

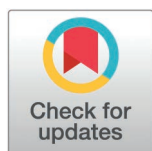
RESEARCH ARTICLE

# A multidimensional procurement literacy instrument: Development and validation among undergraduate procurement students in Ghana

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## Abstract

Procurement remains one of the central functions in public- and private sector governance, yet relatively little attention has been given to how procurement capabilities develop during undergraduate education. This study addresses this gap by developing and validating an instrument to measure Procurement literacy of undergraduate students in Ghana. Drawing on CIPS Global Professional Standards and other policy frameworks, this study initially conceptualised six domains of procurement literacy. The initial instruments were refined through expert review before being administered to a sample of 554 students from selected public universities. The structure and psychometric properties of the administered instruments were examined using exploratory and confirmatory factor analyses. In total, a 30-item instrument grouped into five domains emerged: Ethical Procurement Practice, Procurement Planning and Decision-Making, Supplier and Contract Management, Digital and E-Procurement competency, and Legal and Policy Knowledge. The final 30-item scale demonstrated strong internal consistency, satisfactory convergent and discriminant validity, and measurement invariance across academic levels. Predictive validity was examined using the intention of students' behavioural intention to engage in ethical procurement practices, with all dimensions showing positive and statistically significant associations. Differences in procurement literacy were also observed at academic levels, with effect sizes ranging from small to moderate. Harman's single-factor test (48.5%) indicated that common method bias was not a threat. The findings suggest that procurement literacy can be measured reliably at the undergraduate level and that the instrument offers a practical tool for curriculum evaluation, instructional planning, and early capability assessment in procurement education.

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## 1. Introduction

Procurement as a key strategic function of organisations is the overarching process of acquiring goods, works, and services. It is critical for ensuring transparency, efficiency, and value for money in public sector management. The mainstreaming of the procurement process was started by the World Bank in the late 1990s and conditioned aid to the adoption of a transparent and competitive procurement system in the early 2000s [1,2]. This has paved the way for several countries to pursue procurement reform, leading to the enactment of laws and the alignment of national systems with international frameworks such as the United Nations Commission on International Trade Law (UNCITRAL) Model Law and the World Trade Organisation (WTO) Government Procurement Agreement [3–5].

As countries strengthen regulatory procurement regimes to mitigate corruption and improve procurement processes, the need to have a competent workforce to manage the procurement functions becomes critical. Ghana, like many other countries, has pursued public procurement reforms through legislation and enacted the Public Procurement Act, 2003 (Act 663, as amended by Act 914 and Act 1139), to strengthen its procurement system. In line with the reforms, universities began to offer undergraduate programmes in procurement at the university level to train procurement professionals. Notwithstanding the progress made, procurement infraction challenges, such as non-compliance, ethical misconduct, and suboptimal decision-making, continue to be reported by the Auditor-General [3,6]. The World Bank and Organisation for Economic Development (OECD) attribute these infractions to deficiencies in knowledge, skills, and ethical dispositions of procurement personnel [3,7,8]. A central question revolves around how well procurement graduates are equipped with functional areas, including legal knowledge, procedural planning, transparency and accountability, supplier engagement, ethical reasoning, and digital skills. A practical way to address the readiness of graduates or students is to assess their level of literacy in these functional areas. Unfortunately, the existing literature on procurement education often focusses on ethics or legal frameworks but lacks comprehensive tools to assess students' competencies [3,9–11]. This leaves a critical gap in understanding whether procurement education is adequately equips students for the professional demands of the field.

Contrary to the traditional notion of literacy being the ability to read and write, the contemporary view presents literacy as encompassing the capacity to apply knowledge, reason critically, and perform effectively in specialised contexts [12]. In the field of procurement, literacy involves a combination of knowledge, practical skills, and ethical awareness necessary to manage procurement processes. The constructivist learning theory [13] emphasises that meaningful learning occurs when learners connect new knowledge with prior experience, which structured education in procurement aims to facilitate. In support of this, competency-based education theory promotes multidimensional assessment as a means of capturing the skills and attributes of the real-world required in professional disciplines [14]; in addition human capital theory [15] suggests that investments in education and training improve individual productivity and contribute to national development. Developing and validating

a procurement literacy instrument is therefore not only essential for professional capacity building, but also for aligning educational outcomes with national policy and institutional goals. Despite its importance, multidimensional validated tools for measuring procurement literacy of procurement students are missing in the literature.

This gap in the literature poses two challenges in the procurement education and practice. Firstly, curriculum design in procurement education mostly lacks feedback mechanisms to assess whether students acquire the necessary practical competencies before entering the workforce. Secondly, in the absence of validated tools for measuring procurement literacy, educators and policymakers are unable to effectively evaluate programme outcomes to identify skill deficits and benchmark student performance over time. The existing literature focusses predominantly on curriculum content and legal or policy reforms in procurement education, with limited attention to assessing how well students develop the necessary competencies in legal, procedural, ethical, and digital domains [11, 16–19].

This study develops and validates a multidimensional instrument designed to measure procurement literacy among undergraduate students in Ghana, focussing on competencies aligned with the Chartered Institute of Procurement and Supply (CIPS) Global Standard (UK 4.0). Within the CIPS Global Standard, proficiency levels 1–4 reflect a progression from tactical support functions, through operational and managerial responsibility, to the ability to contribute to strategic procurement planning and decision-making. The instrument targets Level 1 (Tactical Support) to Level 4 (Strategic), reflecting the typical scope of undergraduate procurement education. This is based on well-established theoretical models of procurement capability development and adheres to key policy and professional standards, including the Ghana Public Procurement Act (Public Procurement Authority, 2003) [20], the OECD Recommendation on Public Procurement [21], and the CIPS Global Standard for Procurement and Supply [22]. These frameworks collectively inform the competency domains and performance expectations relevant to procurement education and practice at the undergraduate level. Informed by the framework, the instrument started with a broad conceptual mapping covering six core domains essential for procurement practice: legal and policy knowledge, procurement planning and decision-making, supplier and contract management, transparency and accountability, ethical procurement practices, and digital/e-procurement competence. These domains align with key competency areas in the CIPS framework and aim to assess the progressive development of students' procurement capabilities throughout their academic careers. However, it is important to note that this initial conceptualisation served as a starting point rather than a fixed structure. Consistent with the process of development of psychometric scale, the final configuration of dimensions was determined through empirical testing. As reported later, one of the initially proposed domains (transparency and accountability) did not demonstrate sufficient empirical distinctiveness and was therefore excluded during the validation process, bringing the final validated instrument to five. The study also examines the ethical disposition of the students to improve the behavioural and predictive validity of the instruments.

This study, using rigorous psychometric tests such as content validation and factor analysis, aims to contribute to theory and practice. It helps in creating standardised metrics for procurement education and paves the way for research on procurement skills, ethics, and educational results in developing regions.

The rest of the study is arranged as follows: Section 2 introduces the research the conceptualisation of procurement literacy. Section 3 presents the theoretical underpinnings while section 4 introduces the procure literacy dimensions. Ethical intention was introduced in section 5 as a criterion for predictive validity in procurement literacy. Section 7 describes the methodology, the study research design, study participants, analytical techniques, and ethical considerations. Results and discussions are presented in section 8 and the conclusion in section 9.

## 2. Conceptualising procurement literacy

The concept of procurement literacy is underdeveloped in the academic literature, but based on frameworks for training procurement professionals, it can be conceptualised as a multidimensional construct encompasses knowledge, skills, and attitudes essential to effectively participate in procurement decision-making [3, 7]. These include understanding legal and regulatory frameworks, strategic planning, managing supplier relationships, upholding ethical and accountability

standards, and appreciating digital platforms for managing the procurement process. Learning from frameworks on functional literacy [23] and financial literacy [24] we define procurement literacy as *the knowledge, skills and ethical competencies required to understand, manage and participate in procurement systems effectively. Unlike to professional procurement competence, procurement literacy is conceptualised as a foundational capability that reflects an individual's understanding, judgement, and ethical orientation in relation to procurement processes. This framing positions procurement literacy as a precursor to professional competence, shaped by formal education rather than occupational experience.*

From the lens of public sector procurement, compliance, transparency, and value for money are actualised through procurement literacy [25]. Within an academic setting, it offers an opportunity to evaluate curricula or measure the extent to which students have acquired competencies necessary for professional success. However, the existence of validated instruments to assess procurement literacy of students has received little attention in the literature, especially in sub-Saharan Africa, where formal procurement education is still emerging [17,26,27]; highlighting the urgent need for robust; and multidimensional tools to assess procurement literacy in educational contexts.

### 3. Theoretical underpinnings

We propose three theoretical frameworks for the development and validation of the procurement literacy instruments: constructivist learning theory, competency-based education and human capital theory. First, the constructivist learning theory of [13] posits that learners build knowledge actively by engaging in tasks that connect new concepts to prior experiences. It emphasises that, through guided instruction, peer interaction, and scaffolded learning experiences, students are better equipped to internalise concepts and apply them to real-world challenges ( [28,29]. In the context of procurement education, this theoretical orientation underscores the relevance of learning environments that integrate theory with authentic practice-based scenarios. We also draw on competency-based education (CBE) [30,31], which suggests that learning should be measured by the demonstration of clearly articulated competencies that reflect industry and professional standards. This model aligns with calls for procurement education for outcome-oriented curricula that promote the mastery of knowledge, ethical reasoning, strategic thinking, and digital literacy [3,7]. It also provides a methodological rationale for constructing and validating an instrument that captures multiple dimensions of procurement literacy in observable and assessable forms.

