No single k dominates on every criterion; $k=3$ was retained as the overall preferred solution for combining comparatively strong internal separation with adequate robustness and, most importantly, instructional interpretability as three groups, despite its modest silhouette coefficient (0.26), which indicates weak-to-moderate rather than strong between-cluster separation. The $k=2$ solution scores higher still on silhouette and Calinski-Harabasz, but reduces to a simple high/low split with limited instructional value.

Table 3. Comparison of k-means solutions, $k=2$ to $k=8$

k	Silhouette	Calinski-H.	Davies-B.	Ward ARI	Bootstrap ARI
2	0.354	162.38	1.037	0.638	0.938
3	0.264	128.96	1.219	0.529	0.862
4	0.206	107.74	1.458	0.357	0.735
5	0.213	97.18	1.386	0.501	0.886
6	0.217	87.49	1.347	0.575	0.821
7	0.213	81.31	1.428	0.610	0.829
8	0.207	74.56	1.431	0.631	0.664

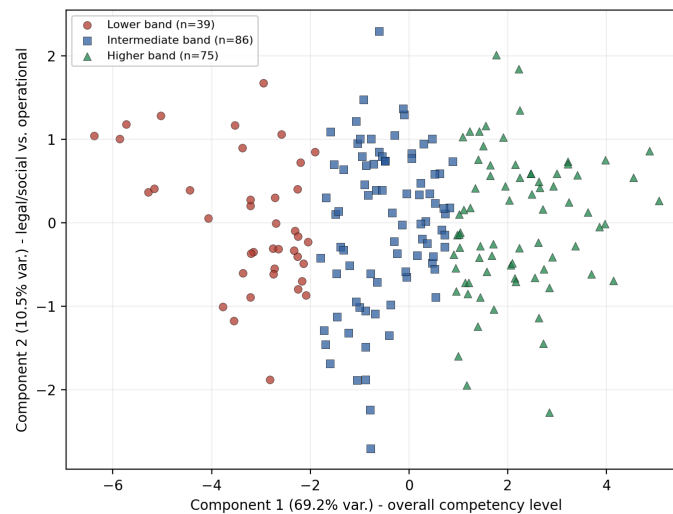


Figure 1. Distribution of the three competency profiles in principal-component space

Figure 1 shows an ordered distribution along Component 1 (overall competency level), with the Lower band concentrated at lower values, the Higher band at higher values, and the Intermediate band occupying an intermediate position; some overlap remains between the Intermediate and Higher bands, consistent with the modest silhouette coefficient reported in Table 3. Figure 2 and Table 4 present the mean competency score of each band across the seven dimensions.

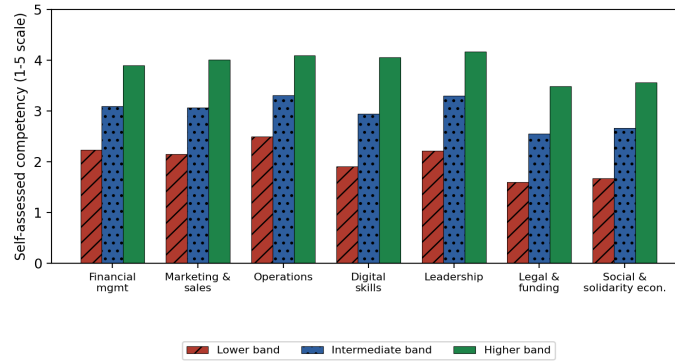


Figure 2. Self-assessed competency by dimension and competency band

Table 4. Mean self-assessed competency by dimension and competency band (1-5 scale)

Dimension	Lower band (n=39)	Intermediate band (n=86)	Higher band (n=75)
Financial management	2.23	3.10	3.89
Marketing and sales	2.15	3.07	4.01
Operations	2.50	3.31	4.09
Digital skills	1.90	2.94	4.06
Leadership	2.22	3.30	4.17
Legal and funding	1.60	2.55	3.48
Social and solidarity economy	1.67	2.66	3.57

