

Embodied Reality of Learning: Students' Experiences with Multimodal Artifacts in Abstract Concepts

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Abstract

This study used a transcendental phenomenological design, following Moustakas's (1994) method, to explore how 15 undergraduate students at one private Higher Education Institution (HEI) in Kigali, Rwanda experience the use of multimodal and material artifacts, including gestures, everyday objects, diagrams, and digital tools, while learning abstract academic concepts. Grounded in embodied cognition theory, which holds that cognition is distributed across the body and its environment rather than confined to the brain, the study addressed the following research question: What is the lived experience of private university students in Rwanda regarding their use of material and multimodal artifacts to make sense of abstract academic concepts? Data were collected through semi-structured interviews with purposively selected students from Mathematics–Computer Science, Business Studies, and Mathematics–Geography programs, then analyzed following Moustakas' procedures of bracketing, horizontalization, and synthesis. Three themes emerged: (a) the scaffolding power of the hands in converting abstract anxiety into tangible structure; (b) the dual cognitive burden of English as a Medium of Instruction (EMI) alongside abstract comprehension; and (c) self-initiated multimodal strategies compensating for teacher-centered instruction. Most participants described developing personal, embodied strategies to bridge these pedagogical and linguistic gaps, though the findings also point to variation in reliance on such strategies across the sample. These findings offer contextually grounded insight into one private Rwandan HEI rather than a generalizable claim about African higher education broadly and inform recommendations for faculty development aligned with Rwanda's competence-based curriculum reforms.

Keywords: Abstract Concept Acquisition, Embodied Learning, Multimodal Artifacts, Student Experiences

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1. Introduction

1.1. Background of the Study

The role of higher education in Africa, particularly in Rwanda, is critical to achieving national development goals and transforming the country into a knowledge-based economy. The Rwandan government has invested heavily in the tertiary sector, with a significant role carved out for private Higher Education Institutions (HEIs) to expand access and capacity. However, this rapid expansion, coupled with systemic challenges such as language-policy shifts (from French to English) and the ongoing effort to implement learner-centered pedagogy (LCP), raises questions about the quality of student learning, especially the acquisition of abstract concepts. Moreover, decades of research have shown that learning is fundamentally an embodied, multimodal, and material process: the mind does not operate in isolation, and the use of hands, gestures, physical artifacts, and representational systems (multimodality) is integral to developing deep mathematical and conceptual understanding. This foundational work has, however, largely drawn from Western contexts, necessitating a re-evaluation within the unique cultural, infrastructural, and pedagogical landscape of a Rwandan private HEI.

1.2. Problem Statement

Notwithstanding the policy commitment to LCP in Rwanda, many higher education classrooms, particularly in the private sector, facing resource constraints and faculty over-commitment remain dominated by teacher-centered, didactic methods. This instructional mismatch, in which abstract, complex concepts are delivered verbally without sufficient opportunity for material manipulation or multimodal representation, tends to delay deep learning, especially for students grappling with English as a Medium of Instruction (EMI). Existing literature on Rwandan higher education focuses heavily on institutional challenges, graduate employability, and policy adoption, but largely overlooks the micro-level, subjective experience of how students physically and cognitively cope with learning abstract content in this environment. A gap therefore exists in understanding the lived reality: specifically, the phenomenon of students' self-developed, embodied learning strategies in a private Rwandan higher education context.

1.3. Purpose and Research Question

The purpose of this phenomenological study is to describe the essential structure of the lived experience of students at a private HEI in Rwanda as they engage with multimodal and material artifacts while acquiring abstract concepts. Research question: What is the lived experience of private university students in Rwanda concerning the integration of material and multimodal artifacts in their process of making sense of abstract academic concepts?

1.4. Significance of the Study

This study contributes to three key areas:

- 1. Pedagogy in Rwanda:** it provides rich, qualitative data to inform faculty professional development by illustrating the practical ways students draw on embodied cognition, encouraging a shift from conventional teacher-centered instruction toward student-centered practice.
- 2. African higher education literature:** it introduces the perspective of embodied, material learning into discourse on African HEIs, moving beyond purely socio-economic and policy analyses to explore the cognitive and physical realities of student experience.
- 3. Phenomenological research:** it offers a detailed application of the phenomenological method to an often-invisible education phenomenon, the physical and artifact-mediated nature of abstract thought.