Finally, we dwell on human capital theory [15], corroborated by [32], which offers an economic rationale for procurement literacy by viewing education as a strategic investment that enhances individual productivity and institutional effectiveness. It views procurement literacy as more than academic, it is a capability that equips students with employable skills, promotes compliance and accountability in public procurement, and supports national development goals, especially in developing economies.

The three theoretical foundations justify the multidimensional conceptualisation of procurement literacy as encompassing cognitive (legal and policy knowledge), behavioural (skills, planning, and ethical dispositions), and technological (digital procurement competence) dimensions. This theoretical framework provides the foundation for the development of a valid and reliable instrument that addresses an existing gap in the assessment of procurement education outcomes. In addition, these theoretical perspectives shaped the design of the instrument. For example, constructivist learning theory guided the development of items that assess applied understanding and contextual judgement rather than factual recall, reflecting how students engage with procurement scenarios in practice-based learning environments. The competency-based education also informed the organisation of items into domains aligned with clearly articulated capability areas and progression expectations. Finally, human capital theory further justified the inclusion of domains such as digital and e-procurement competence, recognising these skills as productive assets that enhance employability and institutional effectiveness. Together, these perspectives provided a coherent foundation for both the conceptualisation and operationalisation of procurement literacy in this study.

## 4. Dimensions of procurement literacy

The conceptualisation of procurement literacy was informed by policy instruments, educational standards, competency frameworks, and procurement capability models. These include the Chartered Institute of Procurement and Supply (CIPS) Global Standard for Procurement and Supply [22], the World Bank's Procurement Competency Framework [33], and the OECD Recommendation on Public Procurement [21]. The dimensions of the instruments reflect competency expectations aligned with Levels 1–4 of the CIPS proficiency hierarchy. The CIPS Global Standard for Procurement and Supply emphasises on four proficiency Levels, representing a progressive development of capability. Level 1 covers basic tactical support and compliance. Level 2 progresses to operational tasks such as sourcing and routine decision-making. Level 3 becomes to a managerial focus, requiring analytical oversight of contracts and suppliers. Finally, Level 4 centres on strategic leadership, aligning procurement with organizational goals and long-term value. These levels encompass tactical and operational competencies expected of graduates from undergraduate procurement programmes, which aim to build the foundational capabilities necessary for professional practice. It also aligned with policy and legal frameworks, including the Ghana *Public Procurement Act* (Act 663, as amended by Act 914 and Act 1139). The instrument covered the core domains necessary for compliance; accountability, and strategic contribution within the procurement function and was supported by competency-based education (CBE) theory and competency modelling approaches in the professional development literature [14,34]. These domains capture distinct but interconnected aspects of procurement proficiency that must be reliably assessed through psychometric validation.

Based on a review of the current literature and competency standards, the following six core dimensions were initially identified and presented in [Table 1](#).

## 5. Ethical intention as a criterion for predictive validity in procurement literacy

Ethical intention refers to an individual's willingness to engage in morally appropriate behaviour and is often used as a benchmark for evaluating the effectiveness of professional training and competence [42,43]. In procurement education, it serves as a meaningful criterion for assessing whether technical knowledge translates into ethical behaviour.

Each dimension of procurement literacy, including Ethical Procurement Practice, Procurement Planning and Decision Making, Supplier and Contract Management, Digital and Electronic Procurement Competency, and Legal and Policy Knowledge, has a direct or indirect influence on ethical conduct. For example, ethical practices have been shown to correlate with ethical intentions [44], while planning and legal knowledge provide a structured decision framework that helps reduce unethical discretion [45,46].

Digital competence also improves transparency, limiting opportunities for misconduct [47,48]. Supplier and contract management introduces practical ethical challenges, and competence in this area correlates with moral decision making in procurement [16].

Given these relationships, using ethical intention to assess the predictive validity of procurement literacy constructs is both theoretically justified and empirically supported. It provides insight into whether knowledge-based competencies foster ethical readiness among students and future practitioners [49,50].

## 6. Methodology

### 6.1. Research design

This study employed a quantitative cross-sectional survey design to develop and validate a multidimensional instrument to assess procurement literacy among undergraduate students in Ghana. The approach allowed for the systematic collection of data and the evaluation of psychometric properties using established statistical procedures.



**Table 1. Dimensions of Procurement Literacy.**

| Dimension                                       | Domain covered                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                               |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Legal and Policy Knowledge</i>               | This dimension covers the awareness and understanding of the legal frameworks, procurement thresholds, regulatory responsibilities, and institutional structures that govern public procurement. It serves as the foundational layer of procurement competence, shaping how professionals navigate procedures and maintain compliance. | Ghana Public Procurement Act, 2003 (Act 663, as amended by Act 914 and Act 1139); CIPS Global Standard for Procurement and Supply [22]; OECD Recommendation on Public Procurement [21]; [9].                                  |
| <i>Procurement Planning and Decision-Making</i> | This dimension focusses on the ability to assess procurement needs, prepare budgets, choose suitable procurement methods, and plan realistic timelines and specifications. It plays a vital role in aligning procurement decisions with a broader strategic objectives of an organisation. [7]                                         | CIPS Global Standard for Procurement and Supply [22]; OECD Recommendation on Public Procurement 21]; Checklist for Supporting the Implementation of the OECD Recommendation of the Council on Public Procurement [7]          |
| <i>Supplier and Contract Management</i>         | This dimension covers the key competencies required to evaluate bids, select suppliers, negotiate contracts, monitor performance, manage disputes, and handle contract variations. These skills are essential to achieve value for money and building strong, sustainable relationships with suppliers.                                | CIPS Global Standard for Procurement and Supply [22]; World Bank Procurement Framework [33]; OECD Recommendation on Public Procurement [21]; [35]                                                                             |
| <i>Transparency and Accountability</i>          | This dimension highlights the importance of clear documentation, readiness for audits, and the use of mechanisms such as whistleblower channels. It reflects a commitment to openness and accountability throughout the procurement process [7].                                                                                       | OECD Recommendation on Public Procurement [21]; Ghana Public Procurement Act, 2003 (Act 663, as amended); OECD Checklist for Supporting the Implementation of OECD Recommendation of the Council on Public Procurement (2016) |
| <i>Ethical Procurement Practice</i>             | This dimension involves the ability to recognise ethical dilemmas, manage conflicts of interest, and act consistently with integrity. It reinforces the moral responsibility of procurement professionals to uphold fairness and public trust.                                                                                         | CIPS Global Standard for Procurement and Supply [22]; OECD Recommendation on Public Procurement [21]; Ghana Public Procurement Act, 2003 (Act 663, as amended); [36–38]                                                       |
| <i>Digital and E-Procurement Competence</i>     | This dimension captures the ability to use digital platforms for tendering, maintain secure procurement systems, and manage electronic records efficiently. It underscores the growing importance of digital readiness in modern procurement practice.                                                                                 | CIPS Global Standard for Procurement and Supply [22]; World Bank Procurement Framework [33] (2016); OECD Digital Government Policy Framework [39–41]                                                                          |

**Note:** These dimensions represent the *initial conceptual framework*. The final validated instrument retained five dimensions after exploratory and confirmatory factor analysis.

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## 6.2. Participants and sampling

A total of 554 undergraduate students from Level 200 to Level 400, enrolled in procurement-related degree programmes at selected public universities, participated in the study. Level 100 students were excluded due to their limited exposure to procurement concepts. The final sample size was deemed adequate for psychometric evaluation, representing an infinite population exceeding 50,000 [51].

In addition, eight procurement experts, comprising academics and industry professionals, were purposively selected to participate in the content validation stage. These experts assessed the initial items for clarity, relevance and representativeness during the instrument development process.

### 6.3. Instrument development and expert review

We started with the development of 40 procurement literacy instruments covering six hypothesised domains informed by the Ghana Public Procurement Act (Act 663, amended by Act 914 and Act 1139), the OECD Recommendation on Public Procurement [21], and the CIPS Global Standard for Procurement and Supply [22]. While these frameworks; the Act and policies informed the development of the instruments, the items were not directly adapted from existing instruments but were newly constructed through expert review to reflect undergraduate learning outcomes. The instruments were grouped into the six domains as follows: Legal and Policy Knowledge (7 items), Procurement Planning and Decision-Making (7 items), Supplier and Contract Management (7 items), Transparency and Accountability (6 items), Ethical Procurement Practices (7 items) and Digital and E-Procurement Competence (6 items). The Item construction was guided by the principle that procurement literacy reflects the ability to interpret, evaluate, and respond to procurement-related situations rather than simply recalling procedural rules. As such, items were framed to capture students' perceived capability in planning decisions, ethical judgement, supplier oversight, and digital engagement. This approach aligns with competency-based education, which emphasises demonstrable capability, and with constructivist views of learning that prioritise meaning-making through experience. Expert reviewers were specifically asked to assess whether the items reflected realistic procurement contexts and decision processes expected at the undergraduate level.

The content validity of the initial items was assessed using eight academic and industry procurement experts using a four-point scale (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = very relevant). The Item-Level Content Validity Index (I-CVI) and Scale-Level CVI (S-CVI/Ave) were calculated [52], and items scoring below 0.78 were revised or excluded [53], and the resultant items were piloted, leading to minor linguistic adjustments to improve clarity and relevance [54].

### 6.4. Data collection procedure

The final instrument was administered through Google Forms to Levels 200, 300 and 400 of selected public universities in Ghana from 18 September 2025 to 25 September 2025. The instrument included a preamble explaining the purpose of the study, confidentiality assurance, and voluntary participation. Measures were taken to ensure data quality, including checking for duplicates and completion thresholds.