Consistent with a general-level interpretation, the Lower band scores low and the Higher band scores high across all seven dimensions; nonetheless, within every band the same two dimensions - legal/funding and social-solidarity economy - are the relative low points, indicating that this specific weakness is not an artifact of overall level. The Lower band (19.5% of the sample) combines a comparatively mature business profile (30.8% operating more than five years) with the lowest self-assessed competency across all dimensions and a stronger relative preference for in-person or mixed delivery; alternative explanations for this pattern - lower objective competency, greater self-critical calibration among more experienced entrepreneurs, reliance on tacit rather than formalized knowledge, or a cohort/education effect, given this group's older average age - cannot be distinguished with the present cross-sectional design. The Higher band (37.5%) is the youngest and most digitally engaged group, with the highest self-assessed competency in every dimension. The Intermediate band (43.0%, the largest group) shows an intermediate score and the highest reported difficulty using a computer or smartphone (22.1%) despite also reporting the highest interest in digital marketing (62.8%), suggesting a gap between stated interest and self-assessed readiness in this group specifically.

5.3 Translation of Findings into the Redbuho Platform Prototype

The diagnostic and segmentation results directly informed the curricular architecture of the Redbuho platform prototype, developed under a Scrum-inspired eight-week iterative process by a six-member team and built on WordPress (content management system) with the LearnDash learning-management system plugin (Coutiño Cruz, 2026). The prototype comprises six thematic courses - financial basics, digital marketing, legal formalization, digital tools, social and solidarity economy, and personal empowerment; each structured into seven units (an introduction, five thematic lessons, and a narrative closing unit), equivalent to thirty formative lessons and forty-two published units. Table 5 traces the correspondence between specific diagnostic evidence and platform design decisions.

Table 5. Traceability between diagnostic evidence and platform design decisions

Diagnostic evidence	Design decision	Delivery implication
Legal/funding mean=2.72, lowest of 7 dimensions and lowest within every competency band	Dedicated legal-formalization course; legal/financing content embedded across other courses	Printed checklists for the mediated-access profile
Unpaid care work cited by 53.0% as main training obstacle	Short, self-paced modular lesson units	Asynchronous delivery, no fixed schedule
54.5% identify a smartphone as primary access device	Mobile-first page design	Lightweight mobile pages, compressed video, and text/audio alternatives to large downloads
Access mode not significantly associated with competency band (Section 5.4)	Competency band informs recommended learning pathways; access conditions inform delivery format, as two separately personalized decisions	Three parallel formats: online, USB, print
81.5% report no network or cooperative membership; social/solidarity economy is a bottom-two dimension in every band	Dedicated SSE and collaboration course with group-oriented activities addressing organizational isolation directly	Locally facilitated peer-networking opportunities across all three delivery formats

Each thematic lesson includes complementary didactic materials (infographic, mind map, and synoptic chart) and three video outlines (concept explanation, specialist interview, and practical implementation); scripted at the time of writing but not yet filmed several anchored in documented real cases of entrepreneurs from Veracruz. Each course further incorporates a pre-formulated spreadsheet for the participant's own business records, a podcast-format narrative reinforcement resource, and a self-contained interactive orientation tool with five multiple-choice items and a profile-type outcome and no visible numeric score; the specific pedagogical function of each resource format determined the need to develop three derivative research projects.

Consistent with the access-mode heterogeneity in Table 8, the prototype uses a three-format distribution strategy: an online platform for the autonomous-access profile via Wordpress, a simplified offline HTML version on a USB drive for community training centers without connectivity, and a printed manual for self-study or for use by local facilitators in remote communities; following technical inclusivity guidelines (Coutiño Cruz, 2026). As of this writing, component status differs by element: the online course structure, the written lesson content across the forty-two units, the six interactive orientation tools, and the accompanying management spreadsheets are built and technically verified as functional on the WordPress/LearnDash platform; the video outlines referenced above are scripted but not yet filmed; and the offline-USB and printed-manual formats, together with the offline version's completion-verification mechanism and physical kit logistics are under production. A formal usability evaluation is set to be conducted under focus groups.

