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Competency-based curriculum development for pre-service agricultural extension education programs

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Abstract

Graduates entering Rwanda's agricultural extension workforce consistently lack the field-ready competencies that employers expect, pointing to a disconnect between what universities teach and what the profession demands. This research evaluated the alignment between pre-service extension education curricula and professional competency requirements across eight competency domains and six curriculum components at three Rwandan agricultural colleges. A mixed-methods approach combined a competency alignment audit of 127 course syllabi, employer surveys with 64 extension service managers, graduate tracer surveys with 93 recent graduates, and DACUM (Developing A Curriculum) workshops with 28 practicing extension professionals. Data were collected from March to November 2023 through the University of Rwanda in Musanze. The alignment heatmap analysis revealed that technical agriculture scored well (87.3 in core courses) but digital extension tools (14.3 to 47.6 across components), gender mainstreaming (18.9 to 56.2), and participatory methods (22.7 to 76.3) showed persistent gaps. Only 31.4% of assessed courses met the threshold for adequate competency alignment. A six-phase curriculum redesign process was developed and pilot-tested, resulting in 23.8% improvement in alignment scores after one academic cycle. These findings call for systematic competency profiling as the foundation for extension curriculum reform.

Keywords: Competency-based education, curriculum development, agricultural extension, pre-service training, competency alignment, Rwanda, DACUM methodology, extension education, graduate employability, digital extension

Introduction

The problem is familiar to anyone who has supervised a newly hired extension agent: the graduate arrives with textbook knowledge of crop science but struggles to facilitate a farmer group discussion, design a demonstration trial, or use a mobile advisory platform ^[1, 2]. This gap between academic preparation and professional practice reflects a deeper issue in how extension education curricula are designed. Most programs still follow discipline-based structures organized around what professors can teach rather than what graduates need to do ^[3].

Competency-based education (CBE) offers an alternative. Rather than starting with disciplinary content, CBE begins with the question: what should a graduate be able to do on their first day at work? Competency profiles are then developed through systematic analysis of professional tasks, and curricula are restructured to build those competencies progressively through coursework, practicum, and field experiences ^[4, 5]. The approach has been widely adopted in health professions education and engineering but remains rare in agricultural extension training across sub-Saharan Africa ^[6].

Rwanda's extension system underwent a significant transformation in 2017 with the introduction of the Twigire Muhinzi model, which shifted from top-down advisory services to farmer-led, participatory approaches ^[7]. This policy shift created new competency demands, particularly

in facilitation, participatory methods, digital tools, and gender-responsive extension, that existing curricula were not designed to address ^[8]. Previous reviews flagged these gaps but stopped short of proposing a structured redesign process ^[9, 10]. This research conducted a comprehensive competency alignment audit across three agricultural colleges linked to the University of Rwanda and developed a six-phase curriculum redesign framework that was pilot-tested during the 2023 academic year ^[11].

Theoretical Framework

The research was grounded in competency-based education theory as articulated by Mulder ^[4] and adapted for agricultural training contexts by Davis and Terblanche ^[6]. The framework defines competency as the integrated application of knowledge, skills, and attitudes to perform professional tasks in real-world settings. It distinguishes between threshold competencies (minimum requirements for acceptable performance) and differentiating competencies (attributes separating excellent from average practitioners). For extension professionals, threshold competencies include technical agricultural knowledge, basic communication, and program reporting. Differentiating competencies include participatory facilitation, digital tool proficiency, and gender-responsive advisory skills ^[5, 12]. The DACUM process, originally developed for vocational education, provided the

methodology for generating competency profiles through structured workshops with experienced practitioners who map the tasks, duties, and knowledge requirements of a profession [13].