### 6.5. Psychometric validation procedures

**6.5.1. Exploratory factor analysis (EFA).** The study employed Exploratory factor Analysis (EFA) to examine the underlying structure of the instrument. The EFA utilised the Principal Axis Factoring with Promax rotation, based on the assumption of correlated factors [55] (Costello & Osborne, 2005), and three considerations were considered to retain a factor: eigenvalues  $\geq 1$ , scree plot inspection, and theoretical interpretability. All items with factor loadings  $< 0.50$  or high cross-loadings were excluded [56], and the final retained factor were subjected to the confirmatory factor analysis.

**6.5.2. Confirmatory factor analysis (CFA).** To cross-validate the emergent structure from the EFA, we used Confirmatory Factor Analysis (CFA) using the lavaan package in R. We evaluated the model using the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Standardised Root Mean Square Residual (SRMR). In line with the threshold recommended by [57,58],  $CFI \geq 0.9$ ,  $TLI \geq 0.9$ ,  $RMSEA \geq 0.08$  and  $SRMR \geq 0.08$  respectively indicate a reasonable fit.

**6.5.3. Convergent validity and construct reliability.** The convergent validity and construct reliability for each factor were assessed using the Average Variance Extracted (AVE) and Composite Reliability (CR). Following Fornell and Larcker [59] (1981) and [60],  $AVE \geq 0.50$  and  $CR \geq 0.70$  were used to establish convergent validity and internal construct reliability.

**6.5.4. Measurement invariance.** To ensure that the scale functioned equivalently across academic levels (Level 200, 300, 400), a multi-group CFA was conducted to assess configural, metric and scalar invariance [61,62]. Invariance supported the appropriateness of comparing procurement literacy scores across different year groups. This was supported with one-way ANOVA tests conducted for each of the procurement literacy constructs to further evaluate the instrument's ability to differentiate between academic levels.

## 6.6. Common method bias

To address concerns related to common method bias, both procedural and statistical remedies were implemented. Procedurally, participants were assured of anonymity and confidentiality to reduce evaluation apprehension and social desirability bias. Items were also designed to minimise ambiguity and common rater effects [63]. (Podsakoff et al., 2003).

Statistically, the Harman's single-factor test was performed to determine whether a single latent factor accounted for the majority of the variance. The analysis revealed that the first unrotated factor explained 48.5% of the total variance, which is below the conventional threshold of 50%, indicating that common method bias was not a significant threat to the integrity of the data [63,64].

## 6.7. Ethical considerations

Ethical approval was obtained from the Committee on Human Research, Publications and Ethics (CHRPE), School of Medical Sciences, Kwame Nkrumah University of Science and Technology, and Komfo Anokye Teaching Hospital, Kumasi, Ghana (Ref: CHRPE/AP/1000/25). Informed consent was obtained from all participants prior to their participation in the study. Consent was documented electronically via a mandatory consent page within the Google Form survey

# 7. Results and discussion

## 7.1. Content validity evaluation

We started the content validation by allowing a panel of eight experts in procurement and education to evaluate the initial 40-item instrument using a 4-point scale ranging from 1 (not relevant) to 4 (highly relevant). Following [52] guidelines, items with an Item-Level Content Validity Index (I-CVI) of 0.78 or higher were retained. Table 2 shows the results of I-CVI and S-CVI/UA of the 40 items. Based on the results, item LEG7, a component of Policy and Legal Knowledge, was deleted, bringing the items to 39. The Scale-Level Content Validity Index based on Universal Agreement (S-CVI/UA) was calculated at 0.925, surpassing the recommended threshold of 0.80 for newly developed instruments [65].

The remaining 39 items, along with demographic questions and a measure of ethical intention, were administered to a sample of 554 undergraduate procurement students from Level 200 to Level 400 for initial dimensionality assessment. The responses were recorded on a five-point Likert scale, ranging from 1 = "Not true at all" to 5 = "Very true," reflecting the extent to which each statement applied to the respondent. Level 100 students were excluded due to minimal course exposure. Table 3 presents the demographic characteristics of the sample. A total of 554 undergraduate procurement students participated in the study. The sample was fairly balanced in terms of gender, with 51.9% identifying as male and 48.1% as female.

In terms of academic level, the highest proportion of participants was in Level 300 (38.6%), followed by Level 200 (35.0%) and Level 400 (26.4%).

Regarding academic performance, a wide range of Grade Point Averages (GPA) was reported. Approximately 17.7% of students fell within the 2.0 to 2.4 GPA range, 28.3% with the range of 2.5 to 2.9, while 31.8% reported GPAs between 3.0 and 3.5. Smaller proportions of students reported GPAs below 2.0 (9.6%) and 12.7% above 3.5.



**Table 2. Content Validity Ratings by Expert Panel (I-CVI and S-CVI).**

| Item Code                                                         | Item                                                                                        | I-CVI |
|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------|
| <b>Section A: Policy and Legal Knowledge (LEG)</b>                |                                                                                             |       |
| LEG1                                                              | I can identify the key principles of the public procurement law in my country.              | 100%  |
| LEG2                                                              | I understand the differences between open tendering and restricted tendering.               | 100%  |
| LEG3                                                              | I am familiar with the thresholds that determine procurement methods.                       | 100%  |
| LEG4                                                              | I can explain the functions of key entities involved in procurement regulation.             | 100%  |
| LEG5                                                              | I am aware of the role of procurement in promoting national development goals.              | 88%   |
| LEG6                                                              | I understand how international procurement laws (e.g., WTO, UNCITRAL) relate to local laws. | 100%  |
| LEG7                                                              | I know the penalties associated with procurement fraud or non-compliance.                   | 70%   |
| <b>Section B: Procurement Planning and Decision-Making (PLAN)</b> |                                                                                             |       |
| PLAN1                                                             | I can develop a procurement plan based on organisational needs.                             | 100%  |
| PLAN2                                                             | I can estimate procurement timelines and delivery schedules accurately.                     | 100%  |
| PLAN3                                                             | I am confident in selecting appropriate procurement methods for different purchases.        | 100%  |
| PLAN4                                                             | I know how to conduct a needs assessment for procurement.                                   | 100%  |
| PLAN5                                                             | I can determine procurement specifications that meet value-for-money principles.            | 100%  |
| PLAN6                                                             | I understand how to manage risks in procurement planning.                                   | 100%  |
| PLAN7                                                             | I know how to forecast budget requirements for procurement activities.                      | 100%  |
| <b>Section C: Supplier and Contract Management (SUP)</b>          |                                                                                             |       |
| SUP1                                                              | I can evaluate supplier bids using pre-defined criteria.                                    | 100%  |
| SUP2                                                              | I understand how to draft and interpret key clauses in procurement contracts.               | 100%  |
| SUP3                                                              | I know how to manage supplier relationships throughout the contract lifecycle.              | 100%  |
| SUP4                                                              | I am confident in applying dispute resolution mechanisms in procurement contracts.          | 100%  |
| SUP5                                                              | I can monitor supplier performance using key performance indicators (KPIs).                 | 100%  |
| SUP6                                                              | I understand contract termination conditions and procedures.                                | 100%  |
| SUP7                                                              | I am familiar with contract variation and amendment processes.                              | 100%  |
| <b>Section D: Transparency and Accountability (TRAN)</b>          |                                                                                             |       |
| TRAN1                                                             | I understand the importance of documentation in procurement transparency.                   | 100%  |
| TRAN2                                                             | I know how to conduct a procurement process that ensures fairness and equity.               | 100%  |
| TRAN3                                                             | I am familiar with whistleblower mechanisms in public procurement.                          | 88%   |
| TRAN4                                                             | I can identify red flags that may indicate procurement malpractice.                         | 100%  |
| TRAN5                                                             | I understand the role of audits and performance reviews in procurement accountability.      | 100%  |
| TRAN6                                                             | I believe procurement decisions should be justified and recorded for accountability.        | 100%  |
| <b>Section E: Ethical Procurement Practice</b>                    |                                                                                             |       |
| ETH1                                                              | I can recognise situations that present ethical dilemmas in procurement.                    | 100%  |
| ETH2                                                              | I believe accepting gifts from suppliers can compromise procurement integrity.              | 100%  |
| ETH3                                                              | I would report any unethical behaviour I observe during procurement.                        | 100%  |
| ETH4                                                              | I understand the concept of conflict of interest in procurement.                            | 100%  |

(Continued)

**Table 2.** (Continued)

| Item Code                                                                         | Item                                                                            | I-CVI |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------|
| ETH5                                                                              | I believe ethical procurement protects public trust.                            | 100%  |
| ETH6                                                                              | I can apply procurement ethics even when under pressure.                        | 100%  |
| ETH7                                                                              | I feel confident making decisions aligned with ethical procurement codes.       | 100%  |
| <b>Section F: Digital and E-Procurement Competence</b>                            |                                                                                 |       |
| DIG1                                                                              | I know how to use e-procurement platforms to publish tender notices.            | 100%  |
| DIG2                                                                              | I can evaluate e-submissions from suppliers in digital tendering platforms.     | 100%  |
| DIG3                                                                              | I understand the benefits of e-procurement for transparency and efficiency.     | 100%  |
| DIG4                                                                              | I can participate in online vendor registration and prequalification processes. | 100%  |
| DIG5                                                                              | I am aware of cybersecurity and data privacy concerns in e-procurement systems. | 100%  |
| DIG6                                                                              | I am confident in managing procurement records in digital formats.              | 100%  |
| <b>Scale-Level Content Validity Index based on Universal Agreement (S-CVI/UA)</b> |                                                                                 | 92.5% |

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**Table 3. Sample Demographic Characteristics (N = 554).**

| Demographic Variable        | Category      | n   | %     |
|-----------------------------|---------------|-----|-------|
| <b>Level of Study (LoS)</b> | Level 200     | 194 | 35.0% |
|                             | Level 300     | 214 | 38.6% |
|                             | Level 400     | 146 | 26.4% |
|                             | Missing       | 0   | 0.0%  |
| <b>GPA Range</b>            | Below 2.0     | 49  | 9.6%  |
|                             | 2.0–2.4       | 91  | 17.7% |
|                             | 2.5–2.9       | 145 | 28.3% |
|                             | 3.0–3.5       | 163 | 31.8% |
|                             | 3.6–4.0       | 33  | 12.7% |
|                             | Missing       | 41  | 7.4%  |
| <b>Gender</b>               | Female        | 264 | 48.1% |
|                             | Male          | 285 | 51.9% |
|                             | Missing       | 5   | 0.9%  |
| <b>Work Experience</b>      | Full-time Job | 10  | 1.8%  |
|                             | Internship    | 258 | 47.3% |
|                             | No Experience | 230 | 42.1% |
|                             | Part-time Job | 48  | 8.8%  |
|                             | Missing       | 8   | 1.4%  |

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Work experience in procurement-related roles also varied in the sample. Nearly half of the students (47.3%) had undertaken internships, while 42.1% reported no prior work experience. A smaller percentage reported having part-time jobs (8.8%) or full-time work experience (1.8%) in procurement-related areas.