5.4 Robustness, External Associations, and Mixed-Methods Integration

Table 6 reports one-way ANOVA results for the seven competency dimensions across the three competency bands. Because these are the variables used to form the groups, large effect sizes are expected by construction and this table should be read as a description of internal separation, not as independent confirmatory evidence.

Table 6. Within-cluster separation on clustering variables (descriptive, not independent validation)

Dimension	F(2,197)	p	η^2
Financial management	103.22	<.001	0.512
Marketing and sales	189.16	<.001	0.658
Operations	120.87	<.001	0.551
Digital skills	154.69	<.001	0.611
Leadership	164.43	<.001	0.625
Legal and funding	107.36	<.001	0.522
Social and solidarity economy	94.88	<.001	0.491

Table 7 reports chi-square tests of independence between competency-band membership and variables not used to form the bands, including two additional behavioral variables (pilot-participation willingness and primary access device) beyond the sociodemographic set. Expected cell counts were inspected and were adequate for the reported tests; because eight association tests were run without correction for multiple comparisons, results are exploratory.

No statistically significant association was detected between band membership and locality, business tenure, team size, sales channel, pilot willingness, or primary device (all $p > .05$, Cramér's $V \leq 0.14$); age showed a significant but weak association ($p = .019$, $V = 0.214$), which would not survive a conventional Bonferroni correction ($.05/8 = .00625$). These results indicate that the competency bands are not simply a proxy for geography, business size, or channel in this sample and with this operationalization; the absence of a significant association does not by itself prove substantive independence, particularly given the modest sample size for some subgroup comparisons.

Table 7. Chi-square tests of independence between competency band and non-clustering variables

Variable	χ^2	df	p	Cramér's V
Locality type	2.33	4	.675	0.076
Modality preference	7.40	8	.494	0.136
Business tenure	8.00	6	.238	0.141
Team size	8.20	6	.224	0.143
Age group	18.26	8	.019	0.214
Sales channel	7.94	6	.242	0.141
Pilot willingness	3.71	4	.446	0.096
Primary device	6.77	8	.561	0.130

Table 8 operationalizes the access-mode classification referenced in Section 4 as an ordered, mutually exclusive, and exhaustive decision rule, applied sequentially to each respondent's reported device, connectivity/literacy obstacles, and modality preference. Because two of its three inputs are a self-reported obstacle and a stated delivery preference rather than a direct infrastructure measurement, this classification should be read as a composite access-and-preference indicator.

Table 8. Decision rule for the access-mode classification (applied in order)

Step	Condition	Assigned profile	% of sample
1	No personal device, OR reports lacking internet access, OR reports difficulty using a computer/smartphone, OR prefers in-person delivery in own community	Mediated by local NGO	33.0
2	Not assigned in Step 1, AND has a laptop or desktop, AND prefers online delivery (self-paced or live)	Autonomous	12.0
3	Not assigned in Step 1 or 2 (residual: primarily smartphone/tablet users with no major reported obstacle, under any remaining modality preference)	Portable-digital	55.0

Cross-tabulating this classification against the three competency bands showed no statistically significant association (chi-square=4.44, df=4, p=.35, Cramér's V=0.105): for example, 30.3% of the mediated-access group still falls within the Higher band. This indicates that no statistically significant association between access mode and competency band was detected in this sample and supports the more modest claim that competency level informs recommended learning pathways, while access conditions inform delivery format, as two separately personalized decisions.