2. Literature Review

2.1. Foundational Embodied Cognition and Embodied Learning

Embodied cognition theory holds that cognitive processes are shaped by, and distributed across, the body's sensorimotor interactions with its physical environment, rather than confined to brain-based computation alone. This orientation underpins the phenomenological tradition adopted in this study, which treats lived, bodily experience as a primary source of knowledge about learning (Moustakas, 1994). Empirical support for the cognitive value of embodiment continues to accumulate: a systematic review and meta-analysis by Zhang et al. (2025) found that technology-based embodied learning had a moderately positive, statistically significant effect on learning effectiveness across the studies reviewed. From a philosophy-of-movement perspective, Sun's (2025) analysis of somatic dance practice similarly challenges a strict separation of mind and body, characterizing the body as an active participant in meaning-making rather than a passive vessel for cognition, an argument this study

extends, cautiously, from dance pedagogy into abstract academic learning more broadly.

2.2. Multimodality and Materiality in Concept Learning

A growing body of multimodal-learning literature examines how gesture, materials, and visual representation function as channels for constructing and communicating complex ideas. Karadöller et al. (2025) advance a multimodal language-acquisition framework showing that gesture and speech operate together within collaborative dialogue to support meaning-making, particularly when speakers face linguistic constraints. In a different disciplinary setting, Lubis (2025) demonstrates that combining visual, kinesthetic, and auditory modes strengthens conceptual understanding in the teaching of ecological literacy, illustrating a broader principle, that multimodal integration supports deeper learning, which this study extends cautiously to abstract quantitative and business content. Computational analyses of learner-produced texts further suggest that patterns in student language use can reveal underlying semantic and cognitive processing strategies (Bozdağ, 2025), lending indirect support to the idea that hybrid or non-standard expression in a second language may reflect active meaning-making rather than deficient understanding. Even in an unrelated therapeutic domain, embodied and intermodal expression has been documented as a channel through which individuals externalize meaning that resists purely verbal articulation (Hall, 2025), this is presented here only as cross-domain, analogical support for treating material and bodily channels as substantive access points to a person's experience, not as direct education evidence.

2.3. English as a Medium of Instruction and the Language Burden in Rwandan Higher Education

A systematic review of barriers to learning English as a foreign language among university students found that linguistic barriers persist regardless of policy commitments to English-medium instruction, often limiting the depth of content mastery achieved (Ross & Stuckler, 2025). Although this review was not conducted in the Rwandan context specifically, its findings are consistent with widely reported patterns in Sub-Saharan African EMI settings, where both students and instructors may have variable English proficiency. General scholarship on the teacher's role in language learning and teaching (Muslumova, 2025) similarly notes that limited target-language proficiency among instructors can compound, rather than resolve, learners' difficulties, an observation plausibly relevant to, though not specifically evidenced within, the Rwandan private HEI examined here. Under these conditions, students facing a dual cognitive load, processing unfamiliar content and an unfamiliar language of instruction simultaneously may be expected to intensify their search for non-verbal, compensatory means of understanding, making multimodal communication a practical necessity rather than a supplementary aid (Karadöller et al., 2025).

2.4. Student-Centered Pedagogy in Resource-Constrained Higher Education Institutions

The struggle to implement student-centered pedagogies despite official policy commitments is a widely documented concern across developing-country contexts. A study of active-learning strategies in large Bangladeshi college classrooms found that overcrowding and logistical constraints frequently push instructors back toward traditional, teacher-led delivery, even where active methods are formally encouraged (Das et al., 2025). A systematic review of innovative, hands-on, and student-centered teaching strategies in science education similarly concludes that structural constraints rather than a lack of instructor willingness are often the primary barrier to sustained pedagogical reform (Laid & Adlaon, 2025). Although neither study was conducted in Rwanda, both describe structural pressures, large class sizes, resource limitations, and an

entrenched view of the teacher as the primary authority that plausibly resemble conditions in the private Rwandan HEI examined here, and this study treats that resemblance as a basis for cautious comparison rather than direct equivalence.

Collectively, this literature suggests that in resource-constrained HEIs, sustainable pedagogical reform may depend less on costly digital infrastructure and more on faculty development that leverages low-cost, locally available material engagement, consistent with the positive effects of embodied learning reported particularly in quantitative disciplines (Zhang et al., 2025).