These demographic characteristics indicate that the sample comprises students with diverse academic backgrounds, varying levels of academic achievement, and a range of work experiences. This diversity provides a suitable basis for assessing procurement literacy between different groups.

## 7.2. Descriptive statistics of procurement literacy items

Descriptive statistics were computed for individual items under each procurement literacy construct to examine response patterns and assess data suitability for further analyses. As presented in [Table 4](#), the mean scores across items ranged from 2.54 to 3.67, indicating generally moderate levels of agreement among students regarding procurement competencies.

Among the item-level means, those belonging to the Transparency and Accountability and Ethical Procurement Practice domains were among the highest (item means up to 3.67 and 3.59, respectively), suggesting students expressed relatively strong awareness or endorsement of ethical norms and transparency expectations in procurement. This pattern is not surprising, as ethics and transparency have become central themes in procurement reforms and discourse in Ghana's public sector [16,66,67].

In contrast, items under the Legal and Policy Knowledge construct recorded lower mean values (minimum item mean = 2.69), possibly reflecting students' limited exposure to formal legal frameworks or their complexity [16,68].

Standard deviations between items ranged from 0.92 to 1.37, reflecting acceptable levels of variability in likert item responses. Skewness values ranged from -0.79 to +0.24 and kurtosis from -0.99 to -0.23, all within the acceptable range for normality assumptions [58,59]. These values support the use of parametric techniques such as Confirmatory Factor Analysis (CFA) and ANOVA.

## 7.3. Exploratory factor analysis (EFA)

To examine the underlying factor structure of the instrument, an Exploratory Factor Analysis (EFA) was conducted. The Kaiser Meyer Olkin (KMO) measure of sampling adequacy was excellent at 0.954, indicating the data were suitable for factor analysis. Bartlett's test of sphericity was highly significant ( $\chi^2(741) = 19,644.17$ ,  $p < .001$ ), further confirming the appropriateness of the analysis.

The EFA was performed using Principal Axis Factoring with Promax (oblique) rotation to allow for potential correlations among factors. The analysis yielded a five-factor solution that collectively explained 66.00 per cent of the total variance in the data.

Several of the items of one of the conceptual domain, Transparency and Accountability, exhibited substantial cross-loadings, particularly overlapping with dimensions related to ethics and supplier and contract management. This overlap suggested a lack of conceptual distinctiveness for this factor in the current sample. Given the aim of developing a parsimonious and interpretable measurement model, the Transparency and Accountability domain was removed at this stage. The remaining items formed a coherent five-factor structure that was retained for subsequent confirmatory analysis. Additionally, four items (SUP3, TRAN1, TRAN3, and ETH1) did not load significantly on any of the five retained factors, suggesting poor alignment with the latent constructs. Subsequently, These items were removed, resulting in a refined instrument consisting of 35 items across five well-defined factors. The factors and resulting factor loadings are presented in [Table 5](#).

**Table 4. Descriptive Statistics of Procurement Literacy Items.**

| Construct                            | Item Range  | Mean Range | SD Range  | Skewness Range | Kurtosis Range |
|--------------------------------------|-------------|------------|-----------|----------------|----------------|
| Legal and Policy Knowledge (LEG)     | LEG1–LEG6   | 2.69–3.43  | 1.15–1.31 | –0.36 to +0.24 | –0.99 to –0.68 |
| Procurement Planning (PLAN)          | PLAN1–PLAN7 | 3.14–3.34  | 1.16–1.23 | –0.31 to –0.08 | –0.86 to –0.74 |
| Supplier & Contract Management (SUP) | SUP1–SUP7   | 2.96–3.32  | 1.17–1.26 | –0.29 to –0.04 | –0.89 to –0.73 |
| Transparency & Accountability (TRAN) | TRAN1–TRAN6 | 2.54–3.67  | 0.92–1.25 | –0.59 to –0.16 | –0.87 to –0.57 |
| Ethical Procurement Practice (ETH)   | ETH1–ETH7   | 3.08–3.59  | 0.93–1.37 | –0.79 to –0.14 | –0.98 to –0.23 |
| Digital & E-Procurement (DIG)        | DIG1–DIG6   | 2.89–3.38  | 1.17–1.26 | –0.30 to +0.04 | –0.98 to –0.75 |

Note: All items demonstrated acceptable skewness (within  $\pm 1$ ) and kurtosis (within  $\pm 2$ ), indicating approximate normality (Kline, 2023).

<https://doi.org/10.1371/journal.pone.0341565.t004>

**Table 5. Factor Loadings from EFA.**

|       | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Uniqueness |
|-------|----------|----------|----------|----------|----------|------------|
| ETH5  | 0.940    |          |          |          |          | 0.278      |
| ETH3  | 0.864    |          |          |          |          | 0.253      |
| ETH4  | 0.814    |          |          |          |          | 0.248      |
| ETH6  | 0.773    |          |          |          |          | 0.298      |
| ETH7  | 0.744    |          |          |          |          | 0.308      |
| TRAN6 | 0.707    |          |          |          |          | 0.283      |
| ETH2  | 0.693    |          |          |          |          | 0.421      |
| PLAN4 |          | 0.826    |          |          |          | 0.294      |
| PLAN6 |          | 0.796    |          |          |          | 0.318      |
| PLAN3 |          | 0.793    |          |          |          | 0.249      |
| PLAN2 |          | 0.781    |          |          |          | 0.299      |
| PLAN1 |          | 0.741    |          |          |          | 0.385      |
| PLAN7 |          | 0.718    |          |          |          | 0.330      |
| PLAN5 |          | 0.598    |          |          |          | 0.320      |
| SUP1  |          | 0.552    |          |          |          | 0.343      |
| TRAN3 |          |          | 0.692    |          |          | 0.470      |
| SUP7  |          |          | 0.636    |          |          | 0.370      |
| SUP5  |          |          | 0.611    |          |          | 0.261      |
| SUP6  |          |          | 0.603    |          |          | 0.359      |
| SUP2  |          |          | 0.562    |          |          | 0.306      |
| TRAN5 |          |          | 0.549    |          |          | 0.350      |
| TRAN4 |          |          | 0.539    |          |          | 0.357      |
| SUP4  |          |          | 0.533    |          |          | 0.314      |
| DIG2  |          |          |          | 0.834    |          | 0.236      |
| DIG4  |          |          |          | 0.813    |          | 0.263      |
| DIG6  |          |          |          | 0.747    |          | 0.350      |
| DIG5  |          |          |          | 0.728    |          | 0.386      |
| DIG3  |          |          |          | 0.615    |          | 0.416      |
| DIG1  |          |          |          | 0.601    |          | 0.343      |
| LEG3  |          |          |          |          | 0.794    | 0.350      |
| LEG4  |          |          |          |          | 0.774    | 0.341      |
| LEG5  |          |          |          |          | 0.683    | 0.437      |
| LEG1  |          |          |          |          | 0.640    | 0.538      |
| LEG2  |          |          |          |          | 0.632    | 0.447      |
| LEG6  |          |          |          |          | 0.614    | 0.459      |
| SUP3  |          |          |          |          |          | 0.318      |
| TRAN1 |          |          |          |          |          | 0.321      |
| TRAN2 |          |          |          |          |          | 0.302      |
| ETH1  |          |          |          |          |          | 0.351      |

Note. Applied rotation method is promax.

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## 7.4. Reliability and internal consistency

The internal consistency reliability was evaluated using Cronbach's alpha coefficients. All constructs exhibited high reliability, with alpha values ranging from 0.875 to 0.930. [Table 6](#) shows that Ethical Procurement Practice ( $\alpha = 0.921$ ),

**Table 6. Cronbach's Alpha Coefficients per Factor.**

|                                          | Cronbach $\alpha$ |
|------------------------------------------|-------------------|
| Ethical Procurement Practice             | 0.921             |
| Procurement Planning and Decision-Making | 0.930             |
| Supplier and Contract Management (SUP)   | 0.913             |
| Digital and E-Procurement Competence     | 0.916             |
| Legal and Policy Knowledge               | 0.875             |
| <b>Total</b>                             | <b>0.963</b>      |

<https://doi.org/10.1371/journal.pone.0341565.t006>

Procurement Planning and Decision-Making ( $\alpha=0.930$ ), Supplier and Contract Management ( $\alpha=0.913$ ), and Digital and E-Procurement Competency ( $\alpha=0.916$ ) demonstrated excellent reliability, while Legal and Policy Knowledge also showed strong reliability ( $\alpha=0.875$ ). The overall scale showed excellent internal consistency ( $\alpha=0.963$ ), indicating robust measurement consistency across the instrument.