Table 9 integrates the quantitative and qualitative phases through a mixed-methods triangulation matrix; the design-implication column begins with the integration type (convergence, complementarity, or divergence) following classic approaches from Denzin (1978), so the qualitative phase is not read solely as confirmatory.

Table 9. Mixed-methods triangulation matrix

Quantitative finding	Qualitative pattern	Design implication (integration type)
Legal/funding is the lowest-scoring dimension in every competency band	None of the five cases had accessed institutional credit or government support programs for their business; one participant's initial equipment was funded by a family member's remittance from the United States, and a university-trained veterinarian with five years in business still reported not feeling capable of managing her fiscal obligations	Convergence: legal/funding content is a cross-cutting need independent of education level, not specific to one band
Leadership shows a relatively high aggregate score (mean=3.42)	One case had identified a needed business restructuring but had not been able to execute it, and another faced a shopping-plaza's branding restrictions blocking a rebranding attempt	Complementarity/qualification : a gap between decision awareness and decision execution, and structural market barriers, are not captured by the self-assessment instrument by design
81.5% report no network or cooperative membership	Family and remittance-based financing was the near-universal capitalization mechanism across cases, rather than peer or institutional networks	Complementarity: reframes the low network-participation finding as part of a broader reliance on informal, family-based support
Digital skills show the widest between-band spread of the seven dimensions (1.90 to 4.06)	Social-media engagement varied sharply across cases, from about 900 Instagram followers with paid campaigns and self-taught web development in one case to under 750 followers across two platforms, fewer than five posts per month, and no smartphone capable of recording video in another; one case had no computer available for administrative tasks at all	Convergence/elaboration: reinforces the case for tiered, mobile-first digital content rather than a single assumed baseline of digital literacy

Comparing these outcomes against previously published research provides external context. The centrality of the legal/funding gap is consistent with regional evidence on the credit-access gap for women-led ventures (Fundación Impulso LATAM, 2025; BID Lab, 2024), and the finding that access mode and competency level are empirically distinct echoes Chile's "Pymes en Línea" evidence that connectivity alone does not equalize digital engagement among online trainees (Revista Emprende, 2026). The three-format, connectivity-independent distribution strategy adopted for the Redbuho platform addresses a design gap left open by comparable regional initiatives, such as the IDB's WE3A project, which generally assume a baseline level of connectivity (BID, 2025).

6. Conclusion

This paper addressed its four objectives through an explanatory sequential mixed-methods design. The main finding is that legal/funding and social-solidarity-economy competencies are the most consistent training gaps across the sample and across every competency band, while unpaid care work is the dominant obstacle to training participation.

The quantitative segmentation is best interpreted as a pragmatic instructional discretization of a general competency-level continuum, not significantly associated with a separately constructed access-mode classification, rather than as fully independent, naturally occurring behavioral subpopulations. A principal methodological contribution of this study is the explicit integration of statistical segmentation, reliability and effect-size reporting, and an explanatory qualitative phase into a single traceability chain linking diagnostic evidence to platform design decisions (Table 5). A principal applied contribution is the resulting Redbuho prototype: six courses, forty-two published units, and a three-format distribution strategy (digital, mixed and print), directly addressing the access-mode heterogeneity documented in the region. To build the first prototype, three new research projects are being conducted, covering specific topics in instructional design, women entrepreneurship and social economics.

This study recognizes that the sample is non-probability and was institutionally recruited, skews toward younger and more educated respondents in predominantly urban localities, and does not separately document participation by rural, older, or Náhuatl-speaking entrepreneurs. Competencies are self-reported rather than independently assessed, and collection combined self-administered and field-assisted modes, which may introduce mode effects. The access-mode classification was constructed specifically for this project and is yet to be validated; although follow up research projects include practical tests with local users through an open call. The five qualitative cases, selected by researcher availability. The design is cross-sectional, with no pre-post comparison, and the platform prototype is being created by a development team choosing Word press (CMS) and Learndash (LMS) as technical baseline.

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