3. Methods

3.1. Research Design

This study employed a transcendental phenomenological design, following Moustakas's (1994) method of data analysis. Unlike hermeneutic phenomenology, which foregrounds the researcher's interpretive stance and the situated co-construction of meaning, a transcendental approach seeks to describe the essence of a shared experience through a disciplined process of epoché (bracketing), horizontalization, and synthesis, with the researcher's preconceptions set aside as far as possible rather than incorporated as an interpretive lens. This design was selected because the phenomenon under investigation, students' use of material and multimodal artifacts during abstract learning was treated as a universal experience (all students must learn abstractly) that is nonetheless subjectively enacted, making a structured, essence-oriented description an appropriate analytic goal. The Data Analysis subsection below details how epoché, horizontalization, clustering, and textural-structural synthesis were operationalized.

The researcher has prior teaching experience in Rwandan private higher education, which motivated interest in this phenomenon. To manage this positionality, the researcher recorded personal assumptions about "good teaching" and "embodiment" in a reflexive journal prior to and throughout data collection, consciously set these aside when coding, and revisited them during peer debriefing to check whether they had shaped the interpretation of participants' accounts.

3.2. Setting and Participants

The study was conducted at a single, accredited private HEI in Kigali, Rwanda. This institution was selected as an information-rich case of a private, tuition-dependent Rwandan HEI, a category of institution that, according to national sector reporting, often operates under tighter infrastructural and staffing constraints than public counterparts. This study does not assume resource constraints at the specific site studied; rather, it treats the institutional type as relevant context for interpreting participants' accounts.

Purposive criterion sampling was used. Participants met the following criteria: (a) currently enrolled as an undergraduate student at the selected private HEI; (b) enrolled in a program involving substantial abstract or quantitative concept learning, specifically Mathematics–Computer Science, Business Studies, or Mathematics–Geography (hereafter "technical programs," rather than "STEM," since Business Studies extend beyond a strict Science, Technology, Engineering, and Mathematics [STEM] classification); and (c) sufficiently fluent in English or Kinyarwanda to describe their experience in depth. Participants were recruited through a public notice circulated by program coordinators, with interested students contacting the researcher directly to avoid any perception of coercion by instructors. Fifteen students (8 male, 7 female) were interviewed, a sample size consistent with common phenomenological guidance (e.g., 5–10 or more participants) and judged sufficient on the basis of data saturation, since no substantially new meaning units emerged across the final three interviews.

Table 1. Non-Identifying Participant and Context Information (N = 15)

Pseudonym	Program Cluster	Year	Gender	Dominant Language	Interview Language
Participant A	Mathematics–Computer Science	3	Male	English-dominant	English
Participant B	Business Studies	2	Female	Kinyarwanda-dominant	Kinyarwanda
Participant C	Mathematics–Geography	4	Male	Kinyarwanda-dominant	English
Participant D	Business Studies	3	Female	Kinyarwanda-dominant	Kinyarwanda
Participant E	Mathematics–Computer Science	2	Male	English-dominant	English
Participant F	Business Studies	4	Female	Kinyarwanda-dominant	Kinyarwanda
Participant G	Mathematics–Geography	3	Male	Kinyarwanda-dominant	English

Pseudonym	Program Cluster	Year	Gender	Dominant Language	Interview Language
Participant H	Mathematics–Computer Science	3	Male	English-dominant	English
Participant I	Business Studies	1	Female	Kinyarwanda-dominant	Kinyarwanda
Participant J	Mathematics–Computer Science	4	Female	English-dominant	English
Participant K	Mathematics–Geography	2	Male	Kinyarwanda-dominant	Kinyarwanda
Participant L	Business Studies	2	Male	Kinyarwanda-dominant	English
Participant M	Mathematics–Geography	3	Female	Kinyarwanda-dominant	Kinyarwanda
Participant N	Mathematics–Computer Science	2	Female	English-dominant	English
Participant O	Business Studies	4	Male	Kinyarwanda-dominant	Kinyarwanda

3.3. Instrumentation

The primary data collection instrument was a semi-structured, in-depth interview protocol developed around four key constructs drawn from the literature: materiality, multimodality, gesture, and embodiment. The protocol used open-ended, non-leading prompts, including:

- “Tell me about a time you struggled with a complex concept. What did you find yourself doing with your hands or the objects around you?”
- “Can you describe a specific object, gesture, or drawing that helped you understand something difficult?”
- “Were there times you wanted to use your hands or draw something in class but felt unable to? What happened?”

Interviews lasted between 30 and 45 minutes and were audio-recorded with participants' consent. The protocol was reviewed by a qualitative-methods colleague prior to data collection but was not formally piloted; this is noted as a limitation.