### 7.5. Confirmatory factor analysis (CFA)

Confirmatory Factor Analysis (CFA) was performed using JASP 0.18.3, employing the Maximum Likelihood estimation with robust standard errors to assess the structural validity of the instrument. The initial CFA model, comprising all 39 items, yielded a suboptimal fit (CFI=0.949, TLI=0.945, SRMR=0.056, and RMSEA=0.085), suggesting the need for model refinement.

Following recommendations of [60,69], the items were iteratively reviewed and removed based on a combination of high modification indices, high residual covariances and theoretical redundancy. Items with overlapping content, poor contribution to the factor, or problematic error covariances were systematically eliminated, with a theoretical justification guiding each decision.

The refined model retained 30 items across five factors, demonstrating a substantial improvement in model fit. The final CFA model met the widely accepted fit criteria proposed by [57]: CFI=0.959, TLI=0.955, SRMR=0.051, and RMSEA=0.080. These results presented in Table 7 confirm the structural validity of the instrument and support its five-factor solution.

The standardised factor loadings for the final confirmatory factor analysis (CFA) model are presented in Table 8. All items significantly loaded ( $p<.001$ ) in their respective constructs, with standardised loadings ranging from 0.719 to 0.924, exceeding the commonly accepted threshold of 0.50 [60]. These results confirm strong convergent validity in all five constructs.

Fig 1 presents the final Confirmatory Factor Analysis (CFA) path diagram for the 30-item, five-factor model. The diagram displays the standardised regression weights, residual variances, and inter-factor covariances among the latent constructs: Ethical Procurement Practice (ETH), Procurement Planning and Decision-Making (PLAN), Supplier and Contract Management (SUP), Digital and E-Procurement Competence (DIG), and Legal and Policy Knowledge (LEG). The factor loadings in the diagram correspond to the values reported in Table 8, visually confirming the strength and clarity of the measurement model [60,69].

All latent constructs demonstrated strong associations with their respective items, with low residual variances and no substantial cross-loadings, thereby supporting the internal consistency of the model. The inter-factor correlations ranged from 0.64 to 0.89. This indicates that while the constructs are conceptually related, which is expected within the multidimensional framework of procurement literacy, they remain sufficiently distinct to be treated as separate dimensions. This pattern supports discriminant validity in line with the criteria proposed by [59] and later extended by [70].



**Table 7. CFA Model Fit Indices – Initial and Final Models.**

|       | Initial | Final |
|-------|---------|-------|
| CFI   | 0.949   | 0.959 |
| TLI   | 0.945   | 0.955 |
| SRMR  | 0.056   | 0.051 |
| RMSEA | 0.085   | 0.080 |

<https://doi.org/10.1371/journal.pone.0341565.t007>

**Table 8. Final Factor Loadings from CFA.**

| Factor                                   | Indicator | Std. estimate | Std. Error | z-value | p      |
|------------------------------------------|-----------|---------------|------------|---------|--------|
| Ethical Procurement Practice             | ETH2      | 0.816         | 0.018      | 44.438  | < .001 |
|                                          | ETH3      | 0.899         | 0.011      | 81.675  | < .001 |
|                                          | ETH4      | 0.924         | 0.010      | 95.770  | < .001 |
|                                          | ETH5      | 0.856         | 0.015      | 58.337  | < .001 |
|                                          | ETH6      | 0.891         | 0.012      | 74.523  | < .001 |
|                                          | ETH7      | 0.911         | 0.012      | 78.141  | < .001 |
| Procurement Planning and Decision-Making | PLAN1     | 0.797         | 0.017      | 46.465  | < .001 |
|                                          | PLAN2     | 0.894         | 0.011      | 80.563  | < .001 |
|                                          | PLAN3     | 0.905         | 0.010      | 92.419  | < .001 |
|                                          | PLAN4     | 0.869         | 0.013      | 68.114  | < .001 |
|                                          | PLAN5     | 0.883         | 0.012      | 71.723  | < .001 |
|                                          | PLAN6     | 0.836         | 0.015      | 57.341  | < .001 |
| Supplier and Contract Management         | SUP1      | 0.858         | 0.013      | 63.917  | < .001 |
|                                          | SUP2      | 0.856         | 0.013      | 63.636  | < .001 |
|                                          | SUP4      | 0.867         | 0.012      | 72.086  | < .001 |
|                                          | SUP5      | 0.889         | 0.011      | 83.211  | < .001 |
|                                          | SUP6      | 0.847         | 0.014      | 61.653  | < .001 |
|                                          | SUP7      | 0.817         | 0.016      | 52.533  | < .001 |
| Digital and E-Procurement Competence     | DIG1      | 0.915         | 0.014      | 64.039  | < .001 |
|                                          | DIG2      | 0.865         | 0.012      | 70.992  | < .001 |
|                                          | DIG3      | 0.840         | 0.016      | 52.598  | < .001 |
|                                          | DIG4      | 0.872         | 0.012      | 71.312  | < .001 |
|                                          | DIG5      | 0.815         | 0.016      | 50.718  | < .001 |
|                                          | DIG6      | 0.832         | 0.016      | 51.384  | < .001 |
| Legal and Policy Knowledge               | LEG1      | 0.719         | 0.028      | 25.657  | < .001 |
|                                          | LEG2      | 0.747         | 0.025      | 30.144  | < .001 |
|                                          | LEG3      | 0.802         | 0.020      | 39.431  | < .001 |
|                                          | LEG4      | 0.845         | 0.018      | 47.972  | < .001 |
|                                          | LEG5      | 0.801         | 0.021      | 38.378  | < .001 |
|                                          | LEG6      | 0.783         | 0.025      | 31.888  | < .001 |

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The final CFA model therefore validates the proposed five-factor structure of procurement literacy and offers strong empirical evidence for the psychometric robustness of the instrument. Clear factor loadings and meaningful correlations among the constructs provide a solid foundation for the application of the instrument in further analyses of procurement knowledge and competency between student populations [58,71].

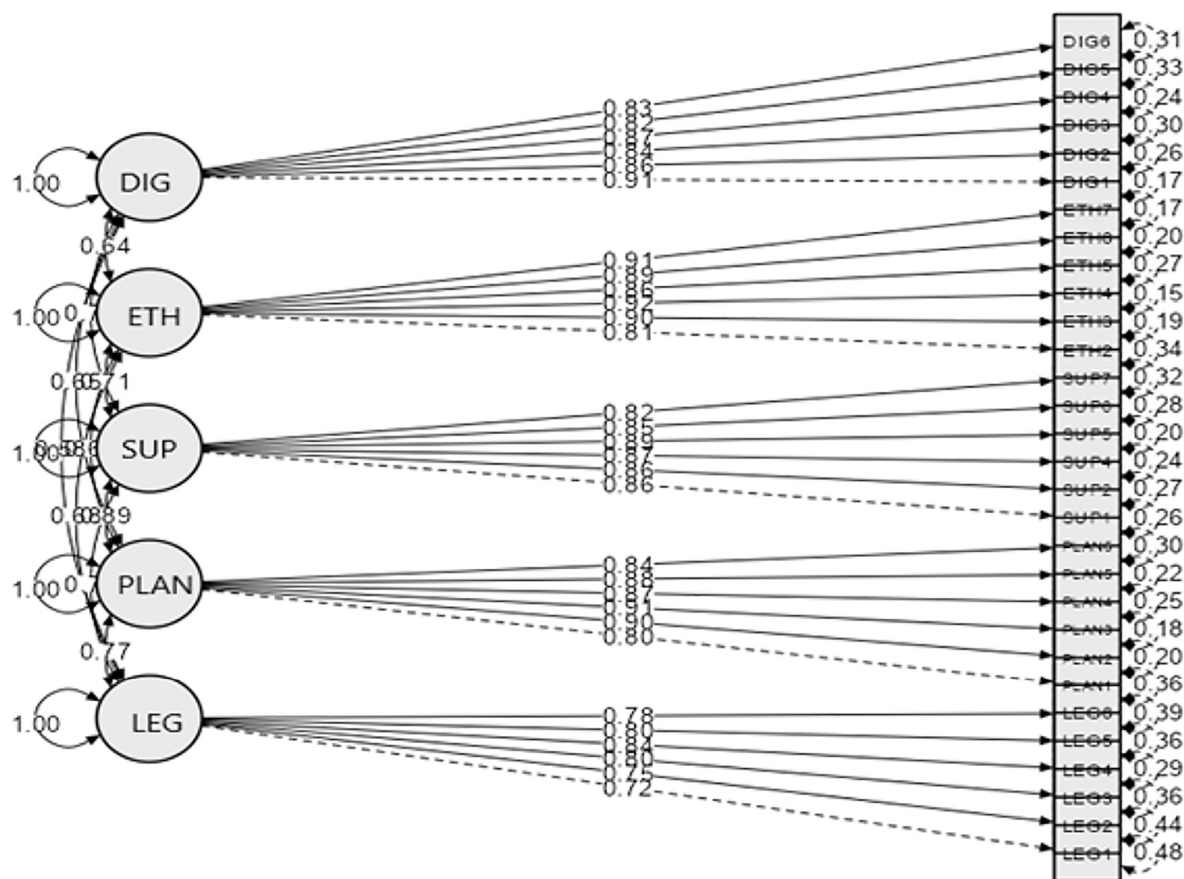


Fig 1. CFA Path Diagram (Final 5-Factor, 30-Item Model).