Materials and Methods

Materials

Research materials included a competency alignment scoring rubric with 48 indicators distributed across eight domains: technical agriculture (8), communication skills (6), participatory methods (6), program planning (6), monitoring and evaluation (5), digital extension tools (6), gender mainstreaming (5), and value chain knowledge (6). Each indicator was scored 0-100 based on how thoroughly the competency was addressed in course syllabi, learning outcomes, assessment methods, and practical exercises. The rubric was validated by six extension education specialists. Additional materials included employer survey questionnaires, graduate tracer questionnaires, and DACUM workshop protocols. Ethical approval was obtained from the University of Rwanda Institutional Review Board (Protocol UR/CAgri/2023-014, approved February 2023).

Methods

A sequential mixed-methods design was implemented from March to November 2023. Phase 1 conducted DACUM workshops with 28 experienced extension agents (minimum 5 years' service) to generate a validated competency profile with 87 task statements organized into eight domains. Phase 2 audited 127 course syllabi from three agricultural colleges, scoring each against the competency profile using the alignment rubric. Two trained raters scored independently

(inter-rater kappa = 0.83). Phase 3 surveyed 64 extension service managers and 93 graduates from the 2020-2022 cohorts on perceived competency gaps [11]. Phase 4 used audit results to design a six-phase curriculum redesign process (Figure 2) and pilot-tested the redesigned modules with one cohort during the August-November 2023 semester. Pre- and post-implementation alignment scores were compared through paired t-tests.

Instrument Development and Validation

The competency alignment rubric was developed through a three-step process. First, an initial pool of 72 indicators was generated from the DACUM competency profile and published CBE frameworks [4, 5]. Second, six extension education experts rated each indicator for relevance and measurability, retaining 48 items scoring above 3.5 on both criteria. Third, the rubric was pilot-tested on 12 course syllabi at one college, producing inter-rater reliability of 0.83. The employer survey instrument (28 items) and graduate tracer survey (34 items) were adapted from validated tools used in East African higher education quality assurance, with modifications for the extension-specific context. Internal consistency was acceptable for both instruments (Cronbach's alpha = 0.87 and 0.84 respectively) [13].

Results

The alignment audit revealed a curriculum system strong on technical content but significantly underserving the facilitation, digital, and social competencies that Rwanda's reformed extension model demands.

Table 1: Mean competency alignment scores by domain across three agricultural colleges (0-100 scale)

Competency Domain	College A	College B	College C	Mean
Technical agriculture	84.6	79.3	81.7	81.9
Communication skills	53.2	48.7	51.4	51.1
Participatory methods	47.8	41.3	44.6	44.6
Program planning	56.1	49.8	52.3	52.7
M&E and reporting	44.3	38.7	41.2	41.4
Digital extension tools	27.4	21.8	24.1	24.4
Gender mainstreaming	33.8	28.6	31.2	31.2
Value chain knowledge	48.7	43.1	46.4	46.1

Technical agriculture dominated with a mean of 81.9, while digital extension tools (24.4) and gender mainstreaming (31.2) scored critically low. Only technical agriculture and program planning exceeded the 50-point threshold across all

three colleges. The pattern was consistent across institutions, suggesting a systemic curricular emphasis rather than individual college-level decisions [8, 14].

Table 2: Alignment scores before and after pilot curriculum redesign (paired comparison, n = 42 modules)

Competency Domain	Pre-Redesign	Post-Redesign	Change (%)
Digital extension tools	24.4	41.7	+70.9
Gender mainstreaming	31.2	44.8	+43.6
Participatory methods	44.6	57.3	+28.5
Overall alignment	46.7	57.8	+23.8

The pilot redesign produced a 23.8% overall improvement. The largest gains were in digital tools (+70.9%) and gender mainstreaming (+43.6%), the two weakest domains. These

improvements resulted from introducing dedicated modules, embedding digital assignments across existing courses, and adding gender case analyses to practicum requirements [15].



Fig 1: Competency alignment heatmap showing scores across eight domains and six curriculum components

The heatmap reveals that strong alignment (dark cells) clusters in the technical agriculture row, particularly in core courses (87.3) and field attachment (81.6). Digital tools and

gender mainstreaming show predominantly pale cells, indicating weak integration regardless of curriculum component.