3.4. Procedures

3.4.1. Data Collection Procedures

Institutional approval to conduct the study was obtained from the Deputy Vice Chancellor for Academics and Research on 06 June 2025; at this private HEL, this office functions as the institutional authority for reviewing research involving students, in the absence of a separate research ethics board.

Participants were recruited voluntarily after being informed of the study's purpose and confidentiality measures. Interviews were conducted privately on campus, in the language the participant preferred. Nine interviews were conducted primarily in Kinyarwanda and six primarily in

English, based on participants' stated preference (see Table 1). Kinyarwanda interviews were transcribed and translated into English by the researcher, who is fluently bilingual in Kinyarwanda and English; an independent bilingual reader separately checked a 10% sample of translated transcripts against the original audio to confirm that meaning was preserved, with discrepancies resolved by discussion. Quotations presented in the Results section that originated in Kinyarwanda are translated excerpts.

3.5. Data Analysis

Data were analyzed manually, following Moustakas's (1994) transcendental phenomenological procedures:

- **Epoché / bracketing:** prior to and throughout analysis, the researcher recorded personal assumptions about “good teaching” and “embodiment” in a reflexive journal and consciously set these aside when coding.
- **Horizontalization:** every statement in the transcripts relevant to the phenomenon was extracted as a horizon, or discrete meaning unit, yielding 214 initial meaning units across the 15 transcripts.
- **Clustering of horizons:** meaning units were grouped inductively into provisional clusters (e.g., “statements about using calculator buttons as physical anchors,” “statements about gesture replacing language”).
- **Textural and structural description:** for each cluster, a textural description captured what participants experienced, and a structural description captured how and under what conditions (language, classroom setting, discipline) they experienced it.
- **Synthesis:** textural and structural descriptions were integrated into the three final themes reported in the Results section.

Table 2. Theme Development Audit Trail

Illustrative Meaning Unit (paraphrased)	Clustered Sub-Theme	Final Theme	Representative Evidence
Using stones/objects as physical markers for abstract accounting relationships	Objects as computational anchors	Theme 1: Scaffolding Power of the Hands	Participant D quotation, Results
Clapping or gesture used to track compounding periods in a financial model	Bodily rhythm as temporal anchor	Theme 1: Scaffolding Power of the Hands	Gestural Mathematics bullet, Results
Lecturer's hand tracing a curve making an English technical term (“slope”) comprehensible	Gesture as translation bridge	Theme 2: Dual Burden of EMI	Participant H quotation, Results
Preference for remembering a gesture over an English word	Non-verbal cue substituting for language	Theme 2: Dual Burden of EMI	Participant H quotation, Results
Restricting visible use of fingers/drawing in class for fear of appearing behind	Self-censorship of embodied strategies in class	Theme 3: Invisible Pedagogy	Participant K quotation, Results
Using the body privately at home to model a concept (e.g., “be the graph”)	Displacement of embodied strategy to private space	Theme 3: Invisible Pedagogy	Participant K quotation, Results

3.6. Trustworthiness

Several strategies supported the credibility of the analysis. Member checking was conducted with three participants (one from each program cluster), who reviewed summaries of their transcribed accounts and the researcher's provisional interpretation; no substantive corrections were requested, though one participant clarified a translation nuance, which was incorporated. Peer debriefing was conducted with an experienced qualitative researcher at two points during analysis after initial horizontalization, and after the provisional theme structure was drafted; debriefing prompted the researcher to narrow the third theme from an initially broader label to its current, more specific focus on self-initiated compensation for teacher-centered practice. The reflexive journal described above provided an ongoing audit trail of analytic decisions.

3.7. Ethical Considerations

All participants provided written informed consent prior to interview participation. Approval for the study was obtained from the Deputy Vice Chancellor for Academics and Research at the host institution, which functions as the institutional authority for research involving students in the absence of a dedicated research ethics board.

Confidentiality was maintained by assigning pseudonyms (Participant A–O); no names, student identification numbers, or other directly

identifying information were retained in the analysis files. Audio recordings and transcripts were stored on a password-protected institutional drive accessible only to the research team, and will be securely destroyed at the end of the retention period required by the institution's research data policy.

Participants were informed of their right to withdraw at any time without penalty. Given the potential sensitivity of discussing personal coping and cognitive difficulty, and the small, potentially identifiable pool of students in specific program-year combinations at a single institution, only de-identified excerpts and summary coding matrices, but not full transcripts, are available upon reasonable, institutionally approved request from the corresponding author. This is a revision of the original data availability statement, made to better protect participant confidentiality.