<https://doi.org/10.1371/journal.pone.0341565.g001>

The alignment between the theoretical framework and the final empirical structure of the instrument strengthens confidence in its validity. The retained dimensions reflect capability areas that are both pedagogically meaningful and practically relevant, supporting the view that procurement literacy at the undergraduate level is best understood as a blend of applied knowledge, ethical orientation, and functional readiness. The coherence between theory, item design, and factor structure suggests that the instrument captures how procurement competence is cognitively organised during early professional formation.

## 7.6. Convergent and discriminant validity

Convergent validity was evaluated by calculating the Average Variance Extracted (AVE) for each construct. All constructs exceeded the recommended threshold of 0.50 [59], confirming adequate convergent validity. Table 9 presents AVE values ranging from 0.614 to 0.781, with particularly strong results observed for Ethical Procurement Practice (AVE = 0.781), Procurement Planning and Decision-Making (AVE = 0.748), and Supplier and Contract Management (AVE = 0.723). Legal and Policy Knowledge also demonstrated satisfactory convergent validity (AVE = 0.614).

Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio of correlations and presented in Table 10. All HTMT values fell below the conservative threshold of 0.90 [70], indicating adequate discriminant validity across

**Table 9. Average variance extracted.**

| Factor                                   | AVE   |
|------------------------------------------|-------|
| Ethical Procurement Practice             | 0.781 |
| Procurement Planning and Decision-Making | 0.748 |
| Supplier and Contract Management (SUP)   | 0.723 |
| Digital and E-Procurement Competence     | 0.735 |
| Legal and Policy Knowledge               | 0.614 |

<https://doi.org/10.1371/journal.pone.0341565.t009>

**Table 10. Heterotrait-monotrait ratio.**

| Ethical Procurement Practice | Procurement Planning and Decision-Making | Supplier and Contract Management (SUP) | Digital and E-Procurement Competence | Legal and Policy Knowledge |
|------------------------------|------------------------------------------|----------------------------------------|--------------------------------------|----------------------------|
| 1.000                        |                                          |                                        |                                      |                            |
| 0.656                        | 1.000                                    |                                        |                                      |                            |
| 0.709                        | 0.888                                    | 1.000                                  |                                      |                            |
| 0.589                        | 0.639                                    | 0.711                                  | 1.000                                |                            |
| 0.657                        | 0.762                                    | 0.752                                  | 0.583                                | 1.000                      |

<https://doi.org/10.1371/journal.pone.0341565.t010>

constructs. The highest HTMT value was found between Procurement Planning and Decision-Making and Supplier and Contract Management (HTMT = 0.888), which, although within acceptable limits, suggests some conceptual overlap that warrants careful interpretation.

To justify group comparisons, measurement invariance across academic levels (Levels 200, 300, and 400) was assessed using multi-group Confirmatory Factor Analysis (CFA). The results supported configural, metric, and scalar invariance, indicating that the factor structure, item loadings, and intercepts were equivalent across groups [61], which confirms that procurement literacy scores are meaningfully comparable across academic levels.

To further evaluate the instrument's ability to differentiate between academic levels, one-way ANOVA tests were conducted for each of the five procurement literacy constructs. The analysis presented in Table 11 revealed significant differences between academic levels for all constructs.

Specifically, significant group differences were observed for Ethical Procurement Practice ( $F(2, 519) = 9.26, p < .01, \eta^2 = 0.034$ ), Procurement Planning and Decision-Making ( $F(2, 541) = 5.89, p < .01, \eta^2 = 0.021$ ), Supplier and Contract Management ( $F(2, 529) = 8.12, p < .01, \eta^2 = 0.022$ ), Digital and E-Procurement Competence ( $F(2, 531) = 6.21, p < .01, \eta^2 = 0.028$ ), and Legal and Policy Knowledge ( $F(2, 530) = 14.15, p < .01, \eta^2 = 0.051$ ). These findings indicate that procurement literacy varies significantly across academic levels for all dimensions measured by the instrument.

The effect sizes ( $\eta^2$ ) ranged from 0.021 to 0.051, representing small to moderate effects according to conventional benchmarks [72,73]. These results suggest that students' procurement literacy generally increases with higher academic exposure and experience across all competency areas.

**Table 11. Results of One-Way ANOVA for five dimensions of Procurement Literacy against Academic Levels.**

| Construct                                | F(df)               | p-value | $\eta^2$ (Effect Size) | Conclusion                    |
|------------------------------------------|---------------------|---------|------------------------|-------------------------------|
| Ethical Procurement Practice             | $F(2, 519) = 9.26$  | <.01    | 0.034                  | Significant group differences |
| Procurement Planning and Decision-Making | $F(2, 541) = 5.89$  | <.01    | 0.021                  | Significant group differences |
| Supplier and Contract Management         | $F(2, 529) = 8.12$  | <.01    | 0.028                  | Significant group differences |
| Digital and E-Procurement Competence     | $F(2, 531) = 6.21$  | <.01    | 0.022                  | Significant group differences |
| Legal and Policy Knowledge               | $F(2, 530) = 14.15$ | <.01    | 0.051                  | Significant group differences |

<https://doi.org/10.1371/journal.pone.0341565.t011>

**Table 12. Correlations between Dimension of Procurement Literacy and Ethical Behavioural Intention.**

|      | Pairings |      | Pearson's r | p      | Effect size (Fisher's z) | SE Effect size |
|------|----------|------|-------------|--------|--------------------------|----------------|
| PIE  | –        | PLAN | 0.616***    | < .001 | 0.719                    | 0.044          |
| PIE  | –        | SUP  | 0.638***    | < .001 | 0.755                    | 0.045          |
| PIE  | –        | LEG  | 0.607***    | < .001 | 0.704                    | 0.045          |
| PIE  | –        | DIG  | 0.552***    | < .001 | 0.622                    | 0.044          |
| PIE  | –        | BEH  | 0.823***    | < .001 | 1.165                    | 0.045          |
| PLAN | –        | SUP  | 0.829***    | < .001 | 1.185                    | 0.044          |
| PLAN | –        | LEG  | 0.695***    | < .001 | 0.858                    | 0.044          |
| PLAN | –        | DIG  | 0.590***    | < .001 | 0.678                    | 0.044          |
| PLAN | –        | BEH  | 0.589***    | < .001 | 0.676                    | 0.044          |
| SUP  | –        | LEG  | 0.669***    | < .001 | 0.809                    | 0.044          |
| SUP  | –        | DIG  | 0.616***    | < .001 | 0.718                    | 0.044          |
| SUP  | –        | BEH  | 0.576***    | < .001 | 0.657                    | 0.044          |
| LEG  | –        | DIG  | 0.512***    | < .001 | 0.565                    | 0.044          |
| LEG  | –        | BEH  | 0.568***    | < .001 | 0.645                    | 0.045          |
| DIG  | –        | BEH  | 0.462***    | < .001 | 0.500                    | 0.044          |

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

<https://doi.org/10.1371/journal.pone.0341565.t012>

## 7.7. Predictive validity

To evaluate predictive validity, Pearson correlation analyses were conducted between the procurement literacy constructs and the students' behavioural intention to engage in ethical procurement practices. The results presented in Table 12 showed that all correlations were statistically significant ( $p < .001$ ), which support for the predictive validity of the instrument.

In particular, the behavioural intention of the students demonstrated strong positive associations with all five procurement literacy dimensions. Among these, Supplier and Contract Management showed a robust correlation with behavioural intention ( $r = 0.638$ ), followed closely by Procurement Planning and Decision-Making ( $r = 0.616$ ), Legal and Policy Knowledge ( $r = 0.607$ ), and Digital and E-Procurement Competence ( $r = 0.552$ ). The strongest relationship was observed between behavioural intention and Ethical Procurement Practice ( $r = 0.823$ ), suggesting that students' ethical dispositions are highly predictive of their intention to engage in ethical procurement actions.

Beyond these associations, the dimensions of procurement literacy themselves were also strongly interrelated, with correlation coefficients ranging from 0.462 to 0.829. This pattern reinforces the conceptual coherence of the constructs and highlights their collective contribution to predicting ethical procurement behaviours. Together, these findings provide compelling evidence for predictive validity of the instrument.

## 7.8. Discussions

This study provides robust empirical support for a five-factor, 30-item instrument designed to measure procurement literacy among undergraduate students. The development and validation process adhered to established psychometric principles, combining exploratory and confirmatory factor analyses to ensure structural validity, convergent and discriminant validity, and internal consistency. The iterative refinement of the instrument, although requiring the removal of several items, was guided by best practices in scale development, prioritising theoretical alignment and model parsimony over item retention [74,75]. While some items demonstrated acceptable loadings during exploratory factor analysis, they were

subsequently excluded based on their adverse impact on the global model fit during confirmatory factor analysis. This trade-off is consistent with established recommendations that underscore the importance of model fit and conceptual clarity in instrument refinement [69].

The resulting instrument offers a multidimensional conceptualisation of procurement literacy, comprising Ethical Procurement Practice, Procurement Planning and Decision Making, Supplier and Contract Management, Digital and Electronic Procurement Competence, and Legal and Policy Knowledge. These dimensions not only reflect core procurement competencies, but also align with Levels 2–4 of the Chartered Institute of Procurement and Supply (CIPS) Global Standard [22] enhancing the tool's relevance for academic benchmarking and professional alignment.

Importantly, the inclusion of ethical disposition and behavioural intention constructs in the validation process adds conceptual depth to the instrument, acknowledging the normative dimensions of procurement decision making. As supported by the literature, ethical reasoning and commitment are central to professional integrity and accountability in procurement environments [43,76]. Strong predictive relationships observed between the procurement literacy dimensions and students' intention to engage in ethical procurement practices underscore the applied value of the instrument in assessing not only knowledge but also ethical orientation.