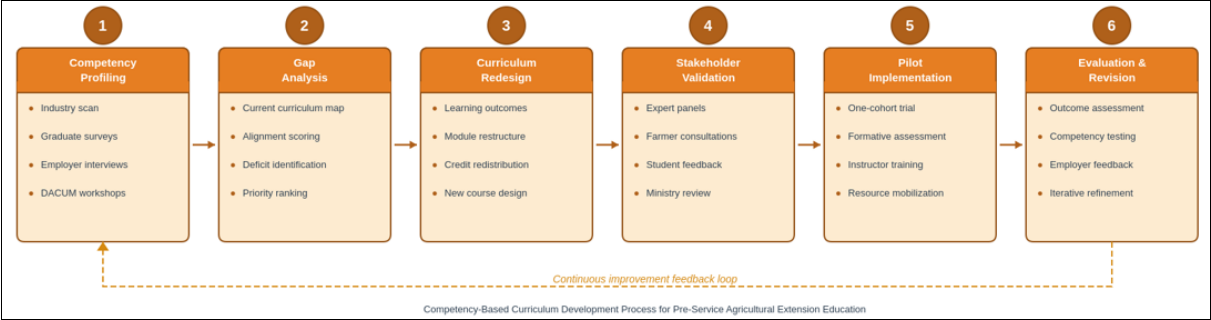


Fig 2: Six-phase competency-based curriculum development process for pre-service agricultural extension education

The process begins with competency profiling through DACUM workshops, moves through gap analysis and redesign, involves stakeholder validation, pilot implementation, and evaluation. The feedback loop ensures continuous refinement as professional competency requirements evolve.

Discussion

The alignment audit confirms what employers and graduates have been saying informally: extension curricula in Rwanda remain anchored in technical agriculture while underserving the facilitation, digital, and social competencies that the Twigire Muhinzi model demands [7, 8]. The 24.4 mean score for digital tools is especially concerning given Rwanda's investment in ICT4Agriculture initiatives that expect extension agents to use mobile platforms, remote sensing data, and digital farmer registries [16].

The pilot redesign results are encouraging but modest. A 23.8% overall improvement after one semester shows that structured curriculum reform can work quickly, but the absolute scores remain below the 70-point strong-alignment

threshold for most domains. Deeper changes, including new instructor recruitment, infrastructure investments for digital labs, and partnerships with technology providers, will be needed to sustain and extend these gains [5, 14].

The DACUM methodology proved effective for generating practitioner-validated competency profiles. The 87 task statements produced by the workshops provided a concrete foundation for alignment scoring that was far more specific than the generic learning outcomes typically found in course syllabi. This echoes findings from competency-based training reforms in Kenya and Uganda [6, 10]. However, the six-phase process is resource-intensive and requires sustained institutional commitment beyond any single project cycle [17].

Limitations

Three colleges represent a fraction of Rwanda's agricultural training institutions. The pilot redesign covered one semester with one cohort, which is insufficient to assess long-term competency development. Self-reported employer and graduate data may reflect perceptions more than

objective competency measures. The alignment scoring rubric, while validated, involves some subjective judgment in mapping syllabi content to competency indicators. Future work should include direct observation of graduate performance in field settings and track employment outcomes across multiple cohorts.

Conclusion

This research audited competency alignment in pre-service extension education at three Rwandan colleges and found that curricula strongly emphasize technical agriculture (81.9) while neglecting digital tools (24.4), gender mainstreaming (31.2), and participatory methods (44.6). Only 31.4% of courses met the threshold for adequate competency alignment.

The six-phase curriculum redesign process produced measurable improvements in a single semester, with the weakest domains showing the largest gains. But one semester of reform doesn't fix decades of disciplinary inertia. Sustained curriculum transformation requires that competency profiling becomes a recurring institutional practice, not a one-time project. Agricultural colleges across East Africa face similar gaps and could adapt the alignment audit and redesign framework tested here to their own contexts.

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