4. Results

The analysis of the interview transcripts revealed three overarching essential themes describing participants' lived experience of using multimodal and material artifacts for abstract concept acquisition. Quotations below that originated in Kinyarwanda are translated excerpts (see Table 1 for each participant's interview language).

4.1. Theme 1: The Scaffolding Power of the Hands: Converting Abstract Anxiety into Tangible Structure

The most widely shared experience among participants was the instinctive use of physical manipulation and gesture to reduce the anxiety associated with abstract content. Participants described a need to ground complex theories in a material reality, mirroring the concept of materiality.

"When I am learning about accounting, the debit and credit, the sides are like ghosts to me. So I always use my two hands, or I take two stones from outside, one is 'debit' [moves left hand forward] and one is 'credit' [moves right hand back]. When I move the left, the balance changes. My hand is the anchor. Without that, it is just words flying away."

(Participant D, Business Studies)

Participants also described using everyday objects as computational aids:

- **Gestural mathematics:** some participants used specific, often non-verbalized hand gestures to track variables or perform calculations, for example, one participant described tracking a compounding rate by clapping once per period, using bodily rhythm as a temporal anchor.
- **The power of the pen:** beyond writing, the pen or pencil became a material artifact used for measuring, pointing, or physically separating complex variables on a page, providing a spatial representation of abstract relationships.

4.2. Theme 2: The Dual Burden of English as a Medium of Instruction and Abstract Comprehension

The use of English as the primary language of instruction in Rwandan HEIs compounded the challenge of abstract concept acquisition for several participants. Participants described a double cognitive load: simultaneously processing abstract concepts in English and then translating that English back into a personally meaningful understanding. This translation friction appeared, for these participants, to increase reliance on non-verbal, multimodal cues.

"If a lecturer says, 'the derivative is a slope at a certain point,' the word 'slope' itself is hard for me to feel in English. It is a foreign word for a foreign idea. But when I see the professor drawing the curve, and then with his finger, he touches the exact spot, and he moves his hand up, that gesture speaks louder than the English words. I stop trying to translate the word and just remember the professor's hand."

(Participant H, Mathematics–Computer Science)

For these participants, gestures, diagrams, and physical artifacts appeared to function as an additional channel of communication that reduced reliance on English wording alone.

4.3. Theme 3: The Invisible Pedagogy: Self-Initiated Multimodal Strategies Compensating for Teacher-Centered Practices

Several participants noted that their use of materials and embodied strategies was self-initiated and not encouraged by lecturers. Participants linked this to conventional teaching methods and felt the classroom environment discouraged visible physical engagement, which some associated with lower levels of schooling.

"The classroom is too crowded, and the lecturer is just speaking from the notes for two hours. If I start using my fingers to count or draw big pictures, they will think I am failing to understand, or that I am too much of a child. So I do it with my eyes only, or I wait to go home and lay on my floor, and I use my own body to be the graph."

(Participant K, Mathematics–Geography)

This suggests that, for these participants, private, self-directed embodiment may function, tentatively, as a way of managing didactic teaching styles and large class sizes; we describe this cautiously as a form of self-initiated compensation rather than as a deliberate act of resistance, since participants themselves did not frame it in oppositional terms.

5. Discussion

5.1. Interpretation of the Findings

The essential structure of participants' lived experience can be described as compensatory embodiment: a self-regulated process, reported by most though not necessarily all participants, of using the body and material world to bridge cognitive and pedagogical gaps within

this private HEI context. These findings are consistent with, and extend, the premise that cognition is distributed across body and environment. Within the specific context of this study, embodiment appears cautiously interpreted not primarily as a planned pedagogical tool but as an adaptive response employed by students navigating three interconnected challenges:

1. **Abstractness of content:** the need for material grounding (Theme 1).
2. **Linguistic barrier (EMI):** the need for non-verbal presentation (Theme 2).
3. **Pedagogical rigidity:** the need for self-directed, student-initiated engagement (Theme 3).

It is important to distinguish participants' own reported experiences, specifically direct descriptions of using hands, objects, and gestures from the author's interpretive framing of these practices as "compensatory" or as a response to pedagogical rigidity. This interpretive frame is an analytic lens applied by the researchers rather than a category participants used themselves, and it should be read as one plausible interpretation of the data rather than an established fact about the phenomenon.