From a pedagogical standpoint, the validated instrument holds substantial potential for use in curriculum design, diagnostics, and monitoring of learning outcomes. Its ability to capture core and evolving competencies such as digital proficiency and regulatory awareness positions it as a relevant framework for educational institutions seeking to strengthen procurement training. Additionally, the ability of the instrument to detect group differences across academic levels further reinforces its diagnostic utility, allowing educators to track student development over time and design targeted interventions where gaps in competencies are identified.

In summary, the final validated procurement literacy instrument is theoretically grounded, psychometrically sound, and practically useful. It offers a valuable resource for improving procurement education in higher education settings and can serve as a foundational tool for future studies examining procurement competence, ethical practices, and behavioural intentions in academic or professional contexts.

## 8. Conclusion

This study developed and validated a psychometrically robust instrument for assessing procurement literacy among undergraduate students. Grounded in contemporary procurement theory and aligned with professional competency frameworks, the instrument captures five core dimensions: Ethical Procurement Practice, Procurement Planning and Decision Making, Supplier and Contract Management, Digital and Electronic Procurement Competence, and Legal and Policy Knowledge. Through rigorous exploratory and confirmatory factor analyses, the final 30-item scale (see [S1 Appendix](#)) demonstrated excellent structural validity, strong internal consistency, and sound convergent and discriminant properties.

Beyond measurement reliability, the instrument exhibits predictive validity by meaningfully correlating with behavioural intentions of students to engage in ethical procurement practices. This connection underscores the practical importance of procurement literacy not only as a technical competency but also as a normative framework for fostering integrity and accountability in public and private sector procurement. The instrument's ability to differentiate student performance across academic levels further enhances its relevance for pedagogy, curriculum evaluation, and tracking of student progression.

The findings have several implications for procurement education. First, the validated instrument offers a foundation for benchmarking and standard setting in procurement training at the tertiary level. Second, it provides educators and curriculum developers with a reliable tool for diagnosing competency gaps and aligning instruction with both academic and industry needs. Lastly, by integrating ethical and digital competencies, the instrument supports the broader goal of preparing procurement professionals who are both technically competent and ethically grounded.

Future research may extend this work by testing the instrument across diverse institutional and cultural contexts, exploring longitudinal changes in student competence, and examining the influence of targeted interventions on procurement learning outcomes. Such studies will further consolidate the instrument's utility and contribute to the global discourse on procurement capacity building in higher education.

## Supporting information

**S1 Appendix. Final validated questionnaire.** This appendix contains the final validated procurement literacy questionnaire used in the study.  
(DOCX)

## Author contributions

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## References

1. Wittig WA. Building Value through Public Procurement: A Focus on Africa. Paper presented to the 9th International Anti-Corruption Conference; 1999 Oct 10-15; Durban, South Africa. Geneva: International Trade Centre (ITC/UNCTAD/WTO).
2. Beth E. Integrity in Public Procurement: Good Practice from A to Z. Paris: Organisation for Economic Co-operation and Development (OECD); 2007.
3. World Bank. Procurement regulations for IPF borrowers: Procurement in investment project financing—Goods, works, non-consulting and consulting services. 4th ed. Washington (DC): World Bank; 2020 [cited 2025 Dec 21]. Available from: <https://www.worldbank.org/en/projects-operations/products-and-services/brief/procurement-new-framework>
4. United Nations Commission on International Trade Law (UNCITRAL). UNCITRAL Model Law on Public Procurement. New York: United Nations; 2011. (Official Records of the General Assembly, Sixty-sixth Session, Supplement No. 17 (A/66/17), annex I).
5. Linarelli J. Global procurement law in times of crisis: Reform and innovation after the global financial crisis. In: Arrowsmith S, Anderson RD, editors. The WTO Regime on Government Procurement: Challenge and Reform. Cambridge: Cambridge University Press; 2011. p. 255–75.
6. Ghana Audit Service. Report of the Auditor-General prepared under Section 14 of the Audit Service Act, 2000 (Act 584), for submission to Parliament in accordance with Section 20 of the Act (June 2024). Accra (GH): Ghana Audit Service; 2024 [cited 2025 Dec 21]. Available from: <https://www.audit.gov.gh>
7. Organisation for Economic Co-operation and Development (OECD). Checklist for Supporting the Implementation of the OECD Recommendation of the Council on Public Procurement. Paris: OECD Publishing; 2016 [cited 2025 Dec 21]. Available from: OECD Public Procurement Toolbox
8. Søreide T. Corruption in public procurement: causes, consequences and cures. Bergen (NO): Chr. Michelsen Institute; 2002 [cited 2025 Dec 21]. 43 p. CMI Report No.: R 2002:1. Available from: CMI Publication Repository
9. Thai KV. Public procurement re-examined. *Journal of Public Procurement*. 2001;1(1):9–50. <https://doi.org/10.1108/jopp-01-01-2001-b001>
10. Basheka BC. Procurement planning and local governance in Uganda: a factor analysis approach. *Int J Procure Manag*. 2009;2(2):191–209.
11. Nguyen PHD, Lines BC, Maali O, Sullivan KT, Hurtado K, Savicky J. Current state of practice in the procurement of information technology solutions: content analysis of software requests for proposals. *Int J Procure Manag*. 2022;15(3):406–23.



12. Organisation for Economic Co-operation and Development (OECD). Reforming Public Procurement: Progress in Implementing the 2015 OECD Recommendation. Paris: OECD Publishing; 2019. <https://doi.org/10.1787/1de41738-en>
13. Vygotsky LS. Mind in society: the development of higher psychological processes. Cambridge (MA): Harvard University Press; 1978. p. 159.
14. Mulder M. Conceptions of professional competence. In: Billett S, Gruber H, Canário R, editors. International handbook of research in professional and practice-based learning. Dordrecht (NL): Springer Netherlands; 2014. p. 107–37.
15. Becker GS. Human capital: a theoretical and empirical analysis, with special reference to education. New York: National Bureau of Economic Research; 1964.
16. Ameyaw C, Mensah S, Osei-tutu E. Public procurement in Ghana: The implementation challenges to the Public Procurement Law 2003 (Act 663). *Int J Constr Supply Chain Manag*. 2012;2(2):55–65. <https://doi.org/10.14424/ijscm201012-55-65>
17. Walker H, Brammer S. Sustainable procurement in the United Kingdom public sector. *Supply Chain Management: An International Journal*. 2009;14(2):128–37. <https://doi.org/10.1108/13598540910941993>
18. Agaba E, Shipman N. Public procurement reform in developing countries: the Ugandan experience. In: Piga G, Thai KV, editors. Advancing public procurement: practices, innovation and knowledge-sharing. Boca Raton (FL): PrAcademics Press; 2007. p. 373–91.
19. Obanda WP. Fighting corruption in tactical procurement [PhD dissertation]. Twente (NL): University of Twente; 2010.
20. Ghana. Public Procurement Act, 2003 (Act 663). Accra (GH): Parliament of the Republic of Ghana; 2003 Dec 31. Available from: [https://ppa.gov.gh/wp-content/uploads/2019/01/Public-Procurement-Amendment-Act-2016-ACT663\\_RePrinted.pdf](https://ppa.gov.gh/wp-content/uploads/2019/01/Public-Procurement-Amendment-Act-2016-ACT663_RePrinted.pdf)
21. Organisation for Economic Co-operation and Development (OECD). Recommendation of the Council on Public Procurement. Paris: OECD Publishing; 2015.
22. Chartered Institute of Procurement and Supply (CIPS). Global standard for procurement and supply. Stamford (UK): CIPS; 2021 [cited 2025 Dec 21]. Available from: [www.cips.org](http://www.cips.org)
23. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International*. 2000;15(3):259–67. <https://doi.org/10.1093/heapro/15.3.259>
24. Lusardi A, Mitchell OS. The Economic Importance of Financial Literacy: Theory and Evidence. *J Econ Lit*. 2014;52(1):5–44. <https://doi.org/10.1257/jel.52.1.5> PMID: 28579637
25. Schapper PR, Veiga Malta JN, Gilbert DL. An analytical framework for the management and reform of public procurement. *Journal of Public Procurement*. 2006;6(1/2):1–26. <https://doi.org/10.1108/jopp-06-01-02-2006-b001>
26. Bigart P. Professionalisation of the practice of public procurement in Africa: using new technologies and approaches [PowerPoint presentation]. Washington (DC): World Bank; 2016 [cited 2025 Dec 21]. Available from: <https://www.afdb.org>
27. Kalinzi C. Level of Professionalism in Public Procurement: a Survey of Selected Districts in Uganda. *SOP Trans Mark Res*. 2014;1(1):43–50. <https://doi.org/10.15764/mr.2014.01004>
28. Schunk DH, DiBenedetto MK. Motivation and social cognitive theory. *Contemporary Educational Psychology*. 2020;60:101832. <https://doi.org/10.1016/j.cedpsych.2019.101832>
29. Fosnot CT. Constructing constructivism. In: Duffy TM, Jonassen DH, editors. Constructivism and the technology of instruction: a conversation. New York: Routledge; 2013. p. 167–76.
30. Frank JR, Snell LS, Cate OT, Holmboe ES, Carraccio C, Swing SR, et al. Competency-based medical education: theory to practice. *Med Teach*. 2010;32(8):638–45. <https://doi.org/10.3109/0142159X.2010.501190> PMID: 20662574
31. Alharbi NS. Evaluating competency-based medical education: a systematized review of current practices. *BMC Med Educ*. 2024;24(1):612. <https://doi.org/10.1186/s12909-024-05609-6> PMID: 38831271
32. Hanushek EA, Woessmann L. The economics of international differences in educational achievement. In: Hanushek EA, Machin S, Woessmann L, editors. Handbook of the Economics of Education. Vol. 3. Amsterdam (NL): Elsevier; 2011. p. 89–200.
33. World Bank. Procurement regulations for IPF borrowers: procurement in investment project financing—goods, works, non-consulting and consulting services. Washington (DC): World Bank; 2016 Jul [cited 2025 Dec 21]. Available from: <https://thedocs.worldbank.org/en/doc/415861533066041404-0290022016/original/ProcurementRegulations2016.pdf>
34. Campion MA, Fink AA, Ruggeberg BJ, Carr L, Phillips GM, Odman RB. Doing competencies well: best practices in competency modeling. *Pers Psychol*. 2011;64(1):225–62. <https://doi.org/10.1111/j.1744-6570.2010.01207.x>
35. Baily P, Farmer D, Crocker B, Jessop D, Jones D. Procurement principles and management. 9th ed. Harlow (UK): Pearson Education. 2008.
36. Mlinga RS, Wells J. Collaboration between formal and informal enterprises in the construction sector in Tanzania. *Habitat International*. 2002;26(2):269–80. [https://doi.org/10.1016/S0197-3975\(01\)00048-0](https://doi.org/10.1016/S0197-3975(01)00048-0)
37. Mpeera Ntayi J, Byabashaija W, Eyaa S, Ngoma M, Muliira A. Social cohesion, groupthink and ethical behavior of public procurement officers. *Journal of Public Procurement*. 2010;10(1):68–92. <https://doi.org/10.1108/jopp-10-01-2010-b003>
38. Alathamneh RD, Negreiros JGM. Ethical dilemmas in oil & gas procurement: a systematic literature review. *Open J Bus Manag*. 2025;13(3):1724–42. <https://doi.org/10.4236/ojbm.2025.133091>

39. Organisation for Economic Co-operation and Development (OECD). The OECD digital government policy framework: six dimensions of a digital government. Paris: OECD Publishing; 2020 Oct 7 [cited 2025 Dec 21]. (OECD Public Governance Policy Papers; no. 02). Available from: <https://doi.org/10.1787/f64fed2a-en>
40. Mishra AN, Devaraj S, Vaidyanathan G. Capability hierarchy in electronic procurement and procurement process performance: An empirical analysis. *J of Ops Management*. 2013;31(6):376–90. <https://doi.org/10.1016/j.jom.2013.07.011>
41. Rodrick F. Competence Level of Graduates on Procurement Strategies for Digital Supply Chains in Tanzania. *Account Bus Rev*. 2024;16(3):24–36. <https://doi.org/10.59645/abr.v16i3.360>
42. Ajzen I. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. 1991;50(2):179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-t](https://doi.org/10.1016/0749-5978(91)90020-t)
43. Treviño LK, Weaver GR, Reynolds SJ. Behavioral Ethics in Organizations: A Review. *Journal of Management*. 2006;32(6):951–90. <https://doi.org/10.1177/0149206306294258>
44. Kwak Y, Ahn J-W, Seo YH. Influence of AI ethics awareness, attitude, anxiety, and self-efficacy on nursing students' behavioral intentions. *BMC Nurs*. 2022;21(1):267. <https://doi.org/10.1186/s12912-022-01048-0> PMID: 36180902
45. Basheka BC, Bisangabasaija E. Determinants of unethical public procurement behavior in Uganda: a conceptual model. *Int J Public Procure*. 2010;3(1):91–104.
46. McCrudden C. Buying social justice: equality, government procurement, and legal change. Oxford (UK): Oxford University Press; 2007. p. 704.
47. Vaidya K, Sajeev ASM, Callender G. Critical factors that influence e-procurement implementation success in the public sector. *Journal of Public Procurement*. 2006;6(1/2):70–99. <https://doi.org/10.1108/jopp-06-01-02-2006-b004>
48. Saeed G, Kohler JC, Cuomo RE, Mackey TK. A systematic review of digital technology and innovation and its potential to address anti-corruption, transparency, and accountability in the pharmaceutical supply chain. *Expert Opin Drug Saf*. 2022;21(8):1061–88. <https://doi.org/10.1080/14740338.2022.2091543> PMID: 35714366
49. Villar Olaeta J. Ethical Competencies and the Organizational Competency 'Responsible University Social Innovation': looking at new ways of understanding universities and the competency-based education model in the context of significant social changes in Latin America. *TJHE*. 2017;4(2):311. [https://doi.org/10.18543/tjhe-4\(2\)-2017pp311-332](https://doi.org/10.18543/tjhe-4(2)-2017pp311-332)
50. Naseer F, Tariq R, Alshahrani HM, Alruwais N, Al-Wesabi FN. Project based learning framework integrating industry collaboration to enhance student future readiness in higher education. *Sci Rep*. 2025;15(1):24985. <https://doi.org/10.1038/s41598-025-10385-4> PMID: 40640511
51. Adam AM. Sample Size Determination in Survey Research. *JSRR*. 2020;26:90–7. <https://doi.org/10.9734/jsrr/2020/v26i530263>
52. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health*. 2006;29(5):489–97. <https://doi.org/10.1002/nur.20147> PMID: 16977646
53. Lynn MR. Determination and quantification of content validity. *Nurs Res*. 1986;35(6):382–5. <https://doi.org/10.1097/00006199-198611000-00017> PMID: 3640358
54. Willis GB. Cognitive interviewing: a tool for improving questionnaire design. Thousand Oaks (CA): SAGE Publications; 2005.
55. Costello AB, Osborne JW. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. *Pract Assess Res Eval*. 2005;10(7):1–9. <https://doi.org/10.7275/jyj1-4868>
56. Hair JF Jr, Howard MC, Nitzl C. Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *J Bus Res*. 2020;109:101–10. <https://doi.org/10.1016/j.jbusres.2019.11.069>
57. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*. 1999;6(1):1–55. <https://doi.org/10.1080/10705519909540118>
58. Kline RB. Principles and practice of structural equation modeling. 5th ed. New York: Guilford Press; 2023.
59. Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. *J Mark Res*. 1981;18(1):39–50. <https://doi.org/10.1177/002224378101800104>
60. Hair JF, Black WC, Babin BJ, Anderson RE. Multivariate data analysis. 8th ed. Boston (MA): Cengage Learning; 2019. p. 834.
61. Vandenberg RJ, Lance CE. A Review and Synthesis of the Measurement Invariance Literature: Suggestions, Practices, and Recommendations for Organizational Research. *Organizational Research Methods*. 2000;3(1):4–70. <https://doi.org/10.1177/109442810031002>
62. Sözer Boz E, Tabak H. Exploring the relationship between learning climate in schools and agile leadership using multi-group path analysis: does "Willingness to work" have a mediating role?. *Curr Psychol*. 2025;44(5):4002–15. <https://doi.org/10.1007/s12144-025-07450-6>
63. Podsakoff PM, MacKenzie SB, Lee J-Y, Podsakoff NP. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol*. 2003;88(5):879–903. <https://doi.org/10.1037/0021-9010.88.5.879> PMID: 14516251
64. Fuller CM, Simmering MJ, Atinc G, Atinc Y, Babin BJ. Common methods variance detection in business research. *Journal of Business Research*. 2016;69(8):3192–8. <https://doi.org/10.1016/j.jbusres.2015.12.008>
65. Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar A-R. Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication. *J Caring Sci*. 2015;4(2):165–78. <https://doi.org/10.15171/jcs.2015.017> PMID: 26161370

66. Agyepong AO, Nhamo G. An assessment of green procurement practices in South African metropolitan municipalities. *J Public Adm.* 2015;50(1):50–69.
67. Ghana Audit Service. Report of the Auditor-General prepared under Section 14 of the Audit Service Act, 2000 (Act 584), for submission to Parliament (June 2024). Accra (GH): Ghana Audit Service; 2024 [cited 2025 Dec 21]. Available from: <https://www.audit.gov.gh>
68. Boateng A, Ameyaw C, Mensah S. Assessment of systematic risk management practices on building construction projects in Ghana. *International Journal of Construction Management.* 2020;22(16):3128–36. <https://doi.org/10.1080/15623599.2020.1842962>
69. Brown TA. Confirmatory factor analysis for applied research. 2nd ed. New York: Guilford Press; 2015.
70. Henseler J, Ringle CM, Sarstedt M. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *J of the Acad Mark Sci.* 2014;43(1):115–35. <https://doi.org/10.1007/s11747-014-0403-8>
71. Byrne BM. A primer of LISREL: basic applications and programming for confirmatory factor analytic models. New York: Springer Science & Business Media; 2012. p. 320.
72. Adam AM. Statistics for business research: a guide for non-statisticians. Accra (GH): Global Research and Publications; 2015. p. 268.
73. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum Associates; 1988. p. 567.
74. Marsh HW, Hau K-T, Wen Z. In Search of Golden Rules: Comment on Hypothesis-Testing Approaches to Setting Cutoff Values for Fit Indexes and Dangers in Overgeneralizing Hu and Bentler's (1999) Findings. *Structural Equation Modeling: A Multidisciplinary Journal.* 2004;11(3):320–41. [https://doi.org/10.1207/s15328007sem1103\\_2](https://doi.org/10.1207/s15328007sem1103_2)
75. Schumacker RE, Lomax RG. A beginner's guide to structural equation modeling. 4th ed. New York (NY): Routledge; 2016. p. 384.
76. Flynn A, Davis P. Explaining SME participation and success in public procurement using a capability-based model of tendering. *J Public Procure.* 2017;17(3):337–72. <https://doi.org/10.1108/JOPP-17-03-2017-B001>