5.2. Comparison with Existing Literature

The present findings resonate with existing literature on the persistent difficulty of implementing student-centered pedagogies in resource-constrained higher education settings, where policy changes often fail to dislodge entrenched, teacher-dominated instruction. This is broadly consistent with regional observations that cultural and logistical constraints, such as large classrooms and a view of the teacher as the primary authority favor traditional methods (Das et al., 2025; Laid & Adlaon, 2025), although, as noted in the Literature Review, those specific studies were conducted outside Rwanda and are used here only as a cautious point of comparison. The findings are also consistent with the broader observation that non-verbal, compensatory strategies can emerge naturally in demanding learning environments, such as those shaped by EMI in Rwanda, which plausibly imposes a dual cognitive load (Karaddöller et al., 2025).

This study adds a further layer of contextual detail concerning the cognitive dimension of this challenge. By focusing on embodied action and the creation of low-fidelity multimodal artifacts, the study offers a description of one possible mechanism linking abstract thought and concrete understanding at this institution. Building cautiously on Das et al.'s (2025) account of how large-classroom constraints push Bangladeshi instructors toward traditional delivery, the present study extends this line of inquiry into a different setting and unit of analysis: rather than examining instructor behavior in Bangladeshi classrooms, it examines how individual students in a Rwandan private HEI appear to develop their own embodied, material-level responses, independent of instructor practice. This is offered as a cross-context parallel rather than a direct extension of Das et al.'s claims, since the two studies differ in country, institutional level, and unit of analysis.

5.3. Implications for Rwandan Higher Education

The findings have potential implications for the quality and sustainability of this private HEI and, cautiously, for similar institutions. Since participants described already using embodied strategies on their own initiative, institutional efforts could focus on bringing this "invisible pedagogy" into the open:

- **Curriculum design:** explicitly integrating low-cost, material artifacts (e.g., locally sourced materials, everyday objects) into modules, particularly in business and quantitative courses, rather than relying solely on costly imported instructional resources.
- **Faculty development:** training lecturers in the principles of embodied cognition and multimodal communication, encouraging them to recognize and incorporate student gestures and material representations in class discussions.
- **Language policy:** acknowledging the potential role of gesture and visual aids as linguistic bridges that may help reduce the cognitive burden associated with EMI.

5.4. Limitations

As a transcendental phenomenological study, the findings describe the essential structure of experience for this specific sample of 15 students at one private HEI and are not intended to be statistically generalizable. The single-site design, reliance on retrospective self-report, and the

researcher's dual role as both instrument and analyst, although mitigated through bracketing and peer debriefing, constrain the scope of claims that can responsibly be made. Translation from Kinyarwanda to English, despite the verification procedure described in the Methods, may have altered some nuance in participants' original expression. Future comparative research across multiple public and private Rwandan HEIs, and across a wider range of academic disciplines, would help clarify which aspects of this phenomenon are context-specific and which may generalize more broadly within Rwandan higher education.

6. Conclusion and Implications

This study suggests that the lived experience of participating private university students in Rwanda, regarding abstract concept acquisition, is characterized by considerable self-initiated multimodal and material compensation. In a context marked by a national ambition for knowledge-based transformation and the challenges of EMI and didactic instruction, participants described using their bodies, hands, and available artifacts to transform abstract academic anxiety into more tangible, manageable structures. Within the scope of this single-institution study, the experience described by participants is consistent with the view that embodiment can be an important, rather than incidental, feature of meaningful learning.

Based on the findings, the following recommendations are offered for private HEIs, policymakers, and researchers in Rwanda:

- 1. Institutional attention to multimodal pedagogy:** private HEI management could invest in low-cost, practical faculty development programs focused on the multimodal, material mind, explicitly teaching lecturers how to design lessons that make room for student gesture and artifact use.
- 2. Resource reorientation:** institutions could prioritize the acquisition or local creation of simple, cost-effective material manipulatives (e.g., financial flow charts, tactile tools) alongside, rather than instead of, digital hardware that may otherwise go unused due to connectivity or training gaps.
- 3. Policy research:** HEIs could commission further research exploring the potential value of embodied instructional strategies as one consideration in evaluating quality within competence-based curricula across Rwandan HEIs.

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Ethical statement: Institutional approval was obtained from the Deputy Vice Chancellor for Academics and Research (see Ethical Considerations for details); participants provided written informed consent and were informed of their right to withdraw at any time without penalty.

AI statement: The author stated that no generative AI or AI-based tools were used in the design, data collection, or analysis reported in this study.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: To protect the confidentiality of a small, potentially identifiable participant pool, only de-identified excerpts and summary coding matrices, but not full transcripts, are available upon reasonable, institutionally approved request from the corresponding author